TAILORING PERSUASIVE MOBILE TECHNOLOGY FOR PROMOTING PHYSICAL ACTIVITY

by

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DEDICATION

I dedicate this thesis to my family members, particularly my parents:

Fahad Aldenaini and Fouzia Aldossary

and to my brother:

Faisel Aldenaini

and my sisters:

Fatima Aldenaini

Fatin Aldenaini

Noof Aldenaini

Farah Aldenaini

Fay Aldenaini

All of you have consistently supported and motivated me to pursue my passion.

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ABSTRACT

Persuasive technology (PT) is increasingly employed in the health and wellness domain to motivate and assist users with various lifestyles and behavioral health issues to alter their attitudes and behaviors. There is increasing evidence that PT can effectively encourage behavior change in many health and wellness areas, including promoting physical activity (PA), healthy eating, and reducing sedentary behavior (SB). Persuasive PA applications (apps) have proven to be effective in promoting desirable behavior change and mitigating non-desirable behaviors by employing various persuasive strategies, such as reminders and suggestions.

Tailoring persuasive PA systems, particularly mobile PA apps, can enhance their effectiveness. However, limited research has been conducted on culturally tailoring persuasive strategies to individuals' PA stages of change (SoC) using the Transtheoretical Model (TTM) and their motivations for behavior change using the ARCS motivation model. Most of these apps follow a one-size-fits-all approach, primarily targeting individuals from developed countries while overlooking other regions, such as Arabic countries.

In this study, I investigate whether there are differences between Arabic and non-Arabic populations and develop a culturally and motivationally based model that offers guidance for tailoring persuasive PA interventions to individuals from both Arabic and non-Arabic populations. This model was developed via a large-scale user study that assessed the effectiveness of various persuasive strategies and their implementations while taking into consideration the participants' needs, preferences, and recommendations. Our findings reveal variations in the persuasiveness and effectiveness of the persuasive strategies and their various implementations for Arabic and non-Arabic audiences. Based on these findings, I developed guidelines for tailoring persuasive PA apps. Finally, using these guidelines, I developed app prototypes illustrating how our model’s results can be employed.

This work contributes to the existing literature by integrating theories and models including the TTM, SoC, the ARCS motivation model, and the Persuasive System Design (PSD) model, along with other strategies beyond the PSD model, to identify patterns in people’s motivations and responses to persuasive strategies and their implementations that will inform the tailoring of PA apps to Arabic populations. It offers valuable guidelines for tailoring persuasive apps in the PA domain.

LIST OF ABBREVIATIONS USED

Application	App
Persuasive Systems Design	PSD
Persuasive Technology	PT
Physical Activity	PA
Sedentary Behavior	SB
Moderate Intensity Physical Activity	MIPA
Metabolic Equivalents	METs
World Health Organization	WHO
Social Networking Sites	SNSs
Transtheoretical Model	TTM
Health Belief Model	HBM
Social Cognitive Theory	SCT
Goal-Setting Theory	GST
Theory of Planned Behavior	TPB
Self-Determination Theory	SDT
Grounded Theory	GT
Theory of Self-Efficacy	TSE
Global Positioning System	GPS
Global System for Mobile Communications	GSM
Application Program Interface	API
Stage of Change	SoC
Human Computer Interaction	HCI
Preferred Reporting Items for Systematic Reviews and Meta-Analyses	PRISMA
Implementation 1	IMPL-1
Implementation 2	IMPL-2
Attention	ATT
Confidence	CON
Relevance	REL
Satisfaction	SAT

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1 CHAPTER 1: INTRODUCTION

In recent years, our increasingly sedentary way of life has become a significant public health issue. Sedentary behavior (SB) is defined as any waking behavior that has an energy expenditure less than or equal to 1.5 metabolic equivalents. This may include sitting or lying in a reclining posture such as while watching television or working at a desk [23]. Compared to previous generations, life has become much more sedentary, and individuals are spending more time in environments that limit physical activity (PA) and require prolonged sitting. A sedentary lifestyle is associated with health complications such as obesity, diabetes, cancer, and cardiovascular diseases, among other conditions [78]. Thus, there is a need to employ strategies that address this sedentary lifestyle and reduce the health risks it poses.

Persuasive technologies (PTs) are computer systems designed to be interactive and to influence the attitudes, beliefs, and behavior of the user to achieve a certain objective [206]. Fogg [92] further defined PTs as '*the computing systems, devices, or applications intentionally designed to change a person's attitudes or behavior in a predetermined way*.' Such technologies have been used in various spheres such as sales and the military, and their use in health care is rapidly increasing. Over the past few years, several PTs have been developed that aim to improve one or more aspects of human health. The term 'persuasive' implies that the attitude and behavior of the user are changed in a predetermined way in accordance with the plans and design intents of the PT designer. These technologies can be used to promote health and prevent disease or to manage diseases and health conditions [202], [205].

To effectively manage SB using PTs, it is essential to focus on technologies that prioritize health promotion and disease prevention. This entails targeting specific individual behaviors or activities and actively encouraging increased PA levels. In recent years, there has been an increase in the research and design of such technologies for use in health care. Despite overwhelming interest in this field, there is still a need for research on how to design mobile PA applications (apps) to increase their effectiveness. This dissertation investigates how to design a tailored persuasive mobile app for promoting PA among Arabic and non-Arabic adults based on their needs, preferences, motivational appeals, and stages of behavior change.

1.1 Problem Statement

Widespread research has been conducted on the effectiveness of technology at influencing behavior in various health and wellness domains such as promoting healthy eating and smoking cessation. There have also been reviews on the use of various persuasive strategies and technologies such as the use of computer games, social cues, or tracking and reminders in persuasive systems to promote desirable behavior.

Despite the widespread persuasive interventions used in persuading people to adopt desirable healthy behaviors and avoid risky ones, most of these PTs are designed using a "one-size-fits-all" or non-tailored method [35] [210]. This "one-size-fits-all" approach might be ineffective because different individuals might be motivated and persuaded to change their undesirable behaviors by various persuasive strategies [195], [214], [213], [207], [46], [144], [213], [210], [219]. Most of the human-computer interaction (HCI) studies on promoting PA were conducted while targeting behavior changes of users from Western countries, resulting in a lack of studies and a huge gap in research on the use of persuasive systems in changing users' behaviors in non-Western countries (e.g., Arabic countries). Most of the existing studies concentrate on Western populations (e.g., American, Australian, European, Canadian populations) that are considered part of individualist cultures [16]. Research also shows there is little knowledge about how PT interventions can be tailored to people in various stages of behavior change, with varying motivational appeals and different perceived persuasiveness [218].

Therefore, the following overarching research questions (RQs) have guided my research work:

RQ1: *How can physical activity applications with persuasive elements be culturally tailored to align with users' motivational appeals and accommodate different stages of behavior change?*

RQ2: *What are the recommended implementation choices for designers of persuasive physical activity applications at different stages of behavior changes, targeting Arabic and non-Arabic users?*

RQ3: *What are the recommended guidelines for designers of persuasive physical activity applications targeting Arabic and non-Arabic users?*

RQ4: *How can these tailored guidelines be applied in designing physical activity apps for Arabic and non-Arabic users?*

1.2 Motivation

Physical inactivity poses a significant risk for numerous non-communicable diseases, including diabetes [167], [302], cardiovascular disease [259], [302], and overweight and obesity [176]. Recent evidence has demonstrated that physical inactivity ranks among the prominent global risk factors for mortality [108]. Alarming statistics reveal that a remarkable 25% of adults aged 18 and older are inactive, with this number steadily increasing due to economic development and urbanization [108]. Consequently, the promotion of PA remains an urgent imperative. The emergence of the COVID-19 pandemic has accentuated concerns about sedentary lifestyles, as obesity rates continue to rise [159]. Additionally, researchers have highlighted the robust link between regular PA and a reduced risk of severe COVID-19 outcomes [251], [36]. Health authorities worldwide recommend that adults engage in a minimum of 150 minutes of moderate to vigorous PA per week [228]. This recommendation has been widely endorsed based on compelling evidence supporting the multitude of health benefits derived from regular PA [251].

To tackle this issue, adopting an active lifestyle and participating in PA is crucial. Adopting a physically active lifestyle through regular exercise brings numerous health advantages [231]. Nonetheless, common complaints associated with PA include time constraints, motivational hurdles, and feelings of exhaustion [189]. Hence, many individuals lack the motivation to consistently engage in PA. Consequently, various persuasive interventions have been proposed to enhance the likelihood of increased PA. However, this task is far from straightforward due to the complexity of interactions and interdependencies between PA and factors including demographics, biology, behavior, psychology, and social influences [16]. Research has firmly established that interventions aimed at boosting PA motivation represent one of the most effective approaches to inspire people to become more physically active [222].The concept of PT refers to intentionally designed applications oriented towards altering behaviors and attitudes through persuasion while not employing coercion or deception [92]. Persuasive mobile apps that center on health and wellness have achieved global popularity, with an estimated over 40,000 mobile apps targeting behavior change in diverse health domains such as smoking cession, dietary choices, and PA [5], [40], [56], [149]. Thus, PTs have been extensively use in multiple behavior change domains, including PA. Critically, there is a consensus that a one-size-fits-all approach is inadequate, highlighting the importance of tailoring persuasive

interventions to distinct user groups according to various aspects such as cultural differences [16], [21], [142], age groups [199], genders [14], [17], health conditions [184], personality traits [192], [19], [20], and stages of behavior change [218], [188]. Consequently, numerous studies have investigated this matter and suggested potential solutions for tailoring PT using different theories and models [22].

Accordingly, most of the persuasive apps designed to promote PA have been developed using a "one-size-fits-all" approach that disregards tailoring behavior theories (e.g., the Transtheoretical Model (TTM) and its stages of change (SoC)) and persuasive strategies for user groups based on different aspects (e.g., cultural variances) [30], [91], [171], [145], [202]. Though SB and physical inactivity remain a global challenge that impacts both individualist and collectivist cultures, most PT intervention studies have been conducted on developed countries, including European, Canadian, Australian, and American cultures, which are identified as individualistic [202], [150]. As a result, the effects of various cultures on the design of PA persuasive and behavior change systems have been largely neglected [279]. Thus, the lack of guidelines for tailoring PT interventions to people from different cultures and at different stages of behavior change in promoting PA has led to the increased adoption of a one-size-fits-all approach to design. Designing tailored PT systems requires more knowledge of the target behavior change (e.g., promoting PA) and the different cultures and their effects on users' thoughts, attitudes, and beliefs. PT designers might not have enough knowledge or time to develop in-depth guidelines for tailoring PTs before starting the actual PT design. Therefore, it is important to design a research study that addresses this issue by offering guidelines for designing tailored PT systems.

1.3 Objectives

This work's main contribution is to provide researchers with guidelines for tailoring persuasive PA interventions. This dissertation provides a comprehensive literature review of PT interventions in promoting PA and introduces the proposed field evaluation methodology in investigating possible similarities and dissimilarities between cultures (Arabic and non-Arabic countries) and culture's influences on people's behavior change with respect to their current stage of change, perceived persuasiveness, and motivational appeals. The study employed a mixed-method research approach involving the use of quantitative and qualitative methodologies to collect different types of data and explore our research questions and objectives. This work is comprised of five stages (see Figure 1):

1.3.1 Stage 1: Identifying Persuasive Technology Platforms

In the first stage, I conducted a systematic review of 170 articles on PTs for promoting PA and reducing SB (presented in Chapter 3) and found that *mobile and handheld devices* were the most frequently employed technology platform in the reviewed articles.

1.3.2 Stage 2: Identifying Initial Persuasive Strategies

In the second stage, I conducted a systematic review of 80 articles on a *mobile phone-based technology* platform for promoting PA and reducing SB (presented in Chapter 4). The most frequently employed technology platforms used in conjunction with mobile phone-based PTs are wearable activity trackers and sensors. This is followed by mobile phone-based PTs with/without embedded (built-in) sensors and cameras. The following are the twelve most frequently employed strategies: *self-monitoring, personalization, reminders, goal setting, rewards, praise, reduction, social competition, suggestion, social comparison, tunneling, and simulation*.

1.3.3 Stage 3: Identifying Persuasive Strategies and Their Implementations

In the third stage, I carried out a comprehensive systematic review of 198 articles (from 2006 to 2021) on mobile-based PT interventions to identify the most and least frequently employed persuasive strategies and to demonstrate how each strategy was implemented and to assess their effectiveness (presented in Chapter 5). The twelve most frequently employed strategies identified were *self-monitoring, goal setting, reminders, rewards, personalization, praise, tailoring, reduction, tunneling, social competition, suggestion, and social cooperation.*

1.3.4 Stage 4: Designing and Conducting a User Study

In the fourth stage, which involved building on the findings of previous systematic reviews, I conducted a large-scale user study (online survey) that included 1100 participants (Arabic and non-Arabic populations) (presented in Chapter 6). I have selected the most frequently employed technology platform (*mobile and handheld devices*) and implemented the most commonly used strategies from these stages in the persuasive mobile app prototypes for promoting PA in the online survey. Twenty-four high-fidelity prototypes operationalizing each persuasive strategy for promoting PA were designed and presented. Each strategy was designed and employed using *two different forms of implementation* based on the third systematic review (Stage 3) and iterative evaluations and

recommendations from 16 researchers in HCI and PT to compare the two implementation strategies. Based on the findings of the systematic review and the assessments made by researchers, the following strategies were incorporated into the user study: *self-monitoring, personalization, goal setting, suggestion, reminders, praise, rewards, reduction, tunneling, social competition, social cooperation, and simulation*. The study revealed notable variations in persuasiveness among both strategies and their implementations and among Arabic and non-Arabic participants, with some proving more effective than others. In the end, this work not only offers a practical guide for app designers but also provides design guidelines tailored to both Arabic and non-Arabic populations, further enhancing the potential impact of persuasive PA apps.

1.3.5 Stage 5: Mapping Persuasive Strategies and their Implementations to App Features

Mapping the persuasive strategies' implementations (features) and guidelines to app features can provide guidance for persuasive PA app designers and researchers. This process helps in selecting the appropriate implementation of each persuasive strategy and transferring it into real-world app development. Drawing upon a comprehensive literature review of PA interventions, analysis of online survey results (such as participant feedback and comments), and the challenges of practically implementing persuasive strategies, I translated these implementations into tangible design features and components. This translation is based on the preferred form of implementation, considering both quantitative and qualitative findings from the user study (presented in Chapter 6). I used these features in designing wireframes (prototypes) for our PA app, with separate versions tailored for Arabic and non-Arabic populations, as presented in Chapter 7.

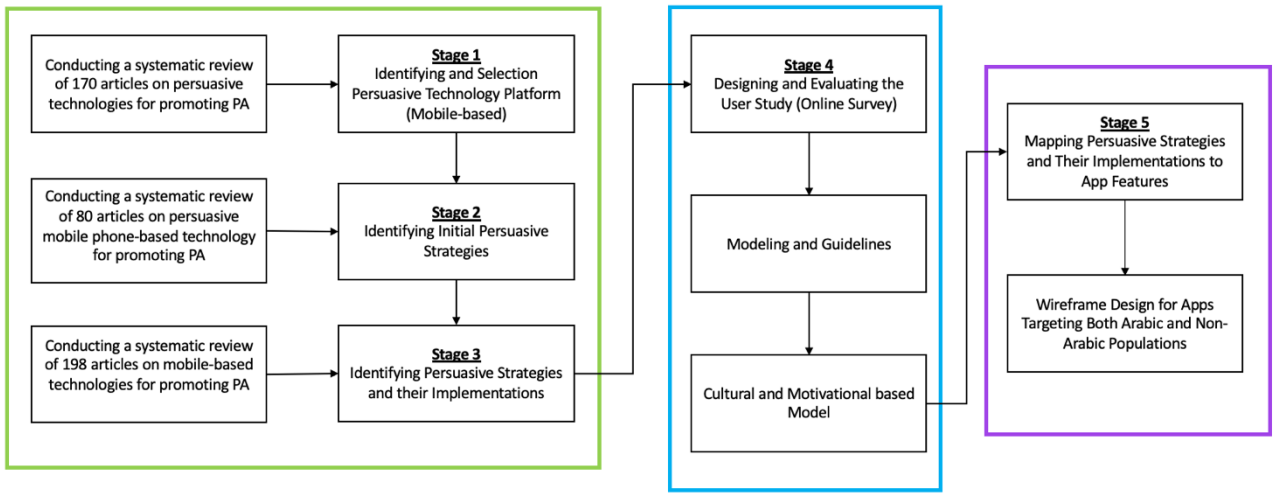


Figure 1: The Five Stages Involved in Tailoring Persuasive Physical Activity Interventions.

1.4 Contributions

The dissertation presents several important contributions derived from the findings at each stage of the research. Figure 2 provides a summary of the main modules and contributions of the dissertation.

Module 1: Examination of Persuasive Technology Platforms and Research Trends

- Assessed the effectiveness of PTs in promoting PA and reducing SB.
- Summarized and highlighted trends in research outcomes, including the technological platforms used, persuasive strategies, targeted demographics, and behavioral and psychological outcomes.
- Identified gaps and pitfalls in existing literature to guide the design of PTs focusing on PA and SB.
- Identified the most effective technology platforms and frequently targeted populations.

Module 2: Evaluation of Mobile Phone-based Technology Platforms Alone and in Combination with Other Technologies

- Evaluated the effectiveness of mobile phone-based PTs in encouraging PA and reducing SB.

- Explored research trends, including persuasive strategies, behavioral theories, technology platforms, targeted demographics, and the integration of mobile phone-based PTs with other technological platforms.
- Identified strengths and weaknesses of current mobile phone interventions in PA and SB domains.
- Provided recommendations for future research in this field.

Module 3: Examination of Persuasive Strategies and Their Implementation in Mobile-based Interventions

- Explored different implementation approaches for persuasive strategies in mobile-based PTs.
- Compared different implementation approaches for each persuasive strategy.
- Identified strengths and weaknesses of interventions based on strategy implementation.
- Highlighted research limitations and provided recommendations for future studies.

Module 4: Tailoring Persuasive Strategies and Implementations to App Features Across Arabic and non-Arabic Populations

- Conducted a large-scale user study involving both Arabic and non-Arabic populations to assess the persuasiveness and effectiveness of various persuasive strategy implementations.
- Investigated the overall persuasiveness of different persuasive strategies and identified preferences among populations.
- Examined the persuasiveness of distinct implementations of each strategy and factors influencing their selection.
- Explored the relationship between ARCS motivational constructs (attention, relevance, confidence, satisfaction) and stages of behavior change (precontemplation, contemplation, preparation, action, maintenance) and provided recommendations for strategy implementation across populations.
- Explored participant preferences, perspectives, and recommendations to inform future app designs.
- Proposed practical guidelines for tailoring persuasive systems based on user preferences and behavior change stages.

- Offered qualitative insights into the reasons behind user preferences and dislikes.
- Established connections between behavior change theories and motivation theory.
- Suggested avenues for future research, including the real-world application of design recommendations and further exploration of strategy implementations in different behavioral domains, cultures, and user characteristics.

In brief, this dissertation contributes significant insights to the fields of PT and HCI. It sheds light on the effectiveness of PTs, the influence of personalized systems, and the complexities of strategy implementation. It also offers practical advice for producing persuasive systems that can accommodate individual user preferences and facilitate behavior change at various stages. Furthermore, it outlines potential directions for future research within this domain and others.

In future research, I aim to enhance the understanding of PT and its use by employing a comprehensive approach. This approach includes implementing the design recommendations in real persuasive systems, studying user preferences during behavior change transitions, exploring the impact of less favored strategies, examining additional strategy implementations, extending our findings to diverse behavioral domains, assessing the influence of age, gender, and personality traits, and investigating cultural variations within specific countries. By addressing these aspects, I intend to contribute valuable insights to the field of PT to enable the development of more effective and culturally sensitive applications.

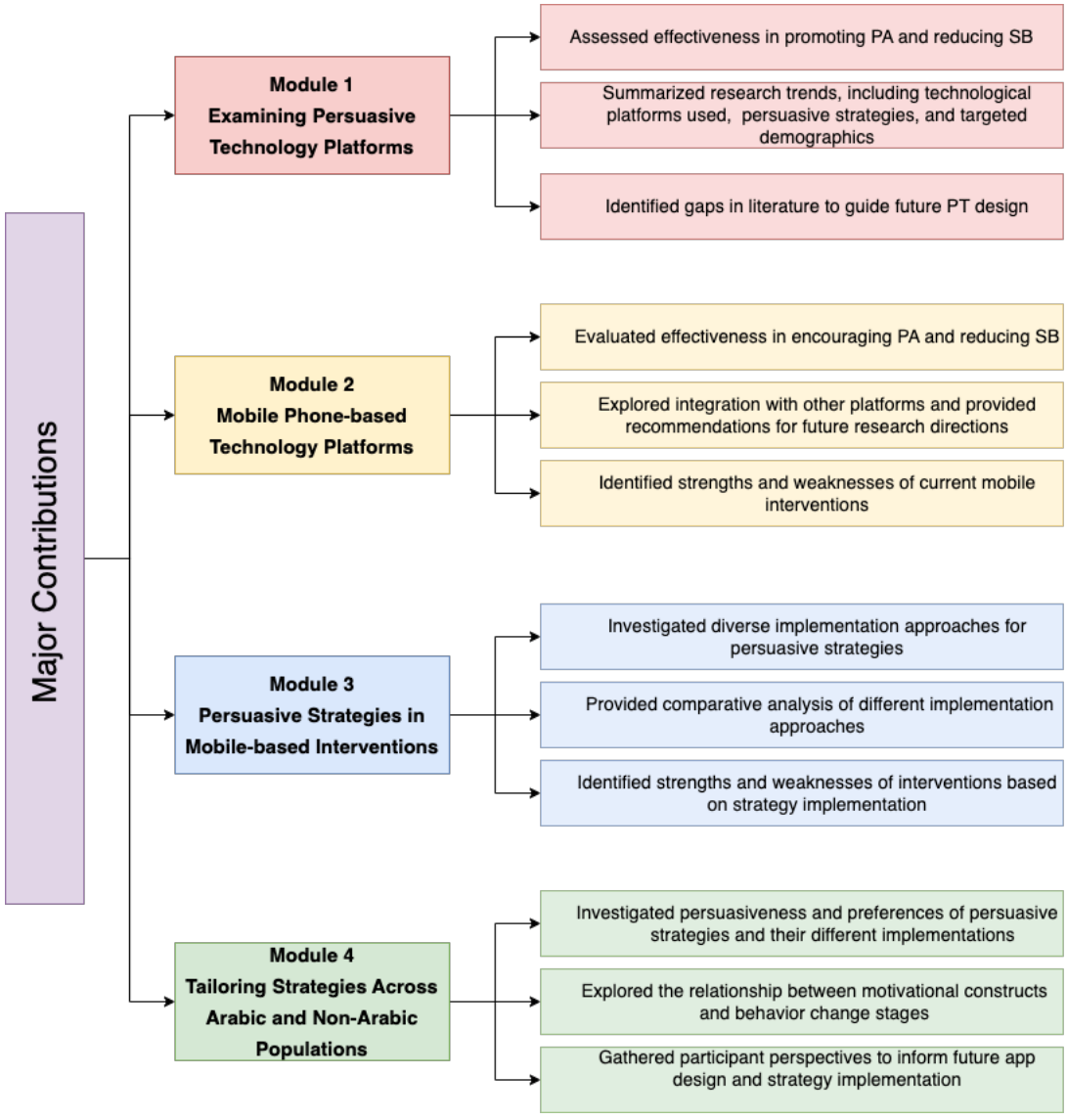


Figure 2: Major Modules and Contributions of the Dissertation.

1.5 Overview of the Dissertation

This dissertation consists of eight chapters, with each chapter presenting detailed information summarized in this introductory chapter.

CHAPTER 1: INTRODUCTION - This chapter provides an overview of the thesis, including the problem statement, motivations, objectives, and contributions of each stage of the dissertation.

CHAPTER 2: RESEARCH BACKGROUND - This chapter discusses the background and literature review of technology-based PA interventions.

CHAPTER 3: PERSUASIVE TECHNOLOGIES FOR PHYSICAL ACTIVITY AND THE REDUCTION OF SEDENTARY BEHAVIOR - This chapter presents the results of a comprehensive systematic review of 170 articles on PTs for promoting PA and reducing SB. The review evaluates the effectiveness of PT interventions across various technological platforms (e.g., websites, social networks, and activity trackers) and identifies trends in system design, the target audience, and psychological and behavioral outcomes.

CHAPTER 4: MOBILE PHONE-BASED PERSUASIVE TECHNOLOGY FOR PROMOTING PHYSICAL ACTIVITY AND REDUCING SEDENTARY BEHAVIOR - This chapter discusses the results of a comprehensive systematic review of 80 articles that focus on mobile phone-based technology platforms for promoting PA and reducing SB. The review evaluates the effectiveness of mobile phone-based PT interventions, discusses insights into the persuasive strategies employed, and explores other technology platforms used in conjunction with mobile phone-based PT interventions.

CHAPTER 5: PERSUASIVE STRATEGIES AND THEIR IMPLEMENTATIONS IN MOBILE INTERVENTIONS FOR PROMOTING PHYSICAL ACTIVITY - This chapter discusses the results of a comprehensive systematic review of 198 articles (from 2006 to 2021) on mobile-based PT interventions. It explores and compares the implementation approaches of various persuasive strategies and identifies the most and least employed strategies.

CHAPTER 6: TAILORING PERSUASIVE AND BEHAVIOR CHANGE SYSTEMS FOR PROMOTING PHYSICAL ACTIVITY - This chapter discusses the process of developing the user study using an online survey and provides a comparison between Arabic and non-Arabic populations. It outlines the

study's objectives, research questions, background, related work, and evaluation methodology. Furthermore, it presents and discusses the results. Additionally, the chapter offers guidance on developing a tailored persuasive system to encourage PA. This development is based on the user-study assessments of the persuasiveness of various persuasive strategies and their implementations. The approach also takes into consideration participants' needs, preferences, recommendations, motivational appeals, and stages of change.

CHAPTER 7: PERSUASIVE PHYSICAL ACTIVITY APP PROTOTYPES TAILORED TO ARABIC AND NON-ARABIC POPULATIONS - This chapter presents wireframes of user interface designs for our mobile PA app called 'Walk4Wellness,' which is specifically tailored for both Arabic and non-Arabic users. These wireframes are developed based on the findings of the user study and follow a series of phases for selecting strategies and features for app design. The chapter introduces two versions of the app (Arabic and non-Arabic) and highlights the similarities and differences in their features.

CHAPTER 8: CONCLUSION - This chapter summarizes the contributions of this dissertation and outlines future work.

2 CHAPTER 2: RESEARCH BACKGROUND

This chapter provides an overview of physical activity (PA) and sedentary behavior (SB) definitions and issues, and the background of persuasive technology (PT) interventions and digital tools employed in such domains. It also provides a brief introduction of the persuasive strategies used in the Persuasive System Design (PSD) model [123] and behavioral change theories.

2.1 Sedentary Behavior

SB is defined as an activity in which an individual consumes very low metabolic energy (≤ 1.5 MET) and is commonly described as prolonged time spent sitting [215]. Therefore, SB is distinct from inactivity, since the latter is defined as not accomplishing appropriate levels of moderate-intensity PA [225]. Simply, SB refers to too much sitting, which is different from too little exercise [215] [216], and [38]. Prolonged SB is described as continuing SB for more than 30 minutes [109]. To clarify this point, an individual can be considered an active person if they meet the guidelines of practicing a sufficient amount of PA; however, they can still spend long amounts of time laying on a couch, sitting while watching TV, or working at a desk. Individuals may believe that meeting PA guidelines is sufficient to compensate for the deleterious health impacts associated with prolonged SB [287]. The physiological research by Hamiliton et al. [119] shows that standing behavior has fewer undesirable metabolic effects compared with sitting behavior, as standing behavior employs the large muscles of a person's lower body. Therefore, SB correlates with death and many undesirable health illnesses, such as colon cancer, high blood pressure, obesity, diabetes, and cardiovascular diseases. [78]. PT can play an essential role in lowering the time users spend on sedentary activity and encourage them to change their behaviors by adopting a healthy and active lifestyle.

2.2 Physical Activity

PA is defined as "*any bodily movement produced by skeletal muscles that results in energy expenditure*" [48]. PA is very beneficial for human health and well-being. Research has indicated that at least 30 minutes daily of practicing moderate-intensity PA can considerably mitigate the risk of various chronic diseases (e.g., diabetes, obesity, cardiovascular disease, cancer, depression, hypertension, and osteoporosis) and improve mental health and general well-being [226], [288]. The WHO's worldwide guidelines for PA suggest that all adults need to have 150 minutes of moderate-

intensity PA each week [309]. Some barriers might hinder people from continuing their commitment and adherence to keeping a healthy level of PA such as environmental barriers (e.g. weather, road construction), social barriers (e.g., social support and external motivation from families and friends), personal barriers (e.g., internal motivation, a lack of awareness), practical barriers (e.g., time, cost, access to facilities) [26], [50], and workplace barriers (e.g., low acceptability in an organization, anxiety about lower productivity) [229]. Therefore, the smart use of PT in the health domain of PA can help users obtain a suitable level of PA and lower their time being sedentary.

2.3 Persuasive Technologies and Digital Technologies' Tools

PTs are computer systems designed to be interactive and influence the attitudes, beliefs, and behavior of the user to achieve a certain objective [206]. Fogg [92] further defined PTs as '*the computing systems, devices, or applications intentionally designed to change a person's attitudes or behavior in a predetermined way*.' Different types of digital technologies can be used in the field of persuasion such as ambient and public displays, desktop computers, smartphones and handheld devices, wearable activity trackers and smartwatches, websites and social networking sites (SNSs).

2.3.1 Ambient Persuasive Technology

PTs can be incorporated unobtrusively into the environment because they are not limited or bound to a specific location [116]. Consequently, new influential forms of PT can be produced through ambient intelligence PT such as ambient objects and ambient displays [24], [116]. For instance, ambient displays deliver people information by presenting it in an environment via small changes in color, smell, sound, movement, form, light or temperature [298]. The perFrame [198] is an example of an ambient display, as it is a picture frame used to persuade people to have an appropriate and healthy sitting posture. Therefore, ambient PT can change the attitudes or behavior of an individual without requiring them to give their conscious attention to that PT [116].

2.3.2 Smartphones and Handheld Devices

Smartphones and tablet devices are widely used among all age groups globally due to their robust computing ability, large screens, significant memory capacity, and additional functionalities including GPS, cameras, embedded sensors, Wi-Fi services, and open operating systems. In general, smart mobile devices contain software applications (apps) that have become crucial in the lifestyle of today's

society with high usage rates since their introduction in 2007 [197], [60]. For instance, 61% of Europeans, 70% of Americans and 74% of Australians use a smartphone and/or tablet in their daily routine [60], [107]. The evolution of smartphones and mobile technologies has encouraged the development of health and PA apps to deliver healthy behavioral interventions that can benefit large numbers of individuals [185]. PA applications on smartphones can track and monitor the PA progress of a user in real-time and help them work toward PA goals over time by using built-in accelerometers and other embedded sensors. Thus, they can offer immediate feedback on the number of calories burned, steps taken, etc. Therefore, using mobile technologies with the included software apps, researchers were able to apply health behavior change techniques and strategies (e.g., self-monitoring, rewards, goal setting, performance feedback, social influence) that have been shown to enable health behavior changes among different populations [185], [73].

2.3.3 Web-based Interventions and Social Networking Sites

A web-based intervention is defined as "a primarily self-guided intervention program that is executed by means of a prescriptive online program operated through a website and used by consumers seeking health- and mental health-related assistance" [32]. Web-based systems have the ability to deliver real-time feedback and instantly link information with the user's level of belief, motivation, and awareness, particularly for health purposes [175].

SNSs can have a significant positive influence on health behavior changes and have the ability to improve technology intervention retention rates [163]. Therefore, integrating social properties from SNSs (e.g., social comparison, social competition, social recognition "ranking") in persuasive health technologies (e.g., mobile and handheld devices, websites, sensors and wearable devices, desktops, ambient displays, games, and others) could play a fundamental role in engaging individuals to change their undesirable behavior or attitudes and encouraging them to adopt a healthy lifestyle. Some examples of globally used and well-known SNSs that appear as websites and/or mobile apps are Facebook, Twitter/X, Instagram, Snapchat, WhatsApp, Skype, and YouTube. The developers of PTs sometimes add social support features to their persuasive design, and they benefit from already-existing SNSs by implementing some of these SNSs' features in their design or simply by linking SNSs (e.g., Facebook, Twitter/X) for social support purposes. Twitter Me [303] showed an example of the use of SNSs in a persuasive design, as Young used the well-known micro-blogging site Twitter

with mobile phone technology to motivate teenage girls to exercise and improve their health knowledge and awareness through social sharing and comparison motivational strategies. PersonaA [30] and Active2Gether [157] used Facebook as a platform for SNSs to provide the social support principle to motivate users to increase their PA level. Consequently, SNSs can persuade the target audience to adopt desirable behaviors or attitudes through social support strategies.

2.3.4 Wearable Activity Tracker Devices and Software

The tracking and documentation of an individual's SB and PA are considered as an approach for monitoring and encouraging a person to engage in PA (e.g., walking, jogging, dancing, cycling, and swimming). Nowadays, with their widespread use, wearable tracking technologies have digitized the operation of tracking and monitoring fitness progress, SB and other health-related issues (e.g., step counts, distance traveled, calories burned, heart rate, speed and pace, time spent stationary) [6], [124], [262]. Wearable PA tracker devices are promising for providing expected positive effects on the user's health, well-being and behavioral lifestyle due to these devices' ability to provide regular and continuous feedback on the user's progress [129], [93]. Wearable tracking devices such as smartwatches and other body-worn sensors (e.g., Fitbit, Jawbone, MyFitnessPal) as well as software applications on smartphones or tablet devices are becoming widely adopted despite the challenges in measuring their efficacy for long-term use and adherence [161], [273], [283]. Therefore, only a few studies have examined the long-term effects of using wearable activity tracking technology [282].

2.3.5 Games and Gamification

The term "gamification", which refers to technology with game-like elements or features, was broadly used by technology and health professionals during the first half of the year 2010 [71]. Gamification is defined as "*the use of game design elements in non-game contexts*" [71]. Gamification has been widely used in the PT industry through applying game-like rewards and incentives to change individuals' behavior, maintain their healthy habits and increase their motivation and awareness [71], [156]. Persuasive games are considered successful methods for reinforcing healthy behaviors and changing people's unhealthy behaviors or attitudes. Evidence of persuasive games' effectiveness in changing behavior in a desirable way has been shown in the studies of [152], [212]. Some PA video games are known as "exergames" or "exertion games" [33] such as Wii Sport [187]. Games in the health domain of PA and SB can be employed in technologies such as smartphones, tablets, desktops,

wearable activity trackers, websites, and SNSs. Therefore, gamification and games are useful techniques that can be employed in PT to promote PA encourage users to adopt a healthy lifestyle through an enjoyable and interactive approach.

2.4 Persuasive System Design Model

In this dissertation, I apply the framework of the PSD model to identify different PT strategies or "techniques" that have been implemented in the reviewed articles [123]. The PSD model employs several theoretical constructs, such as the theory of reasoned action/planned behavior [7], goal-setting theory [173], and the elaboration likelihood model [227]. The PSD model is explained in detail in the article of Oinas-Kukkonen & Harjumaa, (2009) [123]. Thus, the PSD model provides a suitable approach to investigate, design, and assess the persuasion context and its associated strategy techniques [166]. Persuasion context analysis involves identifying the intent, the event, and the strategy techniques for persuasion purposes [123].

The persuasive system principles of the PSD model [123] are divided into four categories: primary task support, dialogue support, system credibility, and social support. The primary task support category includes seven strategies that support the user's primary task: reduction, tunneling, tailoring, personalization, self-monitoring, simulation, and rehearsal. The dialogue support category contains strategies that provide the form of interaction between the user and the persuasive system such as through praise, rewards, reminders, suggestions, similarity, liking, and social roles. The system credibility support category includes strategies that have credibility and reliability features that utilize persuasion such as trustworthiness, expertise, surface credibility, real-world feel, authority, third-party endorsements, and verifiability. Lastly, the social support category involves strategies that make use of the social influence of the system such as social learning, social comparison, normative influence, social facilitation, cooperation, competition, and recognition. Every strategy "principle" under the PSD model has a specific role and description, as is shown in Table 1 [123].

Table 1: Principles "Strategies" of Persuasive System Design (PSD) Models (Oinas-Kukkonen and Harjumaa).

Descriptions of PSD Model Strategies "Principles"
Primary Task Support

Reduction	The system has to decrease users' effort and strain when they are engaging in their target behavior. The reduction principle can be achieved by reducing a complex behavior into simple and easy tasks for users.
Tunneling	The system has to guide users in the attitude change process or experience by providing opportunities for action performance that makes user the nearer to the target behavior.
Tailoring	The system has to offer tailored information to its user group according to their interests, needs, personality, or other factors.
Personalization	The system has to provide personalized content and customized services for users.
Self-monitoring	The system has to provide a way for users to track and monitor their performance, progress, or status in accomplishing their goals.
Simulation	The system needs to provide a way to observe and notice the connection between the cause and effect of users' behavior.
Rehearsal	The system must deliver a way of rehearsing a target behavior.
Dialogue Support	
Praise	The system has to deliver praise through images, symbols, words, videos, or sounds as a way to give the user feedback information regarding their behavior.
Rewards	The system should offer virtual rewards for users to provide credit for doing the target behavior. The virtual rewards come in different forms such as collecting points or trophies and changing media elements (e.g., backgrounds, sounds, or avatars).
Reminders	The system has to remind users to perform their target behavior while using the system.
Suggestion	The system has to suggest ways that users can achieve the target behavior and keep performing the behavior while using the system.
Similarity	The system must imitate its users in some particular manner, so the system should remind the users of themselves in a meaningful way.
Liking	The system should be visually attractive and contain a look and feel that meets its users' desires.

Social role	The system has to adopt a social role by supporting the communication between users and the system's specialists.
System Credibility Support	
Trustworthiness	The system has to give truthful, fair, reasonable, and unbiased information.
Expertise	The system has to offer information displaying experience, knowledge, and competence.
Surface credibility	The system must have a competent look and feel that demonstrates the system's credibility based on an initial assessment.
Real-world feel	The system must give information on the organization and/or the real individuals behind its content and services.
Authority	The system should refer to the individuals in the role of authority.
Third-party endorsements	The system should deliver endorsements from well-known and respected sources.
Verifiability	The system has to provide a way to investigate the accuracy of the system content through external sources.
Social Support	
Social learning	The system has to give a user the ability to observe other users and their performance outcomes while engaging in their target behavior.
Social comparison	The system should enable users to compare their performance with other users' performance.
Normative influence	The system has to have a feature for gathering together individuals that have identical objectives and let them feel norms.
Social facilitation	The system should enable a user to see other users who are performing the target behavior along with them.
Cooperation	The system should offer the opportunity for a user to cooperate with other users to achieve the target behavior goal.
Competition	The system should allow a user to compete with other users. In the competition principle, there is a chance to win or lose.

Recognition	The system has to offer public recognition (e.g., ranking) for users who perform their target behavior.

2.5 Behavior Change Theories

Behavioral theories "*refer to the social-psychological theories of behavior change, which explain and predict human behavior*" [286]. Health behavior theories help researchers and health professionals comprehend health behavior issues, design and introduce persuasive interventions with particular features that support intended behavior changes, and assess the efficacy of health interventions [205]. Accordingly, once a PT intervention is behaviorally focused and theory-driven [61], it is considered an effective and successful intervention [205]. Many health behavior theories have been employed in the development of PT designs, such as the Transtheoretical Model (TTM) [233], Health Belief Model (HBM) [247], Social Cognitive Theory (SCT) [31], Goal-Setting Theory (GST) [173], and Theory of Planned Behavior (TPB) [7]. Each behavioral theory has influential cognitive features for determining a behavior [249]; therefore, behavioral theories support the proper design of PT, help in evaluating the persuasive strategies used, and assist in choosing a target audience [286]. This dissertation examines studies that implemented one or more behavior change theory and identifies the theories most frequently employed. This dissertation also identifies what studies applied behavior change theories and those that did not.

3 CHAPTER 3: PERSUASIVE TECHNOLOGIES FOR PHYSICAL ACTIVITY AND THE REDUCTION OF SEDENTARY BEHAVIOR

This chapter represents the first stage of the five main stages in this dissertation and involves identifying persuasive technology (PT) platforms for our user study. This chapter undertakes a comprehensive review of PTs in the context of promoting physical activity (PA) and reducing sedentary behavior (SB). It aims to answer key questions about PT design and effectiveness, drawing on an empirical analysis of 170 research papers from 2003 to 2019. It details the research design, including paper selection methods, and explains the coding scheme for the PT analysis. The chapter concludes by presenting the findings and insights derived from this extensive investigation.

3.1 Motivation of This Module

The literature review of the related work indicated that some systematic review studies have focused specifically on either PA ([39], [179], [268], [164], [180], [87], [278], [122] , [80], [118], [240], [101], [15], [297], [296]) or SB ([287], [52], [126], [261], [77], [57], [98]). Others have considered both reducing SB and increasing PA ([232], [257], [255], [300], [172]) while focusing on targeting a particular technology, population, or strategy. However, none of these studies have provided a comprehensive overview of the development and trends of PTs in the PA and/or SB domains. For example, some reviews concentrated on a particular PT such as the use of smartphone apps, wearable devices, or games in promoting PA. Other papers focused only on reviewing studies that used one or a particular set of persuasive strategies such as personalization or social support features, whereas other papers focused on a specific target audience, such as children, the elderly, or adults. Therefore, there is a need for a systematic review paper that offers a comprehensive overview of PTs in both the PA and SB domains to bridge existing research gaps.

3.2 The Objective of This Module

This systematic review examines studies that involved interventions in the SB and PA health domains. Some of these interventions were applied as stand-alone interventions, such as using a mobile app only or a wearable tracker device alone. Another methodology of these interventions was applied as multi-component interventions containing, for example, a desktop app as an additional intervention

component. Consequently, this chapter provides a comprehensive review of the PT interventions (e.g., desktop, electronic and mobile devices; wearable trackers; cameras; ambient objects; thermal sensors; games) used to mitigate SB in individuals and society and to promote an active lifestyle. This review aimed 1) to evaluate the effectiveness of PTs used to promote PA and reduce SB; 2) to summarize and highlight trends in the outcomes such as the system design, persuasive strategies employed, and technological platforms used; and 3) to reveal pitfalls and gaps in the present literature that could be used to inform the design of PTs targeting PA and SB. It is essential to mention that despite the rapid evolution in the design of PTs to motivate PA and reduce SB, their complex nature presents difficulties in assessing their impact and effectiveness. Many researchers have designed PTs to help people change their lifestyle and become more active.

3.3 Materials and Methods

This study evaluates the effectiveness of PT in reducing sedentary lifestyles and increasing PA levels. The research questions (RQs) of our systematic review chapter are:

- **RQ1:** To what extent are PTs effective in promoting PA and reducing SB?
- **RQ2:** What are the outcomes' trends of employing PTs in promoting PA and reducing SB?
- **RQ3:** What persuasive strategies were employed in designing PTs for PA and SB?
- **RQ4:** What are the pitfalls and gaps in the present literature on PT for PA and SB?
- **RQ5:** What are the opportunities and recommendations for future PT design?

I conducted a systematic review of 170 papers published in the PA and SB domains between 2003 and 2019. To achieve this, I used quantitative content analysis, a technique that enables the comparison, contrast, and categorization of data according to different themes and concepts [246], [206]. This entails collecting data in a rigorous way while paying special attention to the objectivity of the results. To retrieve articles for this review, I searched various databases including Springer, PubMed, ACM Digital Library, EBSCOHost, ProQuest, Google Scholar, Elsevier Scopus, and IEEE Xplore. The databases were selected to ensure that articles across various fields would be accessed for the study.

Various keywords were used in the search process such as "Physical Activity", "Physical Activity Applications or Apps", "Sedentary Behavior or Behaviour", "Sedentary Behavior or Behaviour

Applications or Apps", "Sedentary Lifestyle", "Prolonged Sedentary", "Prolonged Sedentary Behavior", "Prolonged Sedentary Sitting", "Prolonged Sitting", "Physical Activity and Sedentary Behavior", "Persuasive Technology and Physical Activity", "Persuasive Technology and Sedentary Behavior", "Persuasive Technology and Physical Activity and Sedentary Behavior", "Persuasive Technology Exercise", "Persuasive Technology Fitness", "Physical Activity and Gamification", "Physical Activity and Exergames", "Exercise Applications Or Apps", "Fitness Applications or Apps", and "Exergames or Mobile Exergames." The search was refined through the use of Boolean terms such as "Persuasive Technology AND Physical Activity AND Sedentary Behavior". I adapted this approach from previous work done by Wang et al. [287] and refined using keywords identified from the literature.

The search in the databases was also refined using inclusion and exclusion criteria. The first criterion was to include recent articles, so articles published earlier than the year 2003 were excluded from the search because the first paper in the field of PT was introduced by Fogg [93] as a seminar paper in the year of 2002. Accordingly, most papers in the area of PT were published after the year of 2003. This was also to ensure that the findings reported in the studies were current and not outdated. The second criterion was that only articles written in English were selected for the study. The search was run through the databases to locate relevant articles. The reference lists of these articles were also reviewed to further identify other potentially relevant articles.

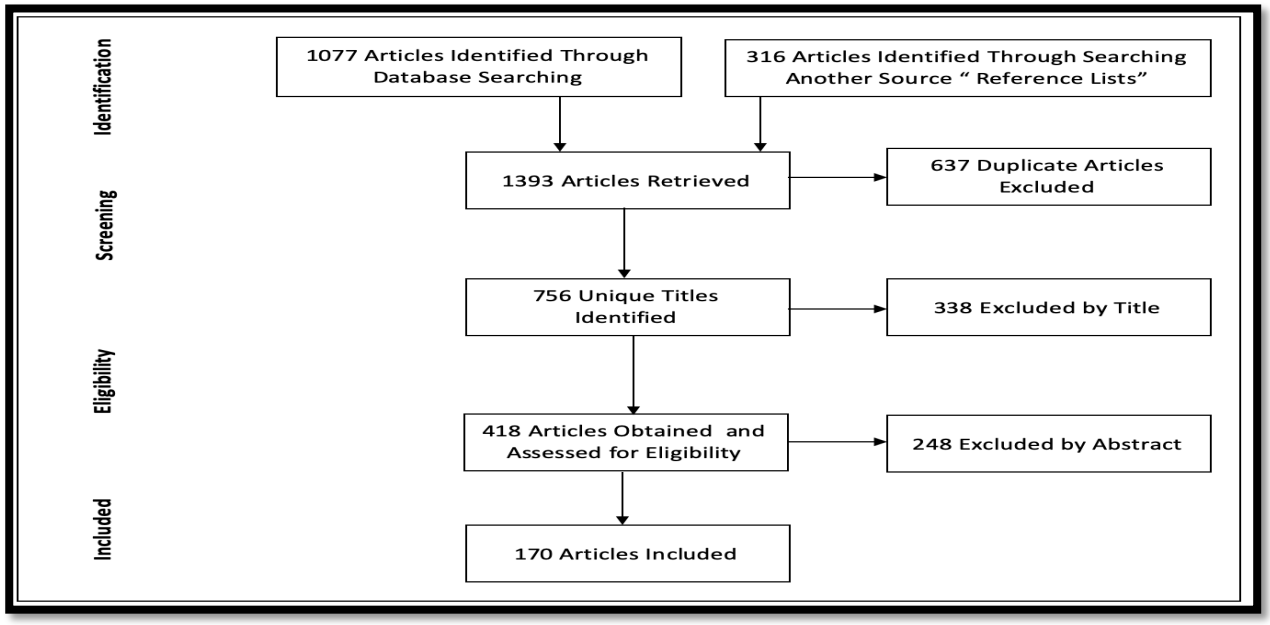


Figure 3: A PRISMA Flow Diagram of the Study Selection Workflow.

I retrieved 1393 articles, of which 1077 were identified through database searching, and 316 were identified through reviewing the reference lists of the obtained articles. There were 637 duplicate articles excluded from the total of 1393 articles. The titles of these articles were examined, and those found not to be suitable were eliminated, such as those that targeted health domains other than PA/SB. Overall, I identified 756 unique titles, of which 338 articles were excluded by titles. After evaluating the abstracts of the remaining 418 articles, 170 were selected for final analysis. The study identification process is summarized in Figure 3 (a PRISMA flow diagram [169]).

I employed Mendeley Desktop and Web Reference Manager [75], a well-known tool widely used by researchers. Mendeley Desktop allows individuals to read, annotate, manage, share, and cite research articles and papers [272]. It is a powerful and efficient tool that can automatically detect duplicate articles and references, which can then be manually removed by clicking the trash icon next to the duplicate entry [181], [160].

3.4 Analysis and Coding Scheme

In the second step of this review, I coded the articles by creating an Excel coding sheet for PT analysis. As a starting point, I adopted a coding sheet that was developed and validated by Orji and Moffatt

[206] and refined it by adding new coding categories that emerged as I iteratively analyzed our data. Table 2 shows how I classified and coded the articles. Once the articles were identified, they were coded and classified.

Table 2: Persuasive Technology Classifications and Coding Scheme Analysis – adapted from Orji and Moffat.

PT Classifications and Coding Scheme		
S/N	**Identification**	**Examples / Meaning**
1	Papers	Name of the research papers and articles.
2	Author(s)	Name of the author(s) who wrote a research paper and conducted a study.
3	Year	The year the study was conducted.
4	Domain Focus	PA, SB, eating, smoking, stress, obesity, sitting posture, mental health, etc.
5	Technology	Mobile, web, games, computer applications, ambient displays, etc.
6	Persuasive Strategies	Motivational affordance strategies used in a PT system design.
7	Targeted Outcomes	Behavior, attitudes, awareness, adherence, motivation, feasibility, cognitive, etc.
8	Targeted Audience based on their Age Group	Children, teenagers, young adults, adults, elderly, etc.
9	Number of Participants	Number of participants in the assessment of a study.
10	Effectiveness / Evaluation Outcomes	Identifying whether the study was successful or not successful.
11	Country/Region of a Study	Country or region where the study was conducted.

3.5 Results and Findings

The analysis of PTs for PA and SB revealed some interesting findings, as shown below. The findings are presented under various categories such as the year and country in which the technology was

developed, platforms, targeted behavioral and psychological outcomes, and evaluation results of the PTs. For the papers that have more than one study, I combined the findings for all the studies in the paper. For example, I reported the total number of participants, all the persuasive strategies used, and the total duration of all the studies in each paper.

3.5.1 Persuasive Technology for Physical Activity and Sedentary Behavior Trends by Year and Country

As shown in Figure 4, a large number of articles and studies were published after 2011 compared to before 2011. There has been a sharp increase in the number of articles published since 2012, though the number fluctuated year to year from 2012 to 2019. While 2019 appears to have the lowest number of studies since 2012, this is probably because most papers for 2019 are yet to be published at the time of this study, the first half of 2019.

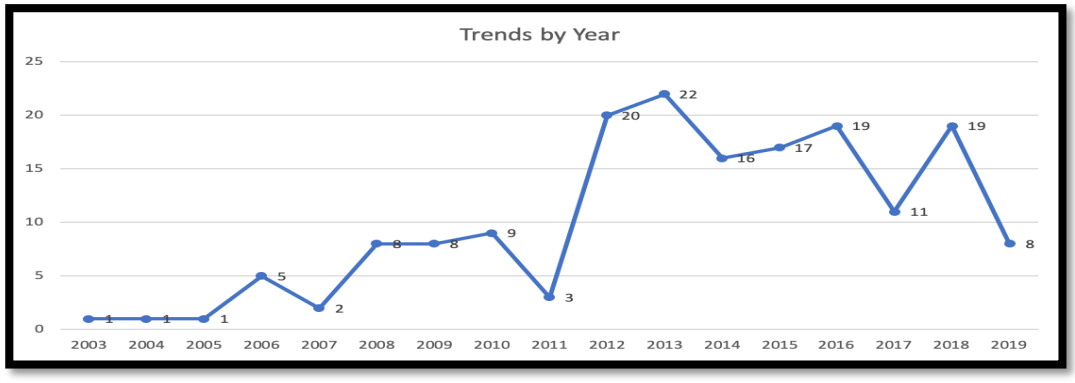


Figure 4: Persuasive Technology for Physical Activity and Sedentary Behavior Trend by Year.

As is evident from Figure 5, the studies were conducted in 29 different countries, with most of the studies, 56 (33%), coming from the USA. This is followed by the UK with a total of 16 studies (9%). Australia and the Netherlands are in third place, with a total of 15 studies (9%) for each. Canada and Germany are in fourth with a total of 9 studies (5%).

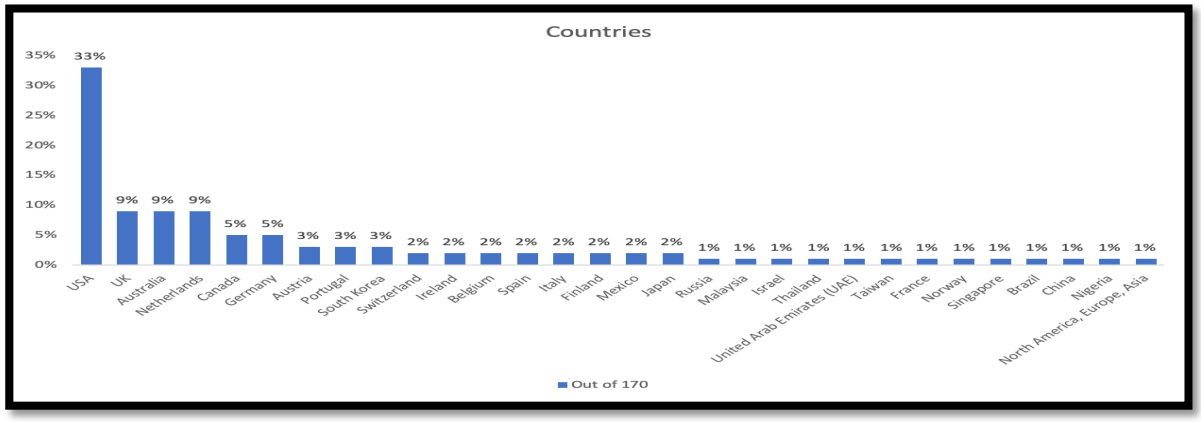


Figure 5: Persuasive Technology for Physical Activity and Sedentary Behavior Trend by Study Country/Region.

3.5.2 Effectiveness of Persuasive Technology for Physical activity and Sedentary Behavior

Figure 6 shows a summary of the results of the effectiveness of PT for PA and SB reviewed in this paper. I found that 87 studies (51%) reported fully successful outcomes and 50 studies (29%) reported partially successful outcomes from using the PT to achieve desired behaviors and attitudes. Partially positive results are used to describe studies that reported a combination of positive with negative or no effect results [206]. However, only 4 (2%) of the studies reported completely unsuccessful results. In the studies reviewed, 6 (4%) did not specify the outcomes of the technology, and 23 (14%) of the studies did not evaluate their PT design. As a result, most of the reviewed studies (80%) reported successful outcomes, whether fully or partially, while only 4% of the studies were unsuccessful. This means that PTs are effective tools for persuading people to engage in more PA and reduce their SB.

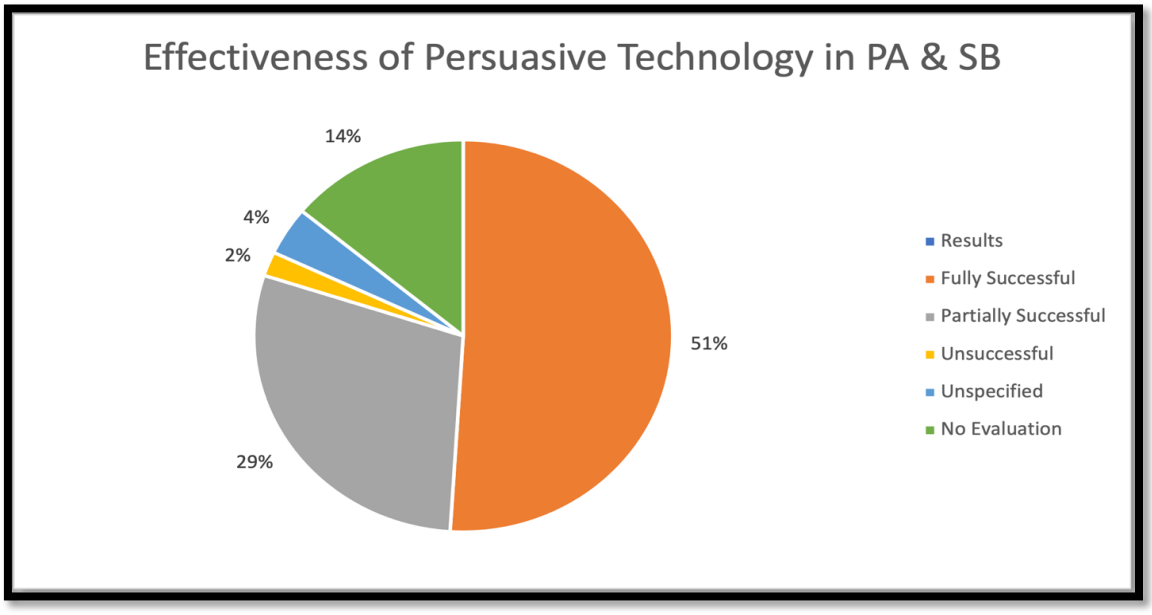


Figure 6: Effectiveness of Persuasive Technology for Physical Activity and Sedentary Behavior.

3.5.3 Major Technology Platforms Employed in Persuasive Technology for Physical Activity and Sedentary Behavior and the Effectiveness of Persuasive Technologies

Figure 7 provides a summary of the major technology platforms employed to design the PTs for PA and SB. Mobile and handheld devices were the most used platform with a total of 61 studies (36%), followed by platforms that employed games and gamifications with 33 studies (19%) and web and social networks with 32 studies (19%). The games category includes all the interventions delivered in the form of games, irrespective of whether the game is played on a web-based, mobile, or desktop device. I found that 31 studies (18%) used commercially available sensors and other activity trackers (e.g., Fitbit, Pebble smartwatch, ActivPAL, and ActiGraph), whereas 19 studies (11%) used custom-designed sensors and activity trackers designed by the researchers in their studies. Ambient and public displays came in fifth place with 16 (9%) studies using this platform. This was followed by interactive workstations and chairs with just 12 studies (7%). Computer-based platforms such as desktop and laptop were the least frequently employed platform for delivering PTs for PA and SB with only 10 studies (6%).

Most of the reviewed studies employed more than one technology platform in their PT design. Generally, the second most employed technology platforms after the mobile and handheld devices are

activity trackers and sensors (whether commercial or custom-designed) with a total of 42 studies (29%). By considering the use of embedded sensors in mobile devices, the dominant technology platforms employed in the PTs for PA and SB were activity trackers and sensors, and most PTs employing them were successful. Thus, it is essential to employ activity trackers and sensors in the PT design to track users' performance and to provide them with accurate feedback about their activity progress to motivate them to change their unhealthy habits such as SB.

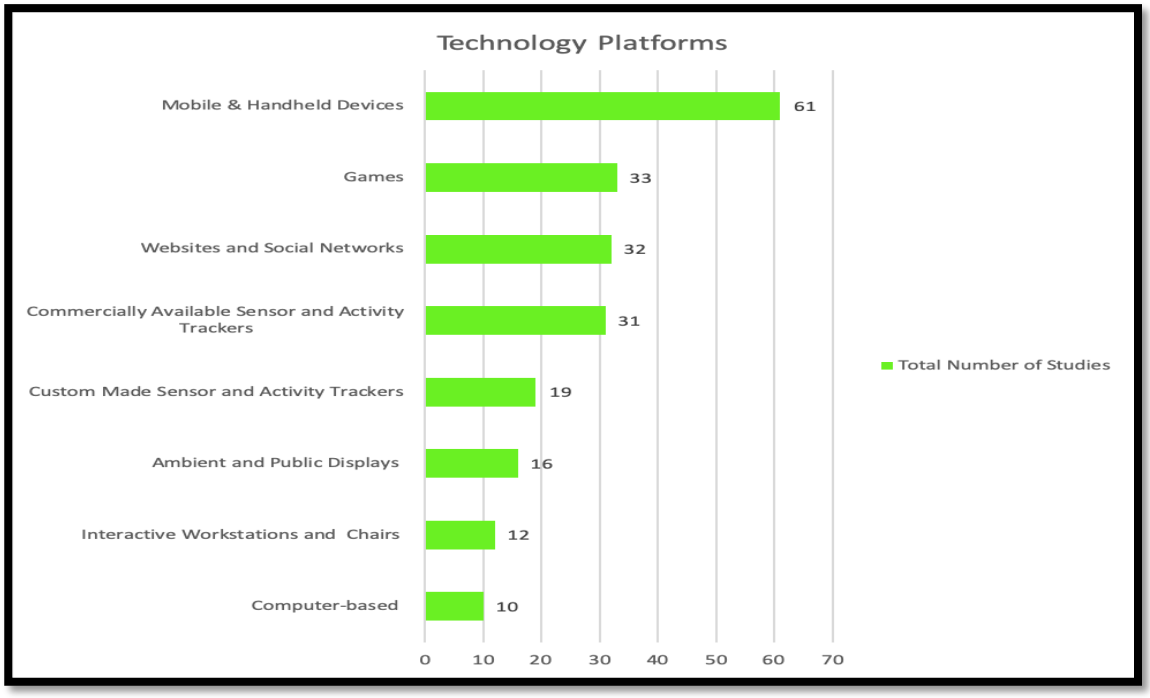


Figure 7: Persuasive Technology Platforms.

Figure 8 demonstrates the effectiveness of employing PT with regard to the technology platforms. For the mobile and handheld devices, I found that 48 (79%) of the studies reported successful results, which includes studies with partially successful or fully successful results. Specifically, 28 studies (58%) were fully successful, and 20 studies (42%) were partially successful. For the games, out of 33 studies employing them, 19 (58%) showed fully successful outcomes, 7 (21%) displayed partially successful outcomes, just 1 (3%) reported unsuccessful outcomes, and 6 (18%) did not provide evaluations. For the commercially available sensors and activity trackers, out of 33 studies using them, 12 (36%) reported fully successful results, 14 (43%) showed partially successful results, only 1 (3%) reported unsuccessful outcomes, 3 (9%) reported unspecified results, and 3 (9%) did not evaluate their

studies. For the websites and social networks, out of the 31 studies that implemented them, 16 (52%) reported fully successful results, 9 (29%) showed partially successful results, only 1 (3%) did not specify the results, and 5 (16%) did not evaluate their PTs. For the custom-made sensors and activity trackers, out of the 19 studies that designed them, 10 (53%) reported fully successful results, 4 (21%) provided partially successful results, 4 (21%) did not show evaluations, and only 1 (5%) reported unspecified results. For the ambient and public displays, out of the 16 studies that employed them, 9 (56%) reported fully successful results, 4 (25%) showed partially successful results, 2 (13%) reported unsuccessful outcomes, and 1 (6%) did not evaluate their studies. For the interactive workstations and chairs, out of the 12 studies that implemented them, 8 (67%) reported fully successful results, 1 (8%) showed partially successful results, only 1 (8%) did not specify the results, and 2 (17%) did not evaluate their PTs. For the computer-based technologies such as desktops, 10 of the studies reported successful results: 6 (60%) studies with partially successful results and 4 (40%) studies with fully successful results. Overall, the findings show that the most effective technology platforms are mobile and handheld devices with 48 successful studies (whether fully or partially successful), followed by activity trackers and sensors (whether commercial or custom-designed) with 40 successful studies, followed by games with 26 successful studies, and then websites and SNSs with 25 successful studies.

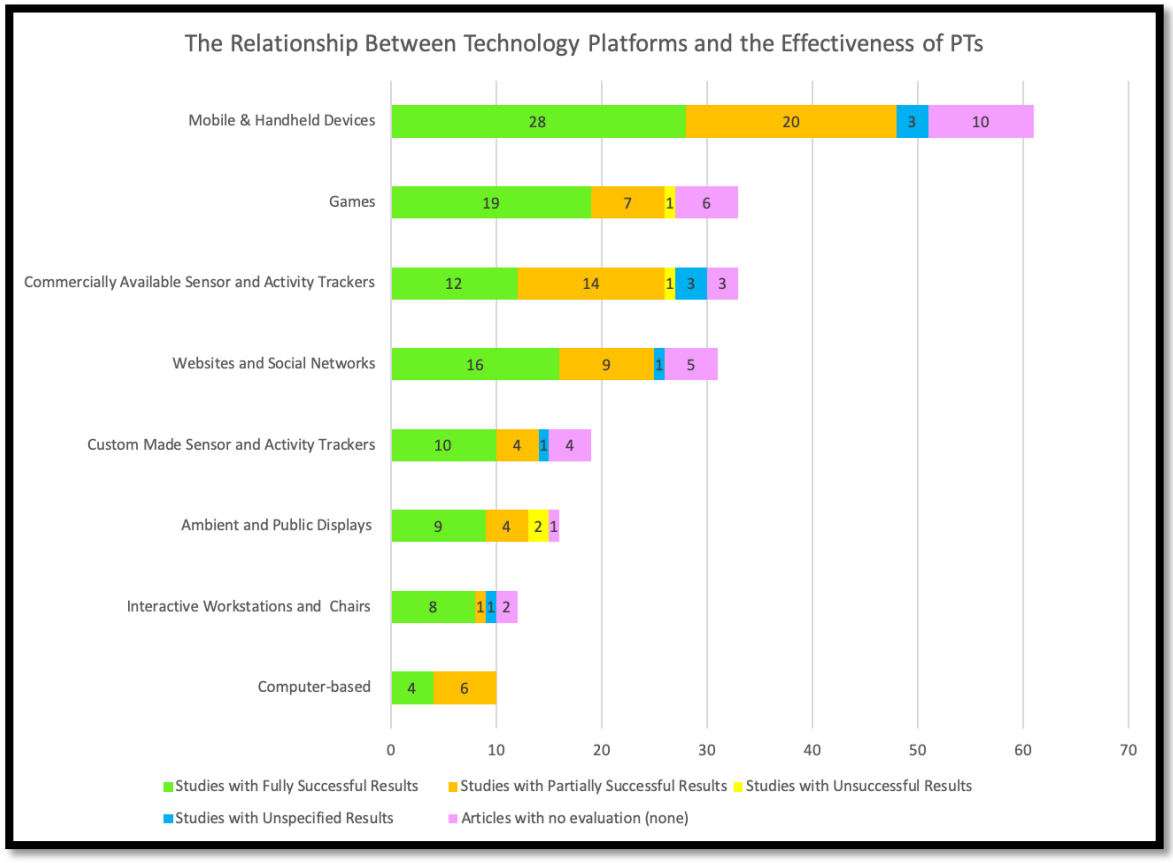


Figure 8: Technology Platforms and the Effectiveness of PTs.

3.5.4 Persuasive Strategies and Motivational Affordances

Figure 9 shows the strategies most commonly employed to bring about the intended behavioral outcomes in the PA and/or SB domains. Tracking and self-monitoring were the most frequently employed strategies with a total of 153 studies (90%). Reminders ranked as the second most employed strategy with 72 studies (42%), and personalization is the third most employed strategy with a total of 64 studies (38%). Rewards and goal-setting ranked as the fourth and fifth frequently employed strategies with 54 studies (32%) and 53 studies (31%) respectively. Other social support strategies (which refer to strategies that did not belong precisely to the PSD model or those that were not specified such as social comments, tags, likes, chatting, and sending invitations) came sixth, with a total of 43 studies (25%) implementing these strategies. Simulation came in seventh place with a total of 42 studies (25%), and praise came eighth with a total of 38 studies (22%). Thirty-two studies (19%) employed the reduction strategy, which was the ninth most frequently used strategy. Suggestion and

social competition strategies emerged as the tenth and eleventh most frequently used strategies with 30 studies (18%) employing each of them. Finally, tailoring, tunneling, social cooperation, surface credibility, social comparison, liking, and expertise emerged as the 12th, 13th, 14th, 15th, 16th, 17th, and 18th most frequently used strategies respectively, with a total of 29 (17%), 25 (15%), 19 (11%), 18 (11%), 17 (10%), 14 (8%), and 13 (8%) studies (see Figure 9).

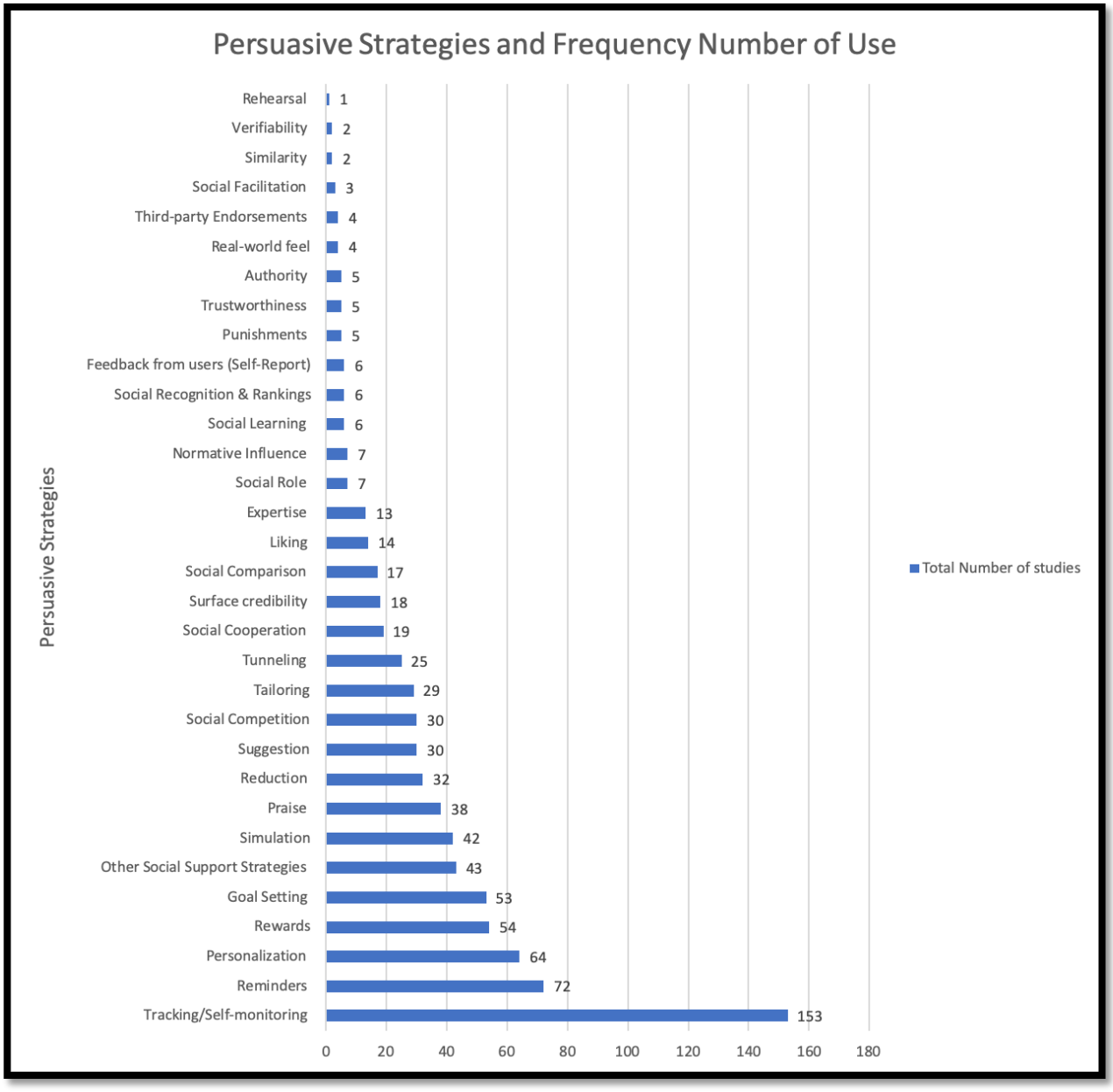


Figure 9: Persuasive Strategies of Persuasive Technology and Frequency of the Total Number of Studies.

3.5.6 Comparative Effectiveness by the Persuasive Strategies

Figure 10 shows the comparative effectiveness of the PTs using persuasive strategies in the domain of PA and SB. The table and figure indicate that some strategies were applied more frequently, and some were more effective than others. For example, the tracking and self-monitoring strategy was employed in 153 studies (19%), with a total of 75 studies (49%) reporting fully successful outcomes, 46 studies (30%) reporting partially successful outcomes, four (2%) studies reporting unsuccessful outcomes, and six studies (4%) not specifying their outcomes, while 23 (15%) studies did not evaluate their strategies.

In summary, I reported the top twelve persuasive strategies most frequently used in the domain of PA and SB with respect to their effectiveness. As shown in Figure 10, out of the total number of studies that implemented each persuasive strategy, tracking and self-monitoring ranked first with a total of 121 (79%) successful outcomes, followed by reminders and personalization, which ranked second and third with 59 (82%) and 58 (91%) successful results, respectively. Goal setting was fourth with 44 (83%) successful outcomes. Rewards ranked at fifth with 41 (76%) successful results. Other social support strategies ranked sixth with a total of 33 (77%) successful studies. Simulation and praise were ranked seventh and eighth with 31 (74%) and 30 (79%) successful studies, respectively. Reduction, social competition, and suggestion were ranked ninth with a total of 26 (81%) successful studies for each. Tailoring, tunneling, and expertise ranked tenth, eleventh and twelfth with 23 (79%), 20 (80%), and 11 (85%) successful studies, respectively.

The five most effective persuasive strategies employed were tracking/self-monitoring, reminders, personalization, goal-setting, rewards, and other social support strategies. Furthermore, if I consider the employment of all social support strategies (e.g., social learning, social cooperation, social comparison, social competition, normative influence, social facilitation, social recognition, and other social support strategies), the second most effective and commonly employed set of strategies were social support strategies, which were mainly used as external motivations to persuade users to engage more in increasing their PA levels and reducing SB.

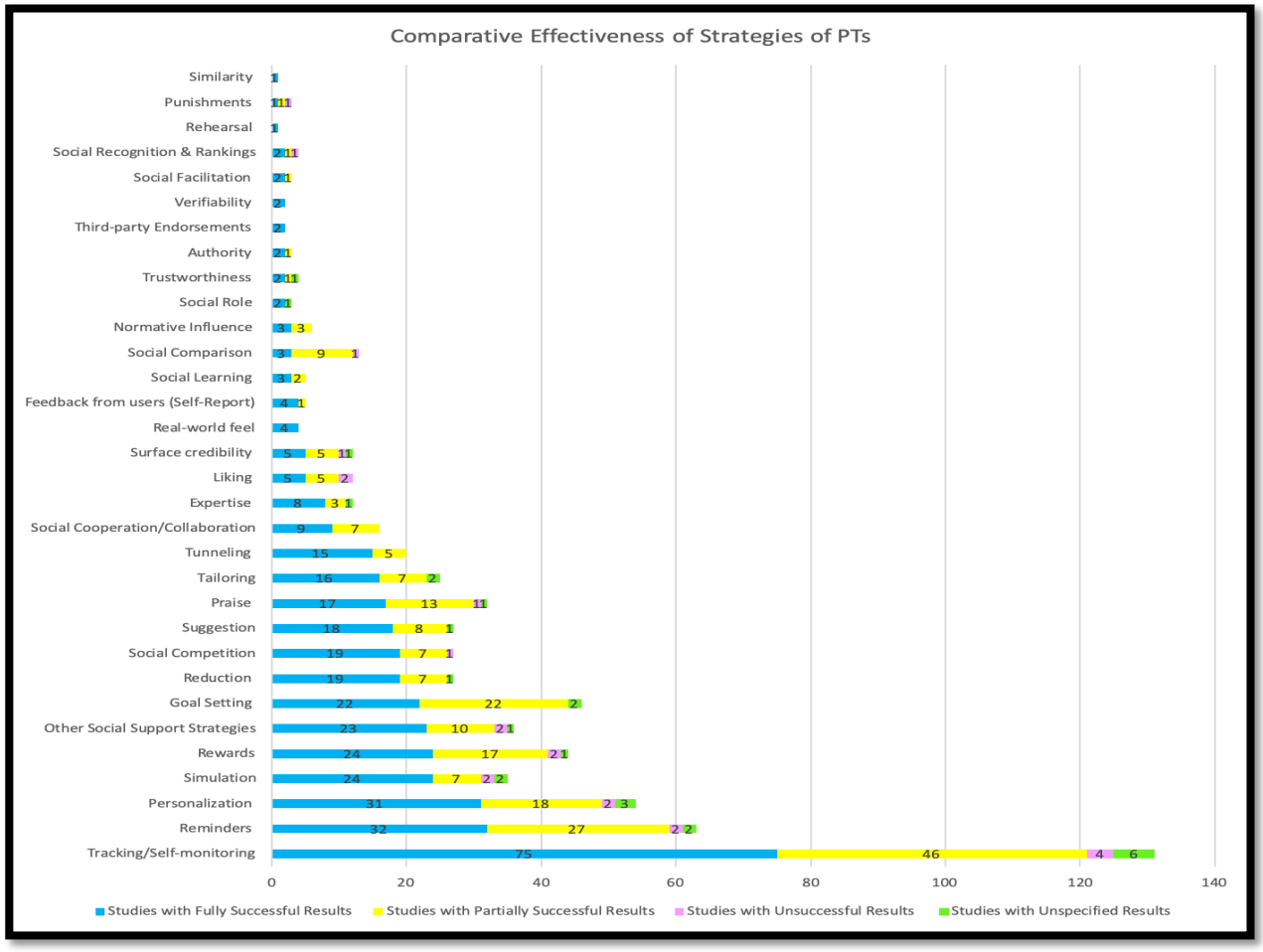


Figure 10: Comparative the Effectiveness of Persuasive Strategies of Persuasive Technology by Persuasion Outcomes.

3.5.9 Targeted Behavioral and/or Psychological Outcomes

Figure 11 displays the behavioral and psychological outcomes targeted by the reviewed articles. The articles targeted 21 diverse outcomes as most of the reviewed studies targeted more than one behavioral and/or psychological outcome. Almost three quarters of the studies 151 (89%) were targeted at actual behavior change, which consists of promoting/encouraging a shift from undesirable behaviors and habits [206], promoting PA and discouraging SB. I found that 51 (30%) of the studies targeted a change in motivation, 42 studies (25%) increased the awareness for the users, and 11 studies (6%) focused on changing the attitude of the individuals. Several of the studies targeted the emotions, loneliness, adherence, intentions, and self-efficacy of the individual, as shown in Figure 11. The category 'Unspecified' refers to studies that did not specify the targeted behavioral and/or

psychological outcomes. Most of the studies targeted more than one behavioral outcome, which means that many of the studies belonged to more than one category. For example, one study could be targeting the behavior and attitude changes in the user.

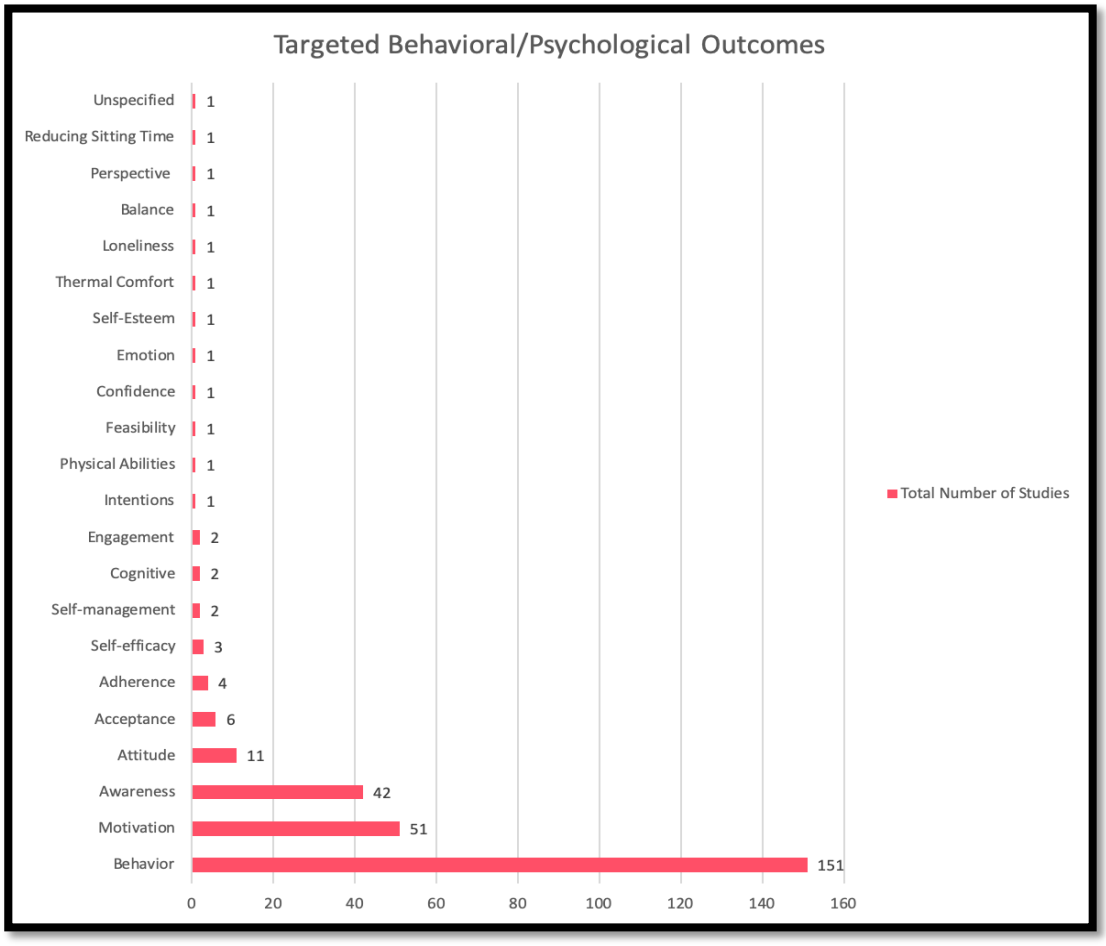


Figure 11: Targeted Psychological and Behavioral Outcomes by Persuasive Technology.

3.5.11 Study Participants and Sample Size

The sample size varies greatly among the studies reviewed, as the mean number of subjects was 798 with a minimum of one subject and a maximum of 129,010 participants. Some studies did not report the total number of participants, whereas others also had varying sample sizes at different stages of the PT evaluation. Figure 12 shows the targeted audience by age demographic, whereas Figure 13 presents the effectiveness of the interventions depending on the targeted audience. Most of the studies (94, or 55%) targeted adults, with most of them reporting successful results. This was followed by 21

studies (12%) that targeted young adults and elderly people. Only 13 studies (8%) targeted children, 8 studies (5%) targeted teenagers, and 2 studies (1%) targeted young children. I also found 17 studies (10%) that did not specify their audience. The most frequently targeted populations were adults and young adults, while the least were older people, children, teenagers, and young children.

Young children include children in the age group 4 to 7, children in the age group 8 to 12, teenagers from 13 to 17 years old and young adults from 18 to around 30 years old. Adults have a wide age range and could start from 31 to 49 years old, whereas the elderly were 50 years old and above.

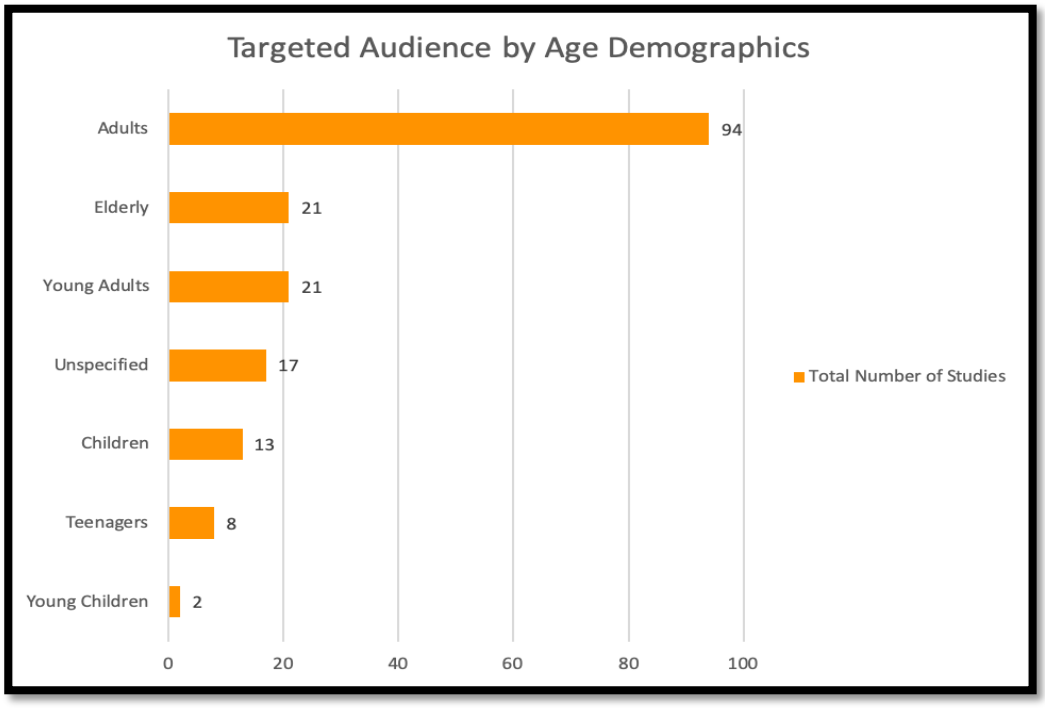


Figure 12: Targeted Audience by Age Demographic.

3.5.12 Effectiveness of Persuasive Technologies Based on Targeted Audience by Age Group

Figure 13 demonstrates the effectiveness of employing PT with regard to the targeted audience by age group. For adults, 81 (86%) of the studies reported successful results, which were either partially successful or fully successful results. Specifically, 47 studies (58%) were fully successful, and 34 studies (42%) were partially successful. For young adults, out of 21 that studies targeted them, 13 (61%) showed fully successful outcomes, 3 (14%) displayed partially successful outcomes, just 2 (10%) reported unsuccessful outcomes, only 1 (5%) represented unspecified outcomes, and 2 (10%)

did not provide evaluations. For the elderly, out of 21 studies that targeted them, 7 (33%) reported fully successful results, 10 (48%) showed partially successful results, only 1 (5%) reported unspecified results, and 3 (14%) did not evaluate their studies. For children, out of 13 studies that targeted them, 8 (62%) reported fully successful results, 3 (23%) showed partially successful results, and just 2 (15%) did not evaluate their PTs. For teenagers, out of 8 studies that targeted them, 4 (50%) reported fully successful results, 2 (25%) provided partially successful results, and only 2 (25%) did not conduct any evaluations. Only two studies provided fully successful outcomes for the age group of young children. Therefore, the most successful outcomes for implementing the PTs were observed in the studies targeting adults and young adults.

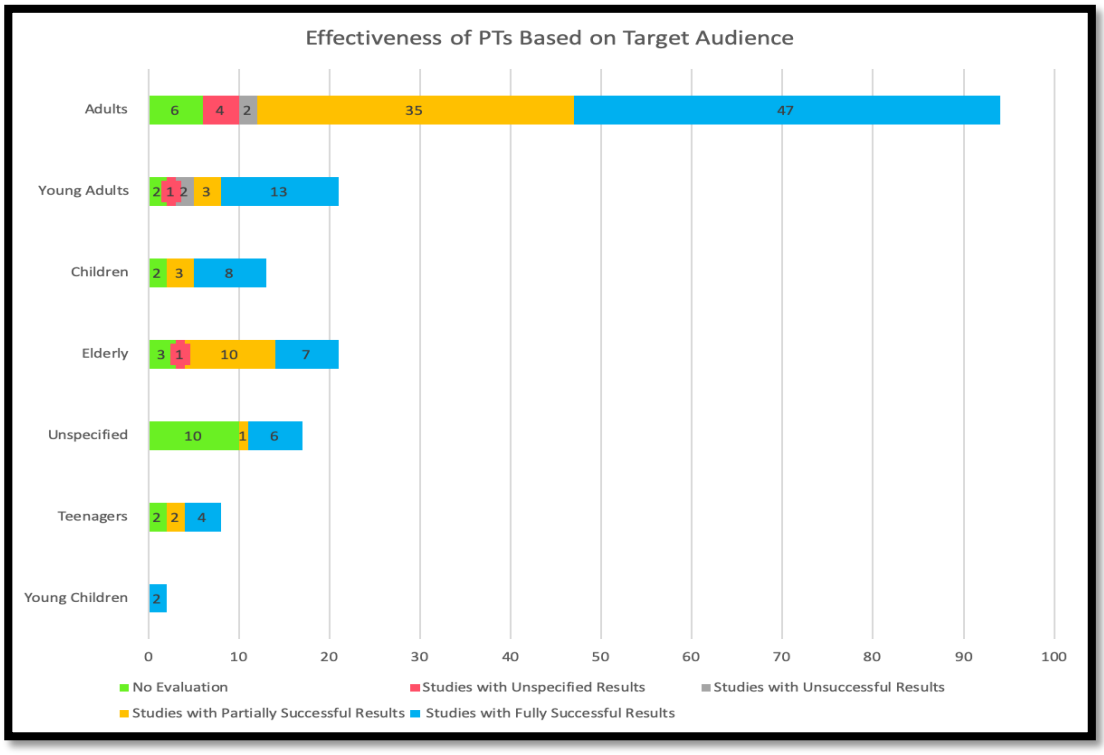


Figure 13: Effectiveness of Persuasive Technologies Based on Target Audience.

3.6 Discussion

The purpose of this study is (1) to evaluate the effectiveness of PTs used to promote PA and reduce SB; 2) to summarize and highlight trends in the outcomes and employed technological platforms; and

3) to reveal pitfalls and gaps in the present literature that could be used to inform the design of PTs targeting PA and SB.

3.6.1 Overall Effectiveness of Persuasive Technologies for Physical Activity and Sedentary Behavior

Overall, 137 (81%) of the articles I reviewed in this study reported successful outcomes, whether fully or partially successful, which proves that PTs are effective tools for promoting PA and decreasing SB. Only 4 (2%) of the reviewed studies had unsuccessful outcomes. There were no common or specific reasons for the failure outcomes of these studies. Each study had a different situation and employed different methods, strategies, and technologies that may have contributed to unsuccessful outcomes. For example, one study failed in designing an appropriate smartphone virtual boat racing game to motivate people to engage in more moderate-intensity physical activity. This is because the game was not optimally implemented, which caused users to suffer from some repetitive strain injuries and drove them to abandon the app [305]. Other studies implemented different technologies such as Persuasive Art reflection [191] and ExerSync, which measure the rhythm of body movements [224]. Therefore, it is difficult to establish the actual reasons for the ineffectiveness of the PTs that reported unsuccessful results. Other reasons may be the target audience, their behavior change stage, and persuasive strategy mismatch, as highlighted in [201].

3.6.2 The Relationship Between Technology Platforms and the Effectiveness of Persuasive Technologies

Mobile and handheld devices were the most dominant technology platforms used, with a total of 61 studies (36%), followed by games, web and social networks, the use of commercially available sensors and other activity trackers, custom-designed sensors and activity trackers, and ambient and public displays, which had a total of 33 (19%), 32 (19%), 31 (18%), 19 (11%), and 16 (9%) studies, respectively (see Figure 7).The second most dominant technologies employed in the reviewed studies were sensors and activity tracker and monitoring devices, with a total of 50 studies (29%), either by using commercially available devices or designing new ones. In fact, if I consider the use of embedded sensors in smartphones and handheld devices such as GPS, GSM, gyroscope, accelerometer, pedometers, and cameras, the most important factor in motivating users to engage in PA is to give accurate feedback and results on their activities using sensors and activity trackers and monitors. This

corroborates our findings, whereby tracking and self-monitoring strategies ranked first with a total of 153 studies (90%), of which 121 studies (79%) reported fully and/or partially successful outcomes, and the reminder strategy ranked second with a total of 72 studies (42%), of which 32 studies (44%) had fully successful outcomes and 27 studies (38%) had partially successful outcomes. These results suggest that a simple nudge such as a reminder to get some exercise (e.g., take a walk) or a notification about how long they have been sitting down and the need to get up can motivate people to increase their PA.

As shown in Figure 8, the most successful outcomes for implementing the PTs were observed in the studies using the mobile and handheld devices, games, sensors and activity trackers in general and websites and SNSs. It seems that these technologies are attractive and promising for delivering interventions because of their ubiquitous nature.

3.6.3 The Relationship Between Persuasive Strategies and the Effectiveness of Persuasive Technologies

In the present review, various persuasive strategies were identified as used and applied to achieve positive behavior change. With respect to the studies that employed persuasive strategies and reported successful results, whether fully or partially, the most common strategies employed were tracking and self-monitoring with a total of 153 studies (90%), of which 121 studies (79%) were successful. Such strategies were implemented by the use of diverse activity tracking and monitoring devices and sensors such as accelerometers, pedometers, heart rate monitoring devices and sensors embedded in smartphones and by providing the user with their activity performance (e.g., step count, heart rate, speed, summary progress) on the screen of the mobile phone devices using various display formats including visualization. PTs that used social support strategies (e.g., social comparison, social cooperation, social competition, normative influence, social facilitation, social learning, social recognition, and other social support strategies) were also effective in promoting PA with a total of 131 studies (77%), of which 104 (79%) had fully or partially successful outcomes. Overall, other strategies that were effective in addressing PA and SB, from the most effective to the least and out of the total studies that employed each persuasive strategy, were reminders, personalization, goal setting, rewards, simulation, praise, reduction, suggestion, tailoring, tunneling, and expertise with a total of 59 (82%), 58 (90%), 44 (83%), 41 (76%), 31 (74%), 30 (79%), 26 (81%), 26 (87%), 26 (90%), 23 (92%),

20 (80%) and 11(85%), respectively. These strategies were either completely or partially successful and were useful in encouraging users to make the appropriate changes in their behaviors and to be more aware and motivated.

Also, most of the PT systems employed more than one strategy to achieve the targeted behavioral outcome. The operationalization and implementation of these strategies varied from one application to another and may contribute to the effectiveness of the strategies. For example, some studies used a social support strategy as well as tracking, whereas others used goal setting or reminders as different motivational strategies. In addition, the self-monitoring strategy came in various implementations, including graphical display; audio, textual, and visual feedback; ambient displays; ambient sculpture displays; and light displays.

3.6.4 The Relationship Between the Target Audience and the Effectiveness of Persuasive Technologies

Many PTs have been employed to persuade different user age groups to change or adopt a desirable lifestyle with regard to PA. As displayed in Figure 13, the reviewed studies showed that PTs targeted at adults recorded the highest success rate, with 82 (87%) successful outcomes, of which 47 (58%) were fully successful outcomes and 34 (42%) were partially successful outcomes. Out of the total studies that targeted each age demographic, the second and third highest success rates were with the elderly and young adults, with a total of 17 (81%) and 16 (76%) of successful result studies, respectively. The fourth rank was children with 11 (85%) successful results. The studies that did not specify their target audience ranked fifth with 7 (41%) successful outcomes. PTs targeted at teenagers and young children were ranked sixth and seventh with a total of 6 (75%) and 2 (100%) successful outcomes, respectively. As previously mentioned, the present study demonstrates that PT was most effective among adults when targeting PA and SB. It is important to note that the majority of the studies evaluated targeted the adult population; hence, comparing success rates across populations may not be appropriate. A possible reason why most studies that targeted adults reported successful results is that adults are in an active stage of life, and at this stage people tend to be more active compared to the elderly group. Again, in comparison to children, adults tend to be more conscious about the way they live because they have the cognitive ability to understand the consequences of a sedentary lifestyle.

3.6.5 General Recommendations for Future Research

The review identified a number of limitations and gaps in the existing works in the area of PT for PA and SB. I offer suggestions for advancing research in this area:

- **Standard Approach for Evaluating Persuasive Technology:** A standard approach for evaluating the effectiveness of PTs is needed to provide standard and reliable data that can be used to inform future PT designs. Most of the reviewed studies presented subjective data with no standard approach through which to measure whether or not the technologies were effective and to what extent they were effective.
- **Effectiveness of Persuasive Technologies Employing Multiple Strategies Versus Those Based on a Single Strategy**: There is also a need to establish the effectiveness of PTs that employ a single persuasive strategy in comparison to those employing multiple strategies. Employing multiple strategies has been the convention in the area based on the rationale that the more strategies used the better; however, this may not be always the case. As shown by Orji et al. [204], PTs employing a single strategy can be effective. Nevertheless, it is unknown whether employing multiple strategies results in more effective PTs; that is, it is not clear whether the strategies have an additive effect. I also acknowledge that employing multiple strategies may lead to cognitive overload on the part of the user. Hence, *I recommend that future research focus on establishing the effectiveness of PTs employing a single strategy in comparison to those employing multiple strategies and also how this may vary depending on how the strategies are implemented*.
- **Accessible Cross-platform Persuasive Technologies:** Many of the evaluated PTs are multi-platform PT interventions. They are implemented to run across multiple technology platforms such as a combination of smartphones, activity tracker devices, cameras, and height-adjustable workstations. I cannot categorically state that this contributes to the effectiveness of such interventions; however, it appears to be a good practice, considering that implementing cross-platform PTs increases the accessibility and reach of such PTs and makes them always available for users owning multiple technologies. Therefore, *I*

recommend that PT designers consider designing cross-platform applications to increase their reach and accessibility.

- **Comprehensive Persuasive Technology Design Framework:** Existing PT design models and frameworks are not comprehensive in guiding the analysis of current PTs. I identified some strategies that do not capture the popular PSD model. This is possibly due to advancements in technology, which have contributed to many strategies that would not have been possible a decade ago. Therefore, I suggest that more work is needed in the area of developing a comprehensive PT design framework that identifies not only the strategies but also various possible implementations, domains, user groups, technologies, and other contextual factors that may impact their effectiveness. This will facilitate the tailoring of PTs based on many contextual factors and user types. The PSD model was useful in organizing the strategies, but it was not comprehensive enough to include all the resulted strategies.
- **Unified Standard for Target Audience Categorization:** The classifications of the demographics by their age groups were sometimes unclear. For example, the age group of adults was varied in the reviewed articles, and this is the same with other age groups such as teenagers and children. This may cause considerable confusion when classifying the targeted audience by their age group. Therefore, *I suggest a unified standard for age group categorization*.
- **Diversification of the Target Audience of Persuasive Technology:** Most of the reviewed studies were targeted at adults; therefore, it is necessary to develop more PT systems that target different populations, such as children, teenagers, and the elderly.

3.7 Conclusion and Future Work

The chapter provides a detailed systematic review of 170 papers to establish the effectiveness of PTs for promoting health and wellness in the domains of PA and SB. Our findings show that almost three quarters (137 studies (80%)) of the total reviewed studies (170 studies) reported successful outcomes, whether fully or partially successful, which means that PTs are effective at promoting PA and discouraging SB. Thus, the findings demonstrate that the use of PT has the potential to promote

desirable behavior change among the users when combined with the proper persuasive strategy. Furthermore, the study summarizes and highlights trends in the outcomes including persuasive strategies and technological platforms employed. The most frequently targeted populations are adults and young adults, while the least are older people, children, teenagers, and young children. The outcomes of this work illustrate that the two most effective and commonly employed technology platforms in the field of PA and/or SB are mobile and handheld devices and activity trackers and sensors (whether commercially available or custom-designed by researchers).

Furthermore, this study shows that the most effective and frequently implemented persuasive strategies in PT design for promoting PA and/or reducing SB are tracking/self-monitoring, reminders, personalization, goal setting, rewards, and social support strategies, in decreasing order. Finally, I identified the gaps in the present literature that could be used to inform the design of a PT that targets PA and SB. Accordingly, I provide a list of general limitations and recommendations to advance and improve future research.

Future works may need to evaluate studies done in the field of PTs in promoting PA and SB according to the different target populations by age demographics (e.g., older people, teenagers, children). Additionally, I suggest analyzing PTs based on each technology platform used in their design. Finally, I also recommend evaluating users' reviews/feedback for the existing PTs (e.g., applications, systems, or devices) to advance the future design of PTs for PA and SB.

4 CHAPTER 4: MOBILE PHONE-BASED PERSUASIVE TECHNOLOGY FOR PROMOTING PHYSICAL ACTIVITY AND REDUCING SEDENTARY BEHAVIOR

This chapter represents the second of the five main stages in this dissertation and assists in identifying the initial round of selecting the twelve most frequently employed strategies for our user study. Accordingly, this chapter focuses on the mobile and handheld devices technology platform, which has been identified as the most dominant platform used in the articles reviewed in Chapter 3. This chapter provides a systematic review of 15 years of research (80 papers) focusing on the effectiveness of mobile phone-based persuasive technology (PT) in promoting physical activity (PA) and reducing sedentary behavior (SB). The chapter outlines the research methodology, including paper selection and coding schemes, and presents the resulting insights and findings.

4.1 Motivation of This Module

Mobile phone technology has been progressively employed in PT interventions designed to promote PA and discourage SB. Because of the ubiquitous nature and seamless integration of mobile phones into users' daily lives, mobile phone-based PTs have the potential to continuously influence and change users' behaviors and attitudes. Furthermore, many studies did not compare mobile phone-based PTs with those used along with other technology platforms (e.g., activity trackers and sensor devices, desktops, websites, social networks, and games) in terms of effectiveness [39], [77], [179]. Therefore, there is still a need to conduct a comprehensive systematic review of the effectiveness of mobile phone-based PTs in persuading users to adopt a healthy lifestyle focusing on both increasing PA and decreasing SB. This chapter provides a comprehensive overview along with a comparison of the effectiveness of using mobile phone-based PTs alone and using mobile phone-based PTs along with other technology platforms.

4.2 The Objective of This Module

In this chapter, I conduct a systematic comparative review of mobile phone-based PTs for increasing PA and reducing SB based on 80 research articles spanning 15 years. To the best of our knowledge, most review studies are limited to smartphone technology without considering traditional cellphones and supporting technology platforms. Our major contribution is to address this gap by providing a

comprehensive and comparative approach that uncovers the implementation and effectiveness of mobile phone technologies (including smartphones and traditional cellphones) along with other technology platforms. The comparative review findings were classified based on health domains, year of publication, country of study, behavior theories employed, persuasive strategies employed, technology platforms, targeted population by age demographic, targeted population based on their occupation and health conditions, behavioral and psychological outcomes, etc. The goal of this review is to: (1) assess the effectiveness of mobile phone-based PTs in persuading users to be more physically active and less sedentary, (2) highlight research trends in this area including other technology platforms implemented along with mobile phone-based PTs, (3) reveal some strengths and weaknesses of existing mobile phone interventions in the PA and SB domains, and (4) provide recommendations to inform future research in this area.

4.3 Literature Review

Our literature review provides examples of other related systematic review papers in the field of PTs for PA and SB and how they are different from our review paper. Some previous studies evaluated the use of mobile phone-based PTs to deliver interventions to increase PA and reduce SB. For example, Bort-Roig et al. [39] provided a systematic review article to show the ability of smartphones in measuring and influencing PA behavior change. They reviewed 26 articles published from 2007 to 2013 that met their inclusion criteria. They found that smartphone technology can accurately measure a range of user behaviors. Furthermore, they emphasized the importance of having more evidence and well-designed studies to assess PA accuracy and the long-term duration of study impacts. The review focused mainly on assessing the ability of smartphone technology to measure a range of PA behaviors. Furthermore, Matthews et al. [179] reviewed the state of mobile applications for health persuasion and behavioral change with an emphasis on PA apps. They used the Persuasive System Design (PSD) model for evaluating PTs implemented in mobile applications. Their findings showed that primary task, dialogue, and social support principles were the most frequently used in their selected studies, while credibility support principles were the least represented in the design of mobile applications for PA. They suggested that developers and authors should have more knowledge and a better understanding of design principles to deliver effective and efficient PTs.

Dunn et al. [77] reviewed free and paid mobile apps targeting SB on both the iTunes app and Google Play stores based on behavior change techniques (BCTs) adoption. Specifically, they examined 36 free apps and 14 paid apps using a taxonomy of 93 BCTs. The study only focused on SB apps since PA apps had already been examined in previous studies. The findings of the review by Dunn et al. [77] showed that SB apps employed fewer BCTs than PA mobile apps and other technology interventions in the domains of PA and healthy eating.

Most existing studies focused on either SB or PA and were based on a segment of mobile phone-based PTs (such as those targeting only smartphones while ignoring traditional cellular phones). Non-smartphone devices or traditional cellular phones do not have similar capabilities as smartphones such as Wi-Fi, global positioning system (GPS), apps, web browsers, Bluetooth, and more [135]. Some of the articles included in our review paper use traditional cellular phones instead of smartphones. This may be due to the prevalence of cellular phones in the earliest studies and the target audience. Evidence shows that smartphones began to gain popularity in the years 2007 and late 2008 when the iPhone and Android smartphones were introduced in the market, respectively [102].

Furthermore, many studies did not compare mobile phone-based PTs with those used along with other technology platforms (e.g. activity trackers and sensor devices, desktops, websites, social networks, and games) in terms of effectiveness. Therefore, there is still a need to conduct a comprehensive systematic review of the effectiveness of mobile phone-based PTs in persuading users to adopt a healthy lifestyle focusing on both increasing PA and decreasing SB. This paper provides a comprehensive overview along with a comparison of the effectiveness of using mobile phone-based PTs alone and using mobile phone-based PTs along with other technology platforms.

In this chapter, I conducted a systematic comparative review of mobile phone-based PTs for increasing PA and reducing SB based on 15 years of 80 research articles. To the best of our knowledge, most review studies are limited to smartphone technology without considering traditional cellphones and supporting technology platforms. Our major contribution is to address this gap by providing a comprehensive and comparative approach that uncovers the implementation, relationship, and effectiveness of mobile phone technologies (including smartphones and traditional cellphones) along with other technology platforms. The comparative review findings were classified based on health

domains, year of publication, country of study, behavior theories employed, persuasive strategies employed, technology platforms, targeted population by age demographic, targeted population based on their occupation and health conditions, behavioral and psychological outcomes, etc.

4.4 Materials and Methods

This systematic review chapter provides a comprehensive overview of the current state of mobile phone-based PT interventions. Thus, it can inform future research and studies in the area of mobile phone-based PTs for PA and SB.

I used quantitative content analysis, a method that applies comparison and contrast and provides taxonomies of data based on different themes and concepts [206], [246]. I used seven databases to search for and select our literature: PubMed, Springer, Elsevier Scopus, EBSCOHost, Google Scholar, ACM Digital Library, and IEEE Xplore. I searched using various terms and their combinations including “Persuasive Technology and Physical Activity”, “Persuasive Technology and Sedentary Behavior”, “Persuasive Technology and Physical Activity and Sedentary Behavior”, “Persuasive Technology and Fitness”, “Persuasive Technology and Exercise”, “Exergames or Mobile Exergames”, “Mobile Health Applications/App and Physical Activity”, “Fitness Applications/Apps”, “Smartphone Applications/Apps and Physical Activity”, “Smartphone and Physical Activity”, “Smartphone Applications/Apps and Sedentary Behavior”, and “Smartphone and Sedentary Behavior.” This ensured a wide coverage of mobile phone interventions in PA and SB across disciplines such as health informatics and human-computer interaction (HCI).

The search outcome revealed 586 unique articles or titles, of which 378 articles were excluded based on their title, while 208 articles were considered relevant. I excluded titles that only targeted, for example, other health domains that do not belong to PA or SB, such as mental health, smoking cessation, and diabetes. In addition, I excluded overview and systematic review articles, behavior theories articles, and questionnaire and survey articles by examining their titles. After examining the abstract of all the relevant articles, a total of 80 articles were selected for review. I only considered articles that discuss the design of mobile phone-based PTs or mobile phone-based PTs in conjunction with other technological platforms to promote PA and reduce SB. In addition, articles had to be

published between 2006 and 2019 and written in English to be included. The search and selection process is summarized in Figure 14 using a PRISMA flow diagram [169].

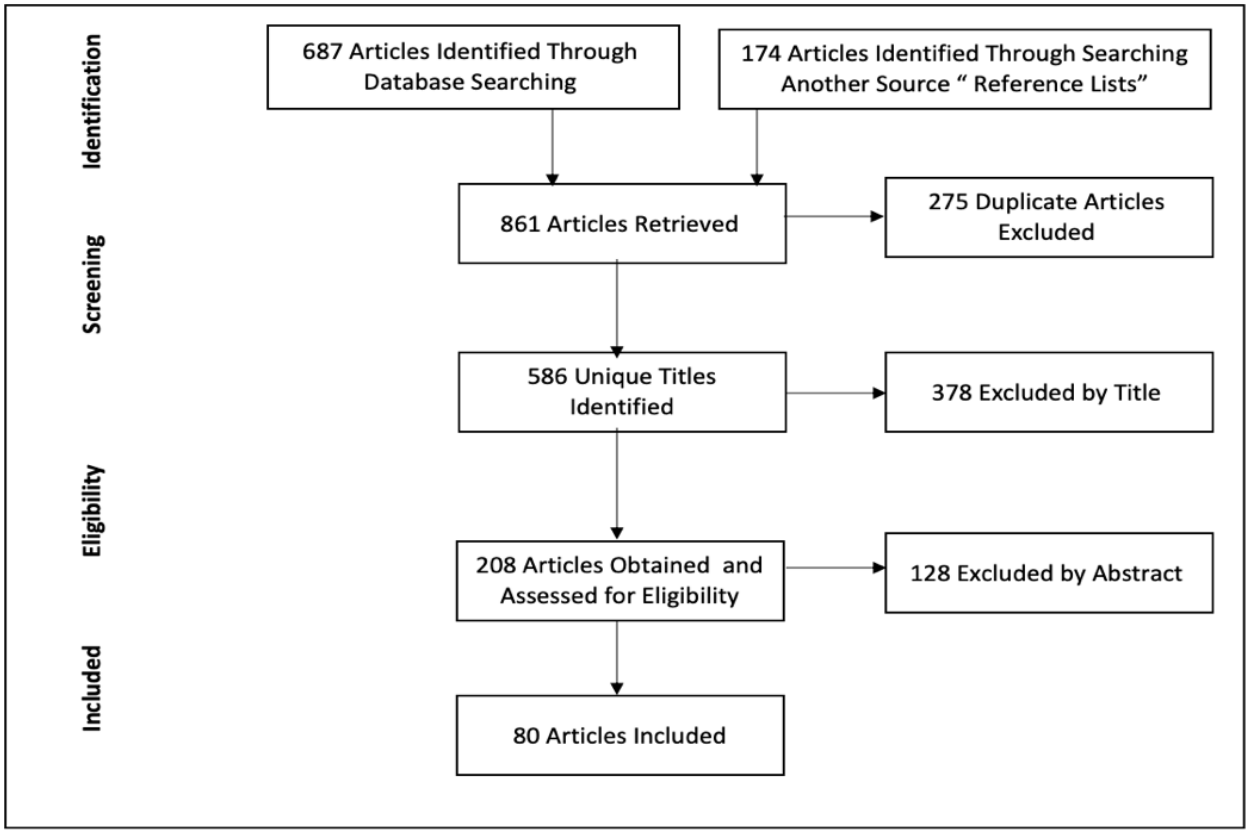


Figure 14: PRISMA Flow Diagram of the Study Selection Workflow.

4.5 Analysis and Coding Scheme

I classified the included articles according to various aspects by adapting a coding scheme developed by Orji and Moffat [206] and validated by Aldenaini et al.[9], Almutari and Orji [15], and Alqahtani et al.[18]. The coding scheme consists of the following taxonomies: the study author(s), year of publication, targeted age group, number of participants, targeted health domain (i.e., PA, SB), technology implemented (e.g., games, desktop, web, social networking sites (SNSs), mobile devices, activity trackers, etc.), duration/length of assessment (i.e., hours, days, weeks, months, and years), behavior theories implemented in the design or evaluation, motivational strategies or techniques, evaluation method (e.g., qualitative, quantitative, and mixed), country/region of the study, targeted behavioral or psychological outcomes (e.g., behavior, attitudes, motivation, awareness, and

adherence), target audience, number of participants used in the evaluation, and findings/results (whether successful or not). Subsequently, I analyzed the 80 articles using this coding scheme. I extended the coding sheet with an additional taxonomy: the target audience's occupation/status/health condition. Furthermore, I employed the PSD model [123] in analyzing the persuasive strategies obtained from the reviewed studies.

4.6 Results and Findings

Our analysis of existing mobile phone-based PT interventions for promoting PA and discouraging SB reveals interesting trends and findings. In this section, I present our results under various categories, including trends by year and country, technology platforms used along with a mobile phone, persuasive strategies and motivational affordances, behavior theories employed, study participants and sample size, and the effectiveness of the mobile phone-based PT for PA and SB.

4.6.1 Mobile Phone-based Persuasive Technologies for Physical Activity and Sedentary Behavior by Year and Country

Figure 15 shows that a substantial number of studies on mobile phone-based PTs for PA and SB were published in 2012. There were some year-to-year fluctuations before 2011 and after 2012, and the number peaked in 2015 with a total of 12 studies. The year 2019 appears to have the fewest number of studies since 2012; this is because our study was conducted in the middle of 2019, while most of the publications for the year were yet to be published.

As shown in Figure 16, the studies are from 15 countries, with the USA having the highest coverage of 36%, followed by the UK, Netherlands, and Germany with 10%, 9%, and 6%, respectively. Belgium, Canada, Italy, Portugal, and South Korea are in fifth place, having 4% each of all the studies.

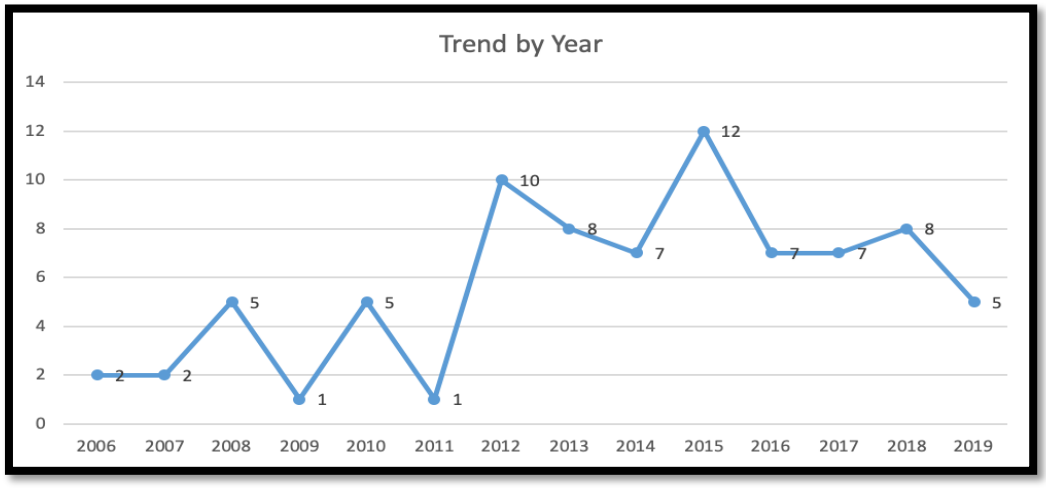


Figure 15: Mobile Phone-based PTs for PA and SB Trend by Year.

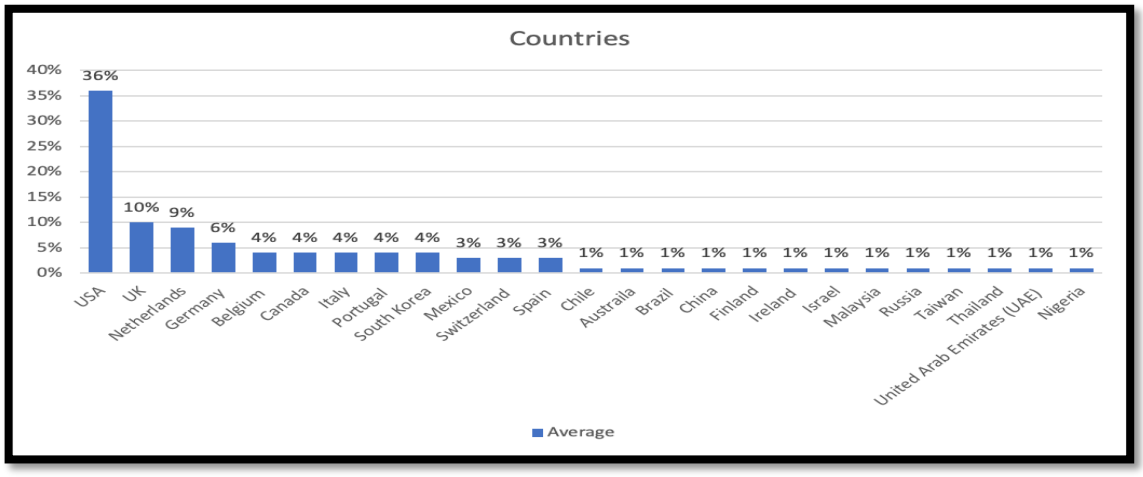


Figure 16: Mobile Phone-based PTs for PA and SB by Study Country/Region.

4.6.2 Evaluation Outcomes of Mobile Phone-based Persuasive Technologies for Physical Activity and Sedentary Behavior

Figure 17 summarizes the results from the evaluation of mobile phone-based PTs for promoting PA and reducing SB reviewed in this paper. Of the 80 relevant articles, thirty-eight (48%) reported fully successful results, and twenty-five (31%) reported partially successful outcomes (which is a combination of positive and negative results). Fourteen articles (18%) did not evaluate their persuasive system design. Only two studies (3%) did not specify their results, and just one (1%) study was unsuccessful at attaining its intended persuasion objective.

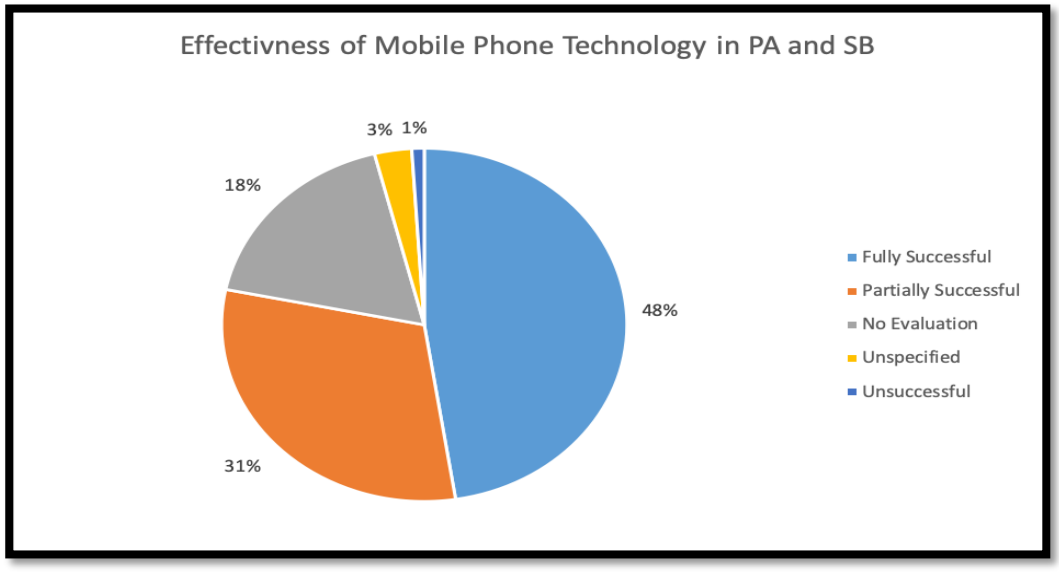


Figure 17: Summary Results of Mobile Phone-based PTs' Effectiveness in Addressing PA and SB.

4.6.3 Major Technology Platforms Employed with Mobile Phone-based PTs for PA and SB

Figure 18 presents the major technology platforms employed along with mobile phones for persuading users to promote PA and discourage SB. The most frequently employed technology platforms used in conjunction with mobile phone-based PTs are wearable activity trackers and sensors (e.g., smartwatches, accelerometers, pedometers, sensory chairs/workstations/pillows) with a total of 35 studies (44%). This is followed by the use of mobile phone-based PTs alone with/without embedded (built-in) sensors and cameras with 25 (31%) studies. Mobile phone-based PTs in conjunction with websites and SNSs is in third place with 19 studies (24%). Mobile phone-based PTs with games ranked fourth with 15 studies (19%). This is followed by mobile phone-based PTs and ambient display, mobile phone-based PTs and desktops, and mobile phone-based PTs and other mobile handheld devices with 5 studies (6%), 4 studies (5%), and 3 studies (4%), respectively.

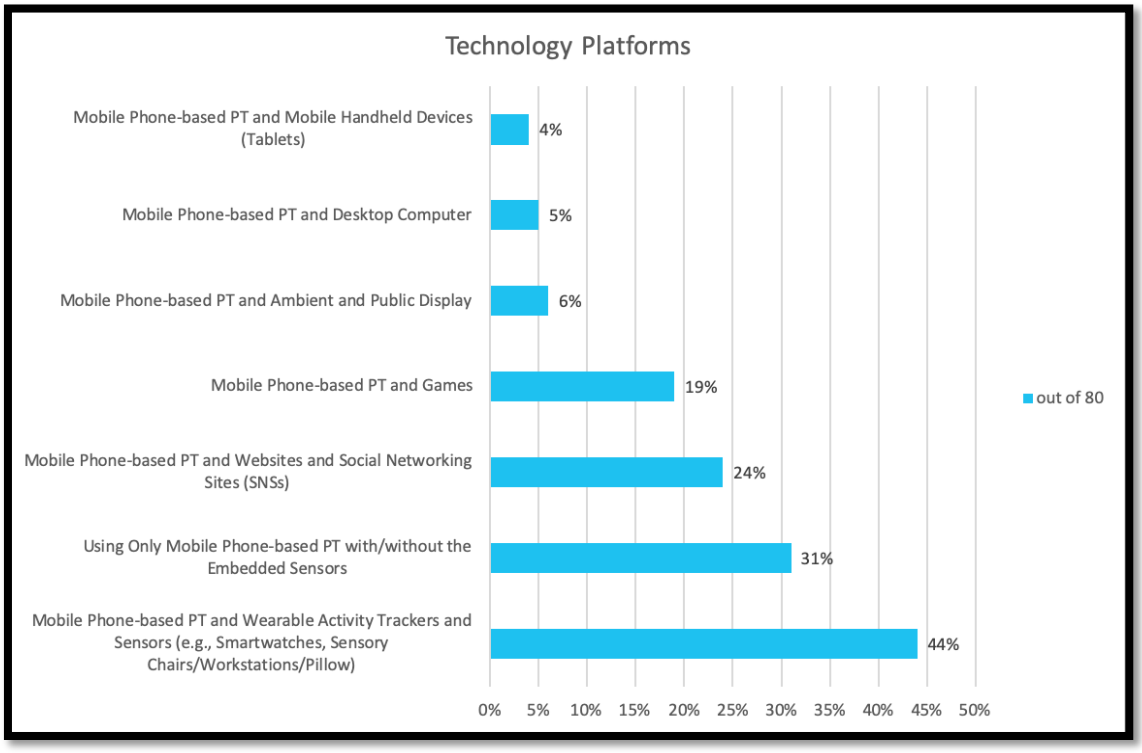


Figure 18: PT Platforms Used with Mobile Phone-based PTs.

Figure 19 illustrates the effectiveness of the technology platforms used along with mobile phone-based PTs. Out of 35 studies that used mobile phone-based PTs along with activity trackers and sensors, 16 (46%) reported fully successful outcomes, 13 (37%) were partially successful studies, 2 (6%) did not specify their outcomes, and 4 (11%) did not evaluate their persuasive application. With respect to apps using mobile phone-based PTs alone, out of 25 studies that employed them, 12 (48%) reported fully successful outcomes, 8 (32%) were partially successful, and 5 studies (20%) did not provide evaluations. For mobile phone-based PTs with websites and SNSs, out of 19 studies that implemented them, 9 (47%) were fully successful, 3 (16%) were partially successful, 6 (32%) had no evaluation, and only 1 (5%) was unsuccessful. Out of 15 studies that employed mobile phone-based PTs along with games, 9 (60%) reported fully successful outcomes, 4 (26%) reported partially successful outcomes, 1 (7%) reported no evaluation, and only 1 (7%) was unsuccessful. For mobile phone-based PTs with ambient displays, out of the 5 studies that used them, 2 (40%) were fully successful, 2 (40%) were partially successful, and only 1 (20%) had no evaluation. Out of the 4 studies that employed mobile phone-based PTs along with desktops, 3 (75%) were fully successful, and only 1 (25%) was

partially successful. Finally, out of the 3 studies that employed mobile phone-based PTs along with other mobile handheld devices, only 1 study (33%) reported fully successful outcomes, while 2 (67%) reported partially successful outcomes.

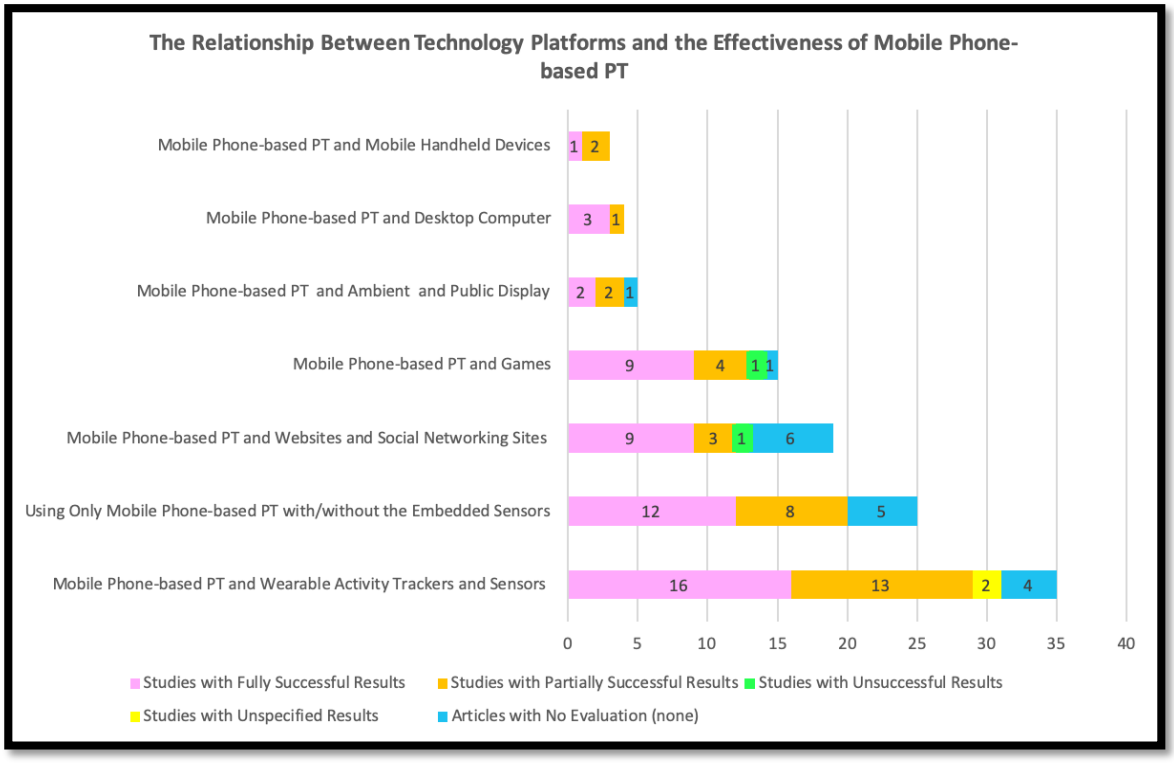


Figure 19: Relationships Between Technology Platforms and the Effectiveness of Mobile Phone-based PTs.

4.6.4 Persuasive Strategies and Motivational Affordances

Figure 20 shows the persuasive strategies most frequently implemented to bring about desirable behavioral outcomes in the PA and/or SB domains. Tracking and self-monitoring were the most commonly used strategies, as they were implemented in all 80 studies (100%). Personalization was the second most frequently implemented strategy, as it was employed in 43 studies (54%). Reminder and goal setting ranked as the third and fourth most frequently employed strategies with 36 studies (45%) and 34 studies (43%), respectively. Rewards and other social support strategies (including those that did not explicitly belong to the PSD model such as social tags, likes, invitations, comments, chatting, and sharing) ranked fifth with 32 studies (40%) for each. Praise and reduction ranked sixth and seventh with 24 studies (30%) and 22 studies (28%), respectively. Social competition, suggestion, and social comparison ranked eighth, ninth, and tenth with a total of 19 studies (24%), 18 studies

(23%), and 17 studies (21%), respectively. Tunneling, simulation, and social cooperation ranked eleventh with 13 studies (16%) for each. The least commonly employed strategies were punishments (negative reinforcements), verifiability, social facilitation, self-reporting (feedback from users) with 2 studies (3%) for each, followed by a rehearsal strategy, which was found in only 1 study (1%).

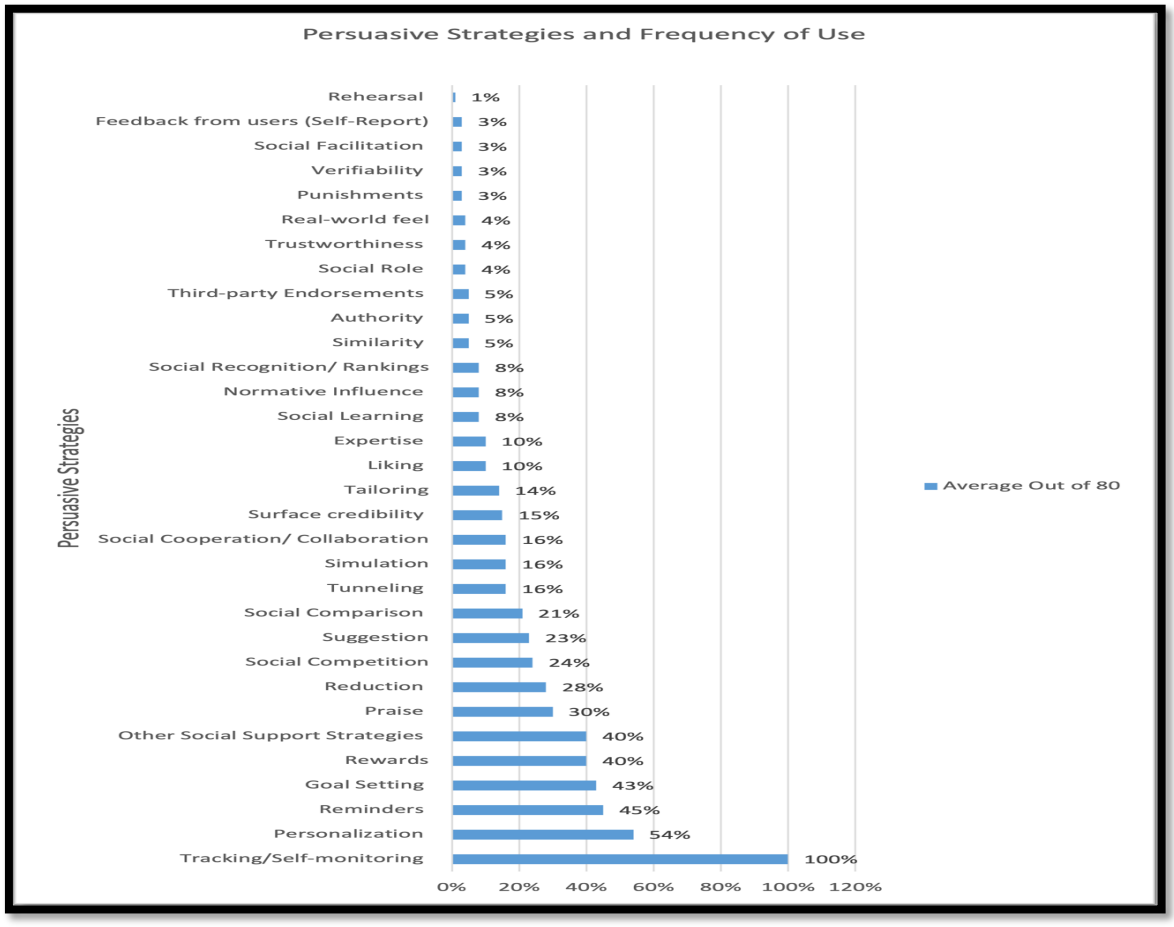


Figure 20: Persuasive Strategies and Frequency of Use.

4.6.5 Comparative Effectiveness of Mobile Phone-based Persuasive Technologies by Persuasive Strategy

I provide the comparative effectiveness of mobile phone-based PTs based on the persuasive strategies employed in the domains of PA and SB as shown in Figure 21. Some strategies were implemented more commonly, and some strategies were more effective than others. A tracking and self-monitoring strategy was applied in 80 studies (100%), out of which 38 (48%) reported fully successful outcomes,

25 (31%) reported partially successful outcomes, 14 (18%) did not evaluate their application, 2 (3%) did not report their outcomes and 1 (1%) reported an unsuccessful outcome.

Briefly, I identify the top eleven persuasive strategies that were most effective for promoting PA and reducing SB. As shown in Figure 21, out of the total studies that employed each persuasive strategy (see Section 4.4), tracking and self-monitoring ranked first with a total of 63 (79%) successful outcomes (either fully or partially successful), followed by personalization, which ranked second with 33 (77%) successful outcomes. Reminders came third with 30 (83%) successful outcomes, followed by rewards, which ranked fourth with 26 (81%) successful outcomes. Other social support strategies ranked fifth with 23 (72%) successful outcomes, followed by reduction and praise, which ranked sixth with 18 (82%) and 18 (75%) successful outcomes, respectively. In addition, social competition ranked seventh with 15 (79%) successful outcomes. Furthermore, suggestion and social comparison ranked eighth and ninth with 14 (78%) and 12 (71%) successful outcomes, respectively. Tunneling ranked tenth with 10 (77%) successful outcomes, followed by simulation, tailoring, and social cooperation, which ranked eleventh with 9 (69%), 9 (82%), and 9 (69%), respectively.

For the assessment and classification of the success ratings of the reviewed articles obtained from the systematic reviews included in our research (e.g., studies with fully successful results, partially successful results, unsuccessful results, unspecified results, and articles with no evaluation), I thoroughly investigated the articles through iterative reading, examining, comprehending, and making necessary comparisons of the abstract, discussion, results, and conclusion sections, in addition to the entire article. Thus, our assessment and classifications are based on evaluating the information provided in the articles and precisely identifying the success of each article according to the authors' assessments and reports of their findings. Consequently, I mapped the success ratings of the persuasive strategies or their implementations in the reviewed articles based on the success of the articles themselves.

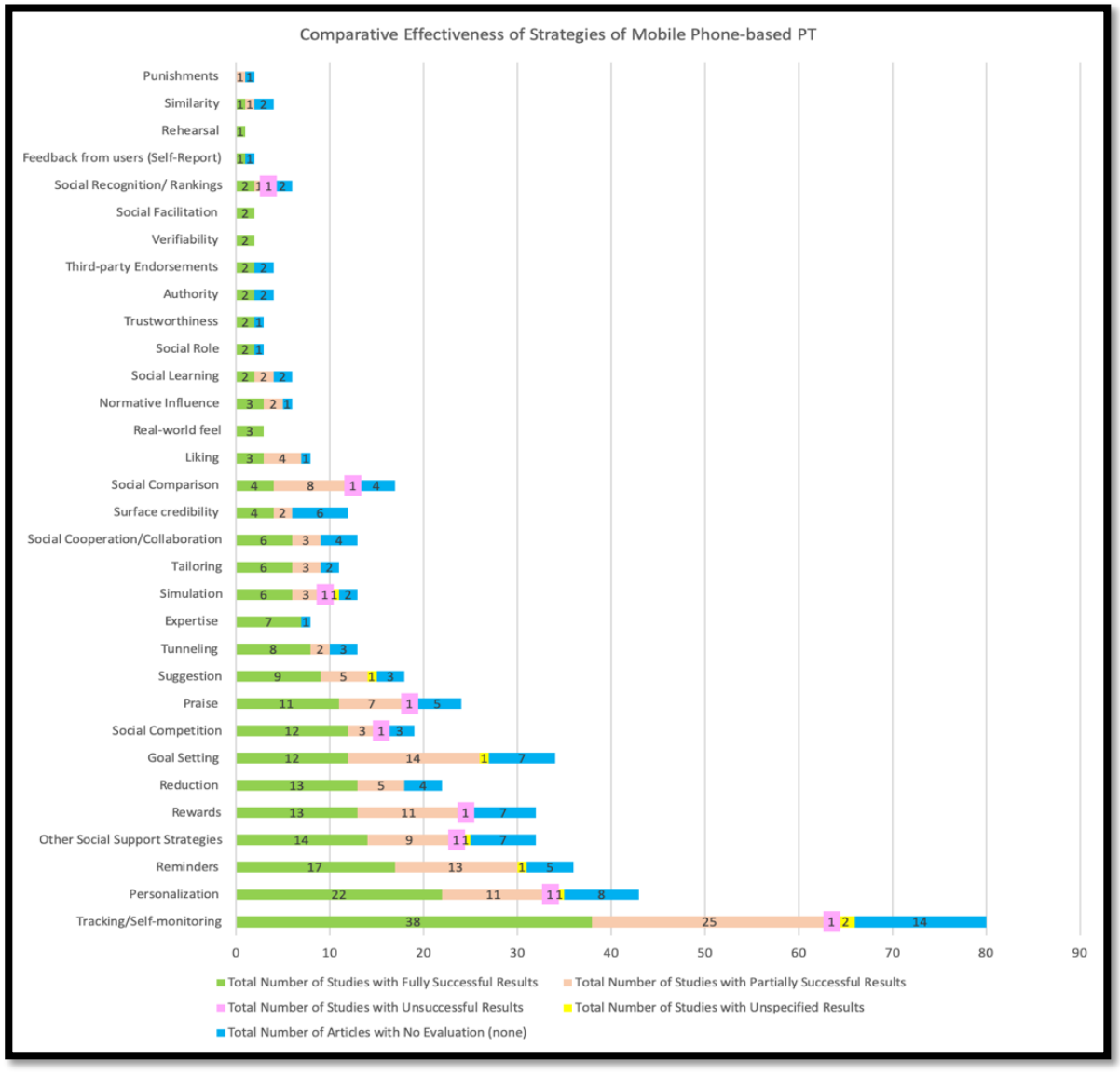


Figure 21: Comparative Effectiveness by Persuasive Strategy.

4.6.6 Behavior Theories Employed

As shown in Figure 22, 53 studies (66%) did not employ any behavioral/psychological theory to support their PT design. The social cognitive theory (SCT) and Transtheoretical Model (TTM) were employed in 8 studies (10%). The goal setting theory (GST) and self-determination theory (SDT) ranked third with a total of 3 studies (4%) each, followed by the theory of self-efficacy (TSE) and theory of planned behavior (TPB), which came fourth with a total of 2 studies (3%) for each.

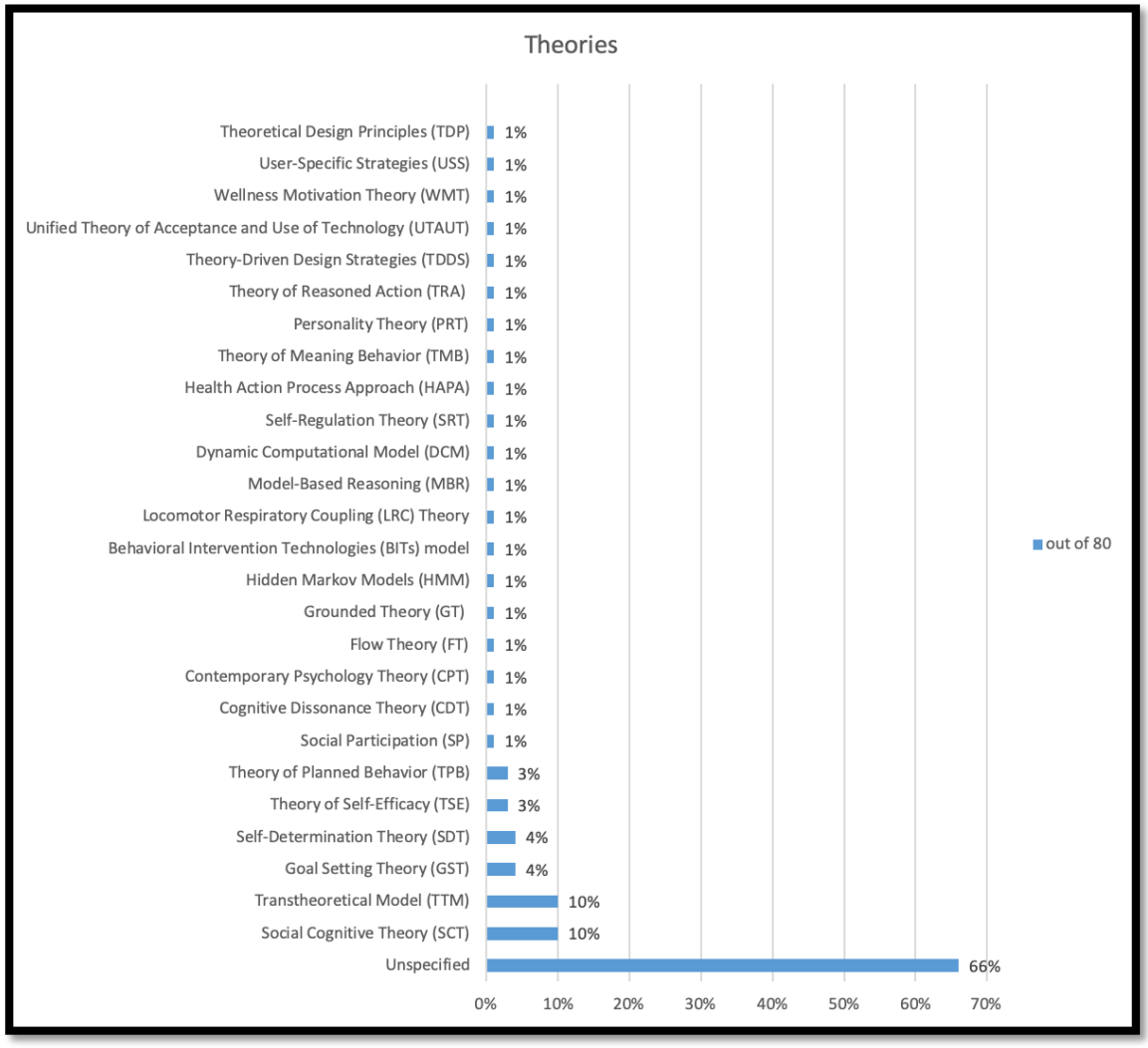


Figure 22: Behavior Theories Used in Mobile Phone-based PTs.

Based on our findings, 27 studies (34%) employed behavior theories to inform their PT designs, while 53 studies (66%) did not employ any theory. Figure 23 shows that out of the studies that did not employ any theory, 40 studies (75%) reported successful outcomes (either fully or partially successful). Moreover, 12 studies (23%) did not provide any evaluation, while 2 studies (4%) had unspecified outcomes, and only 1 study (2%) was unsuccessful. Out of the studies that employed behavior theories, 13 (48%) reported successful results, 11 (40%) reported partially successful results, and only 4 (15%) reported unsuccessful outcomes.

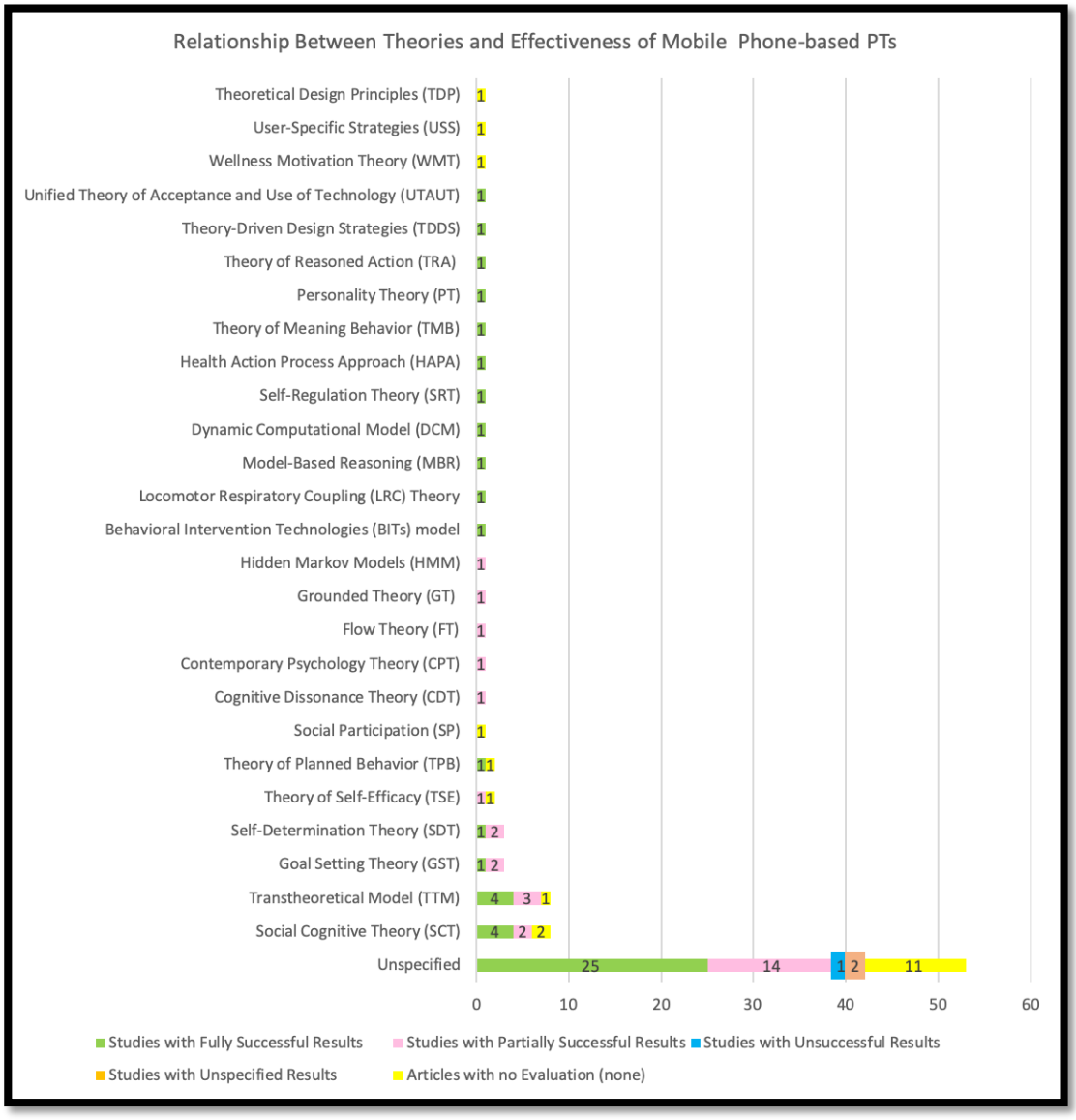


Figure 23: The Relationship Between Behavior Theories and the Effectiveness of Mobile Phone-based PTs.

4.6.7 Targeted Health Behavior Domains

In this review, I searched for and selected articles that targeted PA and/or SB. Figure 24 shows the distribution of the articles across these domains. Sixty-five studies (81%) focused on promoting PA levels, while 11 studies (14%) focused on discouraging SB. Only 4 studies (5%) aimed to achieve both goals.

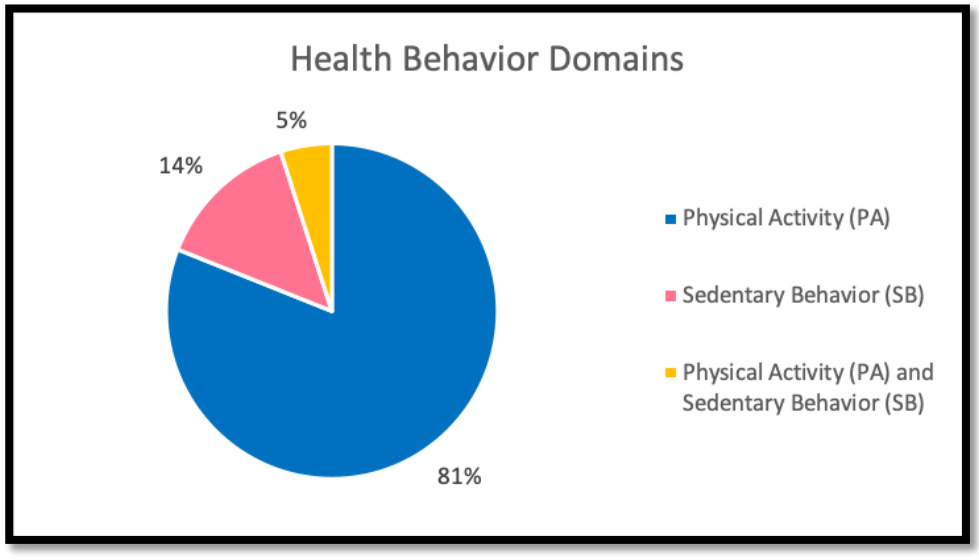


Figure 24: Targeted Health Behavior Domains.

4.6.8 Targeted Behavioral or Psychological Outcomes

Figure 25 shows the targeted behavioral or psychological outcomes of the reviewed studies. Nine different outcomes were targeted by the reviewed studies. The most commonly targeted outcome was behavior with a total of 72 studies (90%), followed by motivation with 28 studies (35%). Awareness came third with 27 studies (34%), and attitude was fourth with a total of 6 studies (8%). Adherence, acceptance, and engagement were fifth with 2 studies (3%) each, while social interaction and self-management were the least targeted outcomes with 1 study (1%) each.

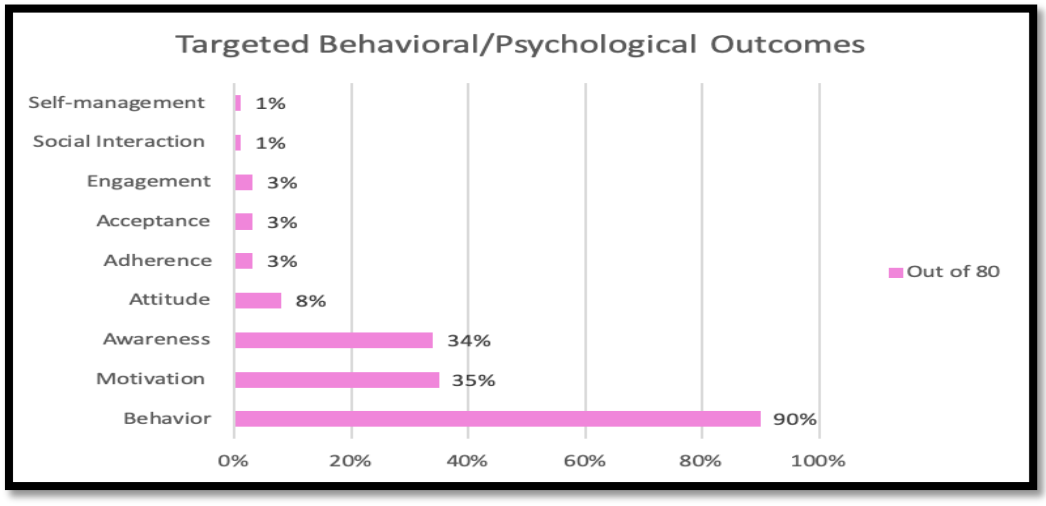


Figure 25: Targeted Psychological or Behavioral Outcomes by PT.

4.6.9 Study Methodology Used and Outcomes

Figure 26 shows the various evaluation methods employed in the study, and Figure 27 compares the effectiveness of the PT based on the evaluation methods employed. Out of 20 studies (25%) that employed a quantitative approach for evaluating the mobile phone-based PTs, 14 (70%) reported fully successful results, 5 (25%) reported partially successful outcomes, and only 1 (5%) reported unspecified outcomes. A total of 33 (41%) of the studies employed a mix of quantitative and qualitative evaluation methods: a total of 19 (58%) reported fully successful outcomes, and 14 (42%) reported partially successful outcomes. This is followed by studies that employed just a qualitative evaluation approach, with a total of 13 studies (16%) having the least effective outcomes. Out of the studies that employed a qualitative methodology, 5 studies (38%) reported fully successful outcomes, 6 studies (46%) reported partially successful outcomes, 1 study (8%) reported an unsuccessful outcome, and another 1 study (8%) did not specify its outcome.

Consequently, the most common evaluation methodology employed was the mixed method approach (quantitative and qualitative) (41%), followed by a quantitative method (25%), and a qualitative approach (16%) in third place. The remaining 14 articles (18%) did not evaluate their persuasive systems, as shown in Figure 26.

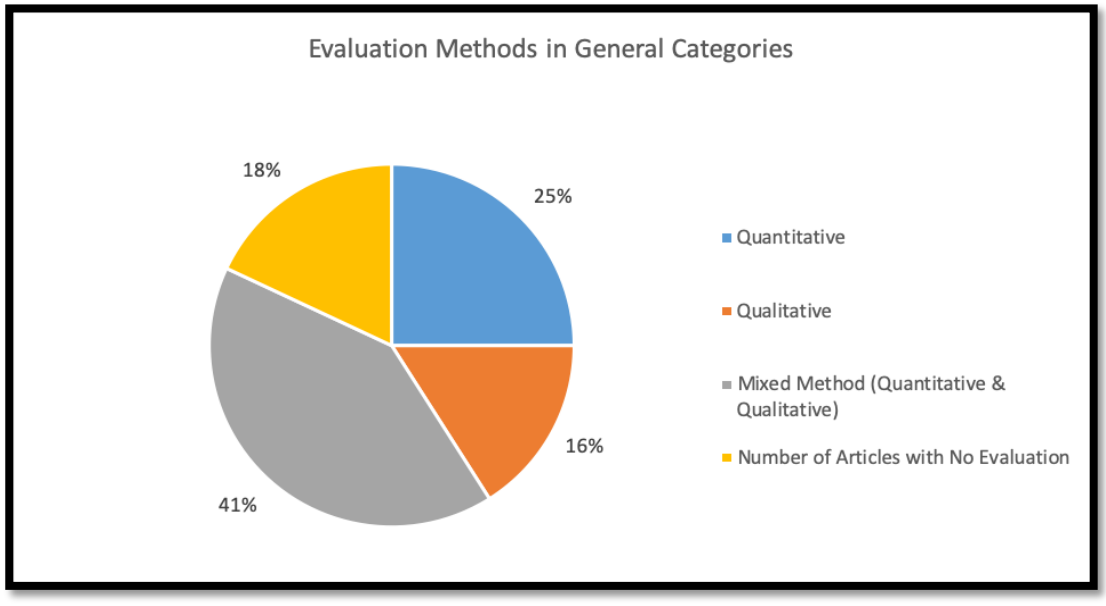


Figure 26: Evaluation Methodologies Employed by Mobile Phone-based PTs.

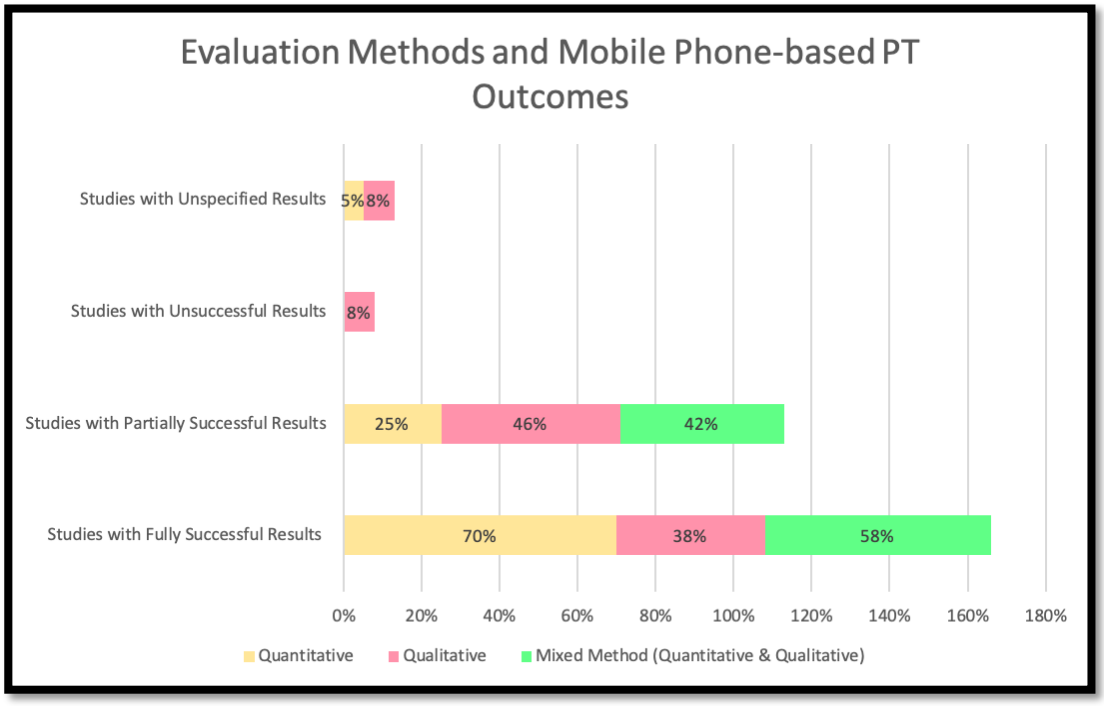


Figure 27: Evaluation Methods and Mobile Phone-based PT Outcomes.

4.6.10 Study Participants and Sample Size

The number of participants (or sample size) used for the evaluation of mobile phone-based PTs for PA and SB differs considerably in the studies. The total sample size ranges from 4 to 749,010 participants, with an average number of 9,393 for all reviewed studies that evaluated PTs.

As represented in Figure 28, 39 (49%) of all the studies were targeted at adults (31–54 years old), 13 studies (16%) were targeted at young adults (18–30 years old), 10 studies (13%) did not specify their target audience, and 9 studies (11%) focused on older people. Teenagers and children were targeted in a total of 5 studies (6%) each.

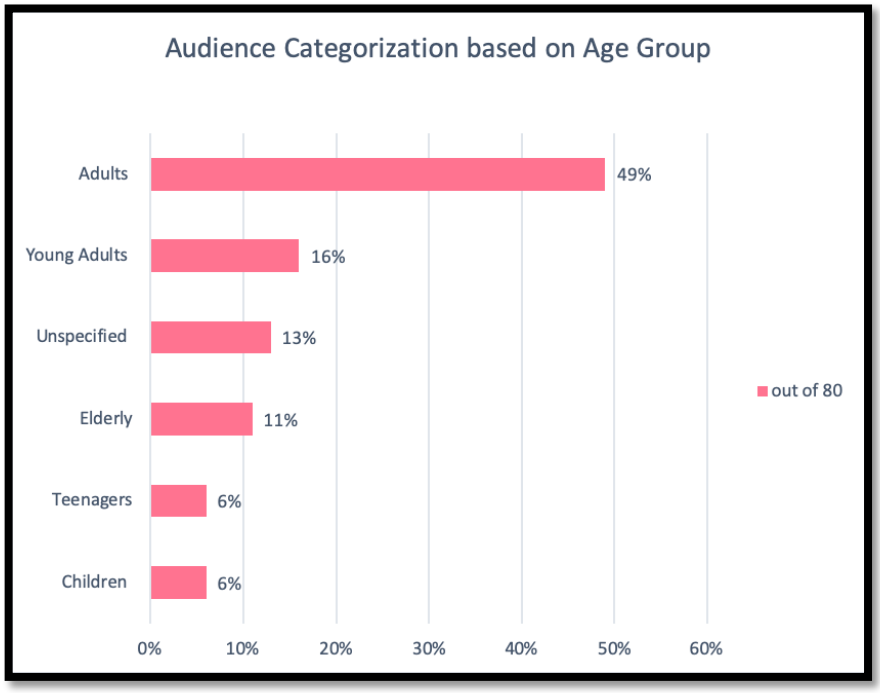


Figure 28: Target Audience by Age Demographics.

4.6.11 Effectiveness of Mobile Phone-based Persuasive Technologies Based on Target Audience by Age Group

Figure 29 illustrates the effectiveness of implementing mobile phone-based PTs based on the target audience and by age group. Out of 39 studies targeted at adults, 15 (38%) reported successful outcomes, 19 (49%) reported partially successful outcomes, 2 (5%) did not specify their outcomes, 2 (5%) did not evaluate their persuasive designs, and only 1 study (3%) was unsuccessful. Out of 13 studies targeted at young adults, 11 (85%) reported fully successful outcomes, and only 2 studies (15%) did not provide evaluation outcomes. Out of 9 studies targeted at the elderly, 4 (45%) were fully successful, 3 (33%) were partially successful, and 2 (22%) had no evaluation. Out of 10 studies that did not specify their target audience, 3 (30%) were fully successful, and 7 (70%) were partially successful. Out of 5 studies targeted at teenagers, 3 (60%) reported fully successful outcomes, 1 (20%) reported partially successful outcomes, and 1 (20%) did not report any evaluation outcome. Out of 5 studies targeted at children, 2 (40%) were successful, 2 (40%) were partially successful, and 1 (20%) had no evaluation.

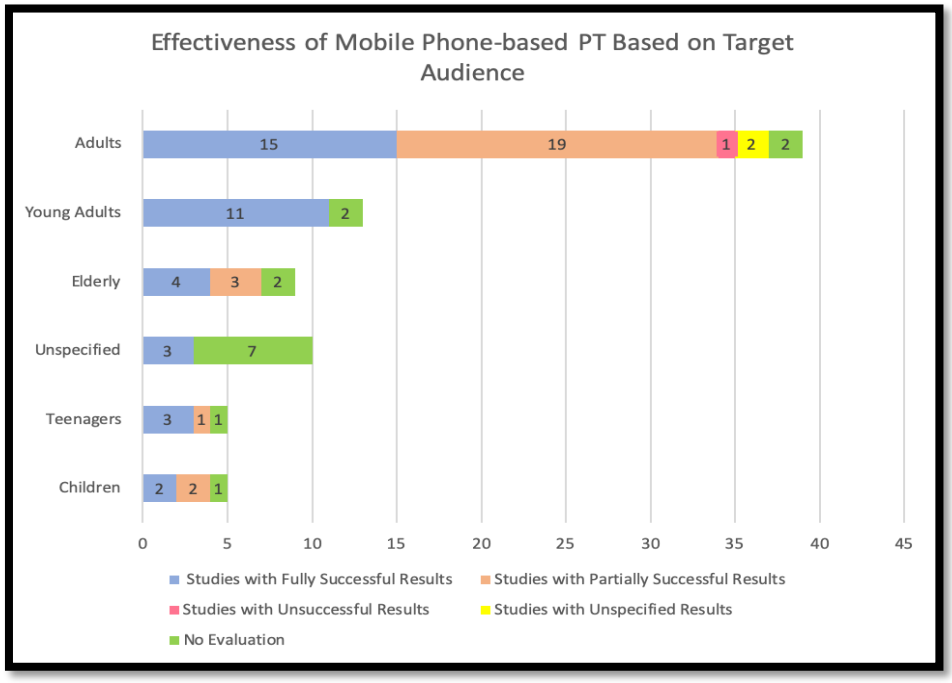


Figure 29: Effectiveness of Mobile Phone-based PTs Based on Target Audience.

4.6.12 Target Audience by Occupation/Status/Health Condition

Figure 30 illustrates our findings in terms of the general status, occupation, or health condition of the target audience. Fifty (63%) of all the reviewed studies did not specify this information in relation to their target audience. There were 7 studies (9%) targeted at office workers, 4 studies (5%) targeted at school students, 3 studies (4%) targeted at university students, and 2 studies (3%) targeted at athletes. The remaining studies were targeted at a different class of people including people with multiple sclerosis, breast cancer patients, breast cancer survivors, individuals with severe mental health problems, overweight and obese individuals, nurses, medical specialists and patients with type 2 diabetes, with a total of 1 study (1%) for each.

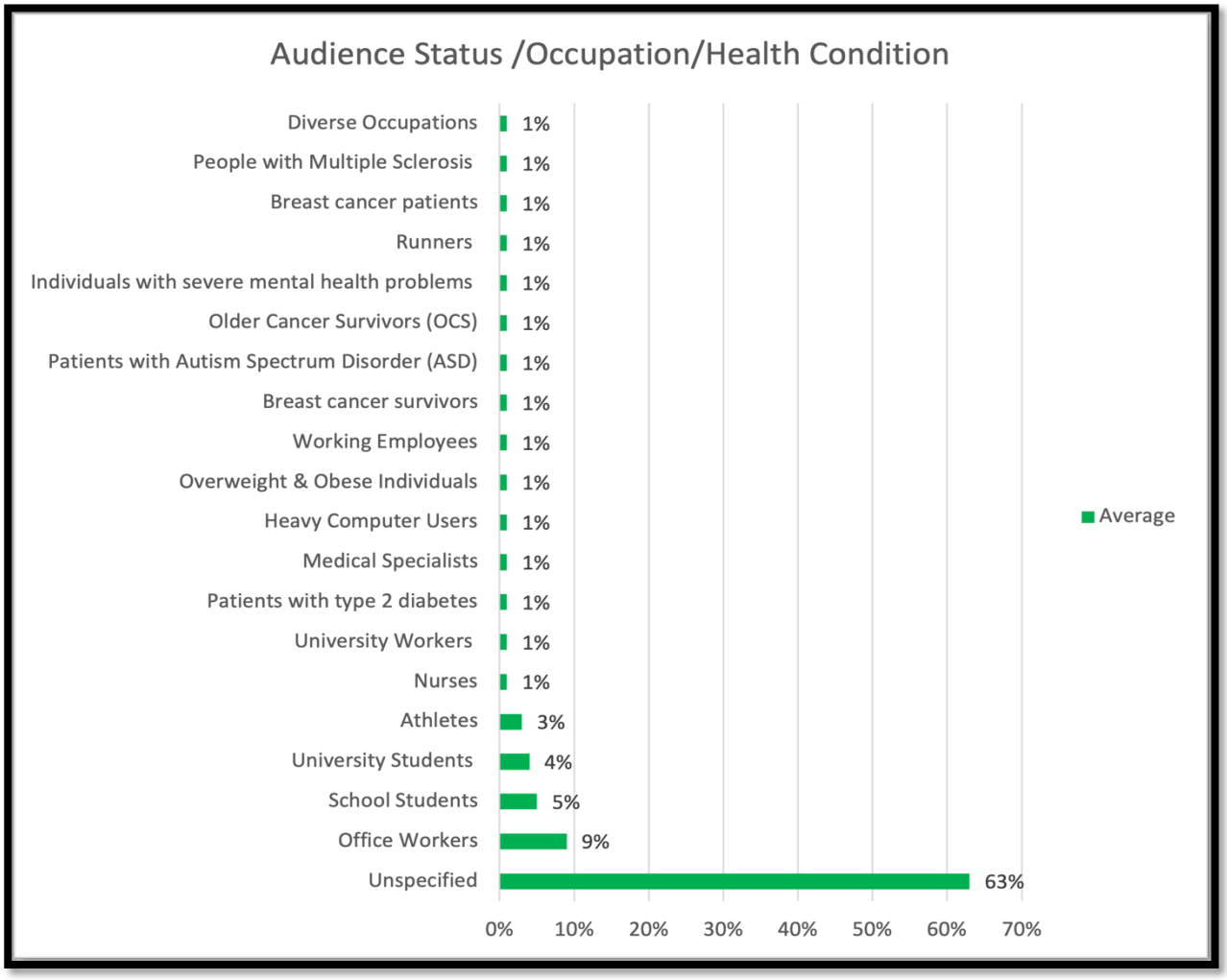


Figure 30: Audience Categorization Based on Their Status/Occupation/Health Condition.

4.6.13 Duration of Evaluation

The duration of the studies that evaluated persuasive system designs ranged from one day to around one year and a half. As shown in Figure 31, thirteen studies (16%) did not report the duration of their experiments (i.e., how long it took to assess their mobile phone-based PT design). The findings show that 24 studies (30%) evaluated their designs for between one and three months, 8 studies (10%) for less than one month, 8 studies (10) for less than one week, and 7 studies (9%) for less than two weeks. Six studies evaluated their designs for either less than one year, within one and a half years, or within four to six months, with a total of 2 studies (3%) per duration.

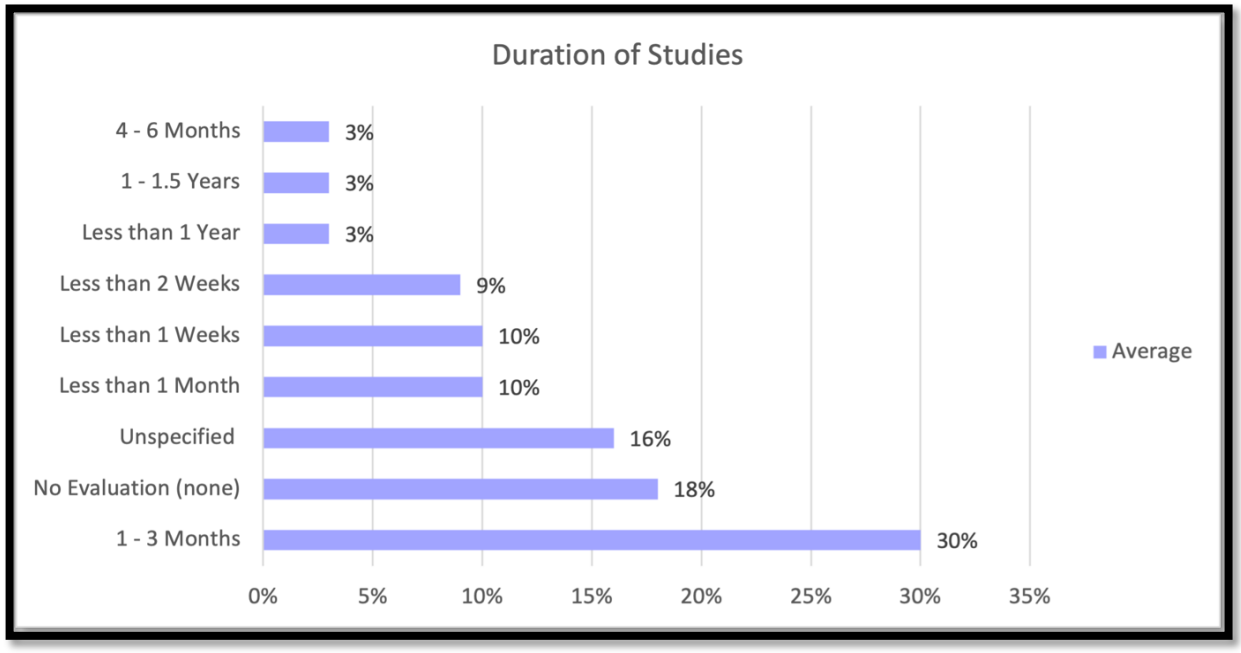


Figure 31: Duration of Studies' Evaluation.

4.7 Discussion

This systematic review covers studies that focus on all segments of mobile phone-based PTs (such as those targeting smartphones and traditional cellular phones) for both SB and PA. I provide a comprehensive overview along with a comparison of the effectiveness of using mobile phone-based PTs alone and using mobile phone-based PTs along with other technology platforms. Our findings from the reviewed studies revealed that mobile phone-based PTs are effective tools for promoting PA and decreasing SB, as 79% of the reviewed studies reported successful or partially successful outcomes. Only one study reported an unsuccessful outcome, which was due to usability problems (such as performance issues, navigation issues, or instability due to bugs) encountered by users as well as the intense physical effort required to interact with the PT, thereby causing repetitive strain injury [305]. Therefore, developers of PT interventions should conduct rigorous functionality and performance testing prior to deployment. In addition, the design concept behind PTs for PA should fit the target audience to avoid undesirable health outcomes, as highlighted by Aldenaini et al.[9] and Orji et al.[201].

4.7.1 The Relationship Between Technology Platforms and The Effectiveness of Mobile Phone-based Persuasive Technology

Our findings revealed that implementing mobile phone-based PTs along with activity trackers and sensors is the most effective approach, with a total of 29 (83%) studies in this category reporting successful or partially successful outcomes. This positively reinforces our findings, as the tracking and self-monitoring strategies were the most frequently employed strategies, and they ranked as the most effective strategies for mobile phone-based PTs in the domains of PA and SB. The second most effective approach is the use of only mobile phone-based PTs along with/without inbuilt (embedded) sensors: 20 studies in this category reported successful outcomes, whether fully or partially successful. Implementing mobile phones together with games ranked third in terms of effectiveness: 13 studies reported successful outcomes, whether fully or partially successful. These results reflect the suitability of mobile phones for deploying persuasive tools, considering their ubiquitous and ever-present nature, coupled with their tracking and monitoring features (such as in-built sensors, GPS, and cameras). These make mobile phones suitable for almost every environment and individual at any time [97], [250], and [264].

4.7.2 The Relationship Between Persuasive Strategies and the Effectiveness of Mobile Phone-based Persuasive Technology

The top 10 most effective strategies (from the most effective to the least effective) are tracking/self-monitoring, personalization, goal setting, reminders, other social support strategies, praise and reduction, social competition, suggestion, social comparison, and tunneling and social cooperation. Also, the majority of the reviewed studies targeted actual behavior change in terms of increasing PA, followed by studies that were targeted at decreasing a sedentary lifestyle, while a few studies targeted both. Others focused on increasing motivation, awareness and attitudes. Some reviewed articles targeted other behavioral and/or psychological outcomes such as acceptance, adherence, engagement, and social interaction. Similarly, the majority of mobile phone-based PTs encourage and reinforce PA behaviors such as increasing daily step counts, practicing some moderate to vigorous intensity PA, and frequently standing and stretching to reduce SB. Thus, mobile phone-based PTs for increasing PA and decreasing SB have improved over the years and have played an essential role in promoting behavior change practices among users. Furthermore, our analysis involves classifying the persuasive strategies obtained using the PSD model of Oinas-Kukkonen and Harjumaa [123]. However, I found

that some strategies were not explicitly mentioned in the PSD model (such as goal setting, punishments (negative reinforcements such as angry facial expressions and losing points), self-report (feedback from users as shown in [303], and [239]), and other social support strategies (e.g., messages, chatting, sharing, invitations, tags, and comments)). This highlights the need to extend the design model to accommodate some emerging strategies used in PT design due to technological advances, as highlighted by [9].

4.7.3 The Relationship Between the Target Audience and the Effectiveness of Mobile Phone-based Persuasive Technology

Adults and young adults are the primary users of mobile phones and wearable activity trackers [15] and [263]. This explains why they are the dominant target groups for mobile phone-based PTs. Generally, our findings revealed that mobile phone-based PTs targeted at adults and young adults are more effective than those targeted at teenagers, children, and older adults. This may be due to the ease of assessing mobile phone-based PTs used by adults and young adults compared to children and older adults. Another reason may be that adults and young adults can be easily motivated to be more physically active since they are in their active years, thereby making it more likely that mobile phone-based PTs for promoting PA and reducing SB would be more effective and successful, as highlighted by [15]. Furthermore, most of the reviewed studies were targeted at office workers and students. This is possibly because these populations are more likely to have sedentary lifestyles since they sit and work at desks for many hours.

4.7.4 The Relationship Between Employing Behavioral Theories and the Effectiveness of Mobile Phone-based Persuasive Technology

Based on our findings, the majority, 53 (66%), of the reviewed studies did not employ any theory in their mobile phone-based PT designs, while only 27 (34%) studies employed theories to inform their mobile phone-based PT designs. Therefore, due to the limited number of studies implementing theories, I could not effectively compare the effectiveness of mobile phone-based PTs that applied behavior theories with those that did not employ any theory. Out of the studies implementing theories, 24 studies (89%) were either fully or partially successful. Thus, it appears that employing behavior theories to support mobile phone-based PTs improves their effectiveness toward achieving the

intended goal of encouraging PA and discouraging SB, which supports previous research by Orji et al. [205].

4.7.5 The Relationship Between the Duration of Evaluation and the Effectiveness of Mobile Phone-based Persuasive Technology

Our findings show the duration of the evaluation of the reviewed studies, which ranged from one day to one year and a half. Only 8% of all the studies conducted longitudinal evaluations of their mobile phone-based PT, with the study duration ranging from 4 months to one year and a half. Thus, it is difficult to determine the long-term effects of the mobile phone-based PTs since the majority of the reviewed studies did not conduct a long-term evaluation of their PT designs.

4.7.6 Limitations of Existing Studies and Recommendations for Future Works

The majority of the reviewed studies employed more than one persuasive strategy, with all implementing the tracking/self-monitoring strategy. Therefore, evaluating the effectiveness of a mobile phone-based PT based on the persuasive strategy employed is complex. This is further complicated by the fact that most mobile-based PTs are integrated with other technology platforms such as external sensors. Furthermore, the duration of the evaluation of the effectiveness of the mobile phone-based PT is usually short, with 59% of studies ranging from one day to three months, making it difficult to establish their effectiveness over the long term. Thus, future research needs to focus on evaluating effectiveness over the long term using a larger target audience. With respect to the demographics of the target populations, the majority of the reviewed studies were targeted at adults and young adults, which makes it difficult to determine the effectiveness of mobile phone-based PTs for other age groups. Thus, future research should target children and older adults as well.

Moreover, studies that employed theories in their persuasive design tend to be more effective compared to those that did not use any theory; however, the majority of the reviewed studies are not based on any theories. Thus, **I suggest that researchers and developers employ behavior change theories to inform their persuasive designs. I also recommend that they illustrate how the theories employed are linked to the design features**.

Also, this review only focused on PTs that are used and implemented in the included articles, and it did not cover PTs available online, at the App Store, or on Google Play. Thus, **I recommend that future research extend to mobile phone apps that are available online and on app stores to learn**

new insights into users' needs and perceptions based on user reviews and assessments of the apps. This will help in the future development of mobile phone-based PTs.

Finally, based on our findings, the mixed method (i.e., quantitative and qualitative) form of evaluation is the dominant method. This is likely due to its ability to reveal both quantitative and qualitative outcomes, hence providing richer insights. Thus, **I recommend that designers employ both quantitative and qualitative methods to achieve a comprehensive evaluation of persuasive systems**.

4.8 Conclusion

This chapter presents a systematic review of the effectiveness of mobile phone-based PTs in promoting PA and discouraging SB among the target audience. Based on the analysis of 80 studies, the paper highlights trends in mobile-based PTs in the domain of PA and SB, including technology platforms implemented along with mobile phones, behavior change theories, and persuasive strategies employed. Finally, based on our findings, I discussed some strengths and weaknesses of existing mobile phone-based PT interventions for motivating PA and discouraging SB and offered suggestions to inform future research in these areas.

5 CHAPTER 5: PERSUASIVE STRATEGIES AND THEIR IMPLEMENTATIONS IN MOBILE INTERVENTIONS FOR PROMOTING PHYSICAL ACTIVITY

Unhealthy lifestyle behaviors such as spending too many hours sitting and inadequate physical activity (PA) can contribute to different chronic diseases. Research has revealed the capabilities of digital technology interventions such as persuasive technologies (PTs) for providing health support and encouraging healthy behavior changes to assist people in preventing chronic diseases and leading healthier lifestyles. Thus, the use of mobile technology to deliver PT interventions has dramatically increased, especially for promoting PA and reducing sedentary behavior (SB) by employing various persuasive strategies. This chapter represents the third stage of the five main stages in this dissertation. This stage involves identifying the second round of the selection of the twelve most frequently employed strategies, along with their various implementations, for our user study. This chapter provides a systematic review of 16 years of research (198 articles) from 2006 to 2021. It outlines the research methodology, including the selection of papers and the development of coding schemes, ultimately leading to the presentation of resulting insights and findings.

5.1 Motivation of This Module

Researchers and practitioners have recognized the role of PTs, and a large number of applications and studies have been introduced in a wide variety of domains. The health and wellness domain has received particular attention. Despite the increased attention toward deploying PT in health and wellness, different factors are yet to be explored. Specifically, there is a lack of research examining how persuasive strategies can be implemented and the effectiveness of different implementations across various PT contexts, including problem domains, technology platforms, and target audiences. These contexts can affect not only the choice of strategy but also its implementation and effectiveness. Thus, there is a need to investigate the different ways persuasive strategies can be implemented and evaluate PTs' effectiveness based on various implementations. Mobile technologies have been widely employed in PT interventions to promote PA and reduce SB. Due to the ubiquitous nature of mobile technology in our daily lives, our research focused on mobile-based PTs for promoting PA and reducing SB.

5.2 The Objective of This Module

The literature contains a number of systematic literature reviews in the domain of PTs for PA and SB [101], [11], [180], [268], [278], [164], [77], [240], [15], [287], [126], [261], [300], [172], [257]. However, these reviews do not provide a comprehensive systematic review that sheds light on mobile-based PT interventions for promoting PA and reducing SB or investigates their effectiveness based on the strategies employed and their different implementations. In general, these studies are limited in one form or another. These limitations can be summarized as follows:

- Most of the existing systematic review papers ignore the different ways of implementing each persuasive strategy from their reviewed articles.
- Few papers address the persuasive strategies' implementation. They focus only on a particular strategy, such as personalization, while ignoring other strategies.

5.3 Related Work

Thus, to the best of our knowledge, our work is the first to provide a comprehensive overview of mobile-based PT interventions by highlighting the different persuasive strategies employed, their different forms of implementation, and their effectiveness. Our review aims to (1) explore the various ways each strategy is implemented on mobile-based PTs (2) provide a comparison of the different ways of implementing each persuasive strategy, (3) show the weaknesses and strengths of the interventions based on the strategies and implementations, (4) highlight the limitations and pitfalls of the existing research, and (5) give recommendations and directions for future research.

An increasing number of systematic reviews are being conducted to determine the effectiveness of PTs in various domains. Ghanvatkar et al. [101] provided a scoping review of personalization strategies employed in PA interventions. They included 49 eligible studies in their review paper. They examined personalization strategies in the form of feedback or recommendations. Furthermore, they identified six types of personalization strategies based on different forms of implementation in their reviewed studies. These personalization types are summarized as shown in Table 4.

There are other interesting review papers on PT interventions in the area of PA and/or SB in general and not focused specifically on personalization. For example, Almutari and Orji [15] provided a systematic review of articles that focused on PT for promoting PA. They analyzed the effectiveness

of PT that employed social influence strategies such as comparison, cooperation, and competition only. Their findings revealed that PTs employing social support strategies to promote PA are promising in motivating users to be physically active.

Similarly, Aldenaini et al. [9] conducted a 16-year systematic review (from 2003 to 2019) of PTs and their effectiveness for promoting PA and discouraging SB. They highlighted trends in their outcomes such as research methods, behavioral theories, persuasive strategies and different ways of implementing each strategy, system design, and employed technology. Their findings revealed that employing PTs was effective and promising in promoting desirable behavior change among different populations when employed with a suitable persuasive strategy. They also provided a list of interesting recommendations for advancing future PT research.

Furthermore, Wang et al. [287] conducted a systematic review of studies targeted at reducing SB in the work environment. They used the persuasive system design (PSD) model [123] to evaluate the effectiveness and utilization of PT in discouraging prolonged SB among office workers. Their findings showed that a reminder was the most frequently employed PSD strategy. They also found that coupling a reminder strategy with education sessions was more promising than using hourly reminders alone.

Our systematic review included studies that employed a personalization strategy in their PT design to promote PA and/or reduce SB. In contrast, many existing studies tend to focus only on either promoting PA or reducing SB but rarely on both. I also aimed at examining various ways of implementing personalization in different PTs. Again, our review specifically focused on PTs employing a personalization strategy in the area of SB and PA.

5.4 Materials and Methods

This review reveals the different forms of implementation of each persuasive strategy of the mobile-based PT interventions for promoting PA and decreasing SB in the existing articles. This study is guided by the following research questions (RQs):

- **RQ1**: What persuasive strategies were used in designing mobile-based PTs for PA and SB?
- **RQ2**: What are the various ways that persuasive strategies were implemented in mobile-based PTs for PA and SB?

- **RQ3**: What are the gaps, pitfalls, and limitations in the present literature on mobile-based PTs for PA and SB?
- **RQ4**: What are the directions and recommendations for future research in the area of mobile-based PTs for PA and SB?

5.4.1 Search Methodology

Our search process was based on searching different online databases, including ACM Digital Library, Google Scholar, PubMed, Springer, IEEE Xplore, ProQuest, Elsevier Scopus, and EBSCOHost. In addition, I employed the snowball search method, as I reviewed the references of the retrieved articles.

I used different keywords to search different terminologies and their combinations such as "Mobile Health Applications/App and Physical Activity", "Smartphone and Physical Activity", "Exergames or Mobile Exergames", "Persuasive Technology and Physical Activity", "Persuasive Technology and Exercise", "Smartphone Applications/Apps and Physical Activity", "Persuasive Technology and Sedentary Behavior", "Persuasive Technology and Fitness", "Smartphone and Sedentary Behavior", "Persuasive Technology and Physical Activity and Sedentary Behavior", "Fitness Applications/Apps", "Smartphone Applications/Apps and Sedentary Behavior", "Physical Activity and Persuasive Strategies' Implementations", "Sedentary Behavior and Persuasive Strategies' Implementations", "Implementations of Strategies and Physical Activity Applications/Apps", "Implementations of Strategies and Sedentary Behavior Applications/Apps", "Implementations of Strategies and Fitness Applications/Apps", "Persuasive Technology and Persuasive Strategy", "Physical Activity and Persuasive Technology and Persuasive Strategy", "Sedentary Behavior and Persuasive Technology and Persuasive Strategy", "Employment of Strategies and Physical Activity", "Employment of Strategies and Sedentary Behavior", "Mobile Applications/Apps and Persuasive Strategies", and "Fitness Applications/Apps and Persuasive Strategies." I used Boolean terms through the search process, such as "Persuasive Technology **AND** Physical Activity," along with different terms to ensure comprehensive coverage of mobile-based PT interventions in the fields of PA and SB.

I retrieved a total of 2723 articles, of which 2272 were identified through online database searching and 451 were identified through snowballing. After excluding the duplicate articles, I identified 2040 unique titles, of which 1107 articles were eliminated by examining their titles. I obtained 255 eligible articles after eliminating 678 articles by evaluating their abstracts. Finally, 198 articles were retained

and included for this study according to our inclusion criteria. I only included articles published between 2006 and 2021, written in English, and that identify the use of mobile-based PT in their systems for promoting PA and reducing SB. I summarized the inclusion and exclusion process in Figure 32 using a PRISMA flow diagram [169].

Two researchers evaluated the reviewed papers against the inclusion/exclusion criteria. The two researchers then worked together to systematically review and synthesize the 198 considered papers. In case of any disagreement or confusion, a third researcher was consulted. I used a quantitative analysis methodology that uses contrast and comparison and gives different data classifications through various aspects and concepts [206], [246]. I also applied qualitative content analysis, which is essential in analyzing large numbers of qualitative data such as verbal or textual data gathered from various venues (e.g., focus groups and interviews). Furthermore, this type of analysis facilitates the quantification of categories and classifications [230], [86], [68]. I also collected qualitative data from surveys based on the types of questions provided to participants. I gathered the qualitative data in this review study by investigating the different ways of implementing each persuasive strategy and their examples. I performed the qualitative analysis by reading and comprehending each example of a persuasive strategy implementation. Based on that, I provided different categorizations and types of implementations for each persuasive strategy employed in the reviewed articles.

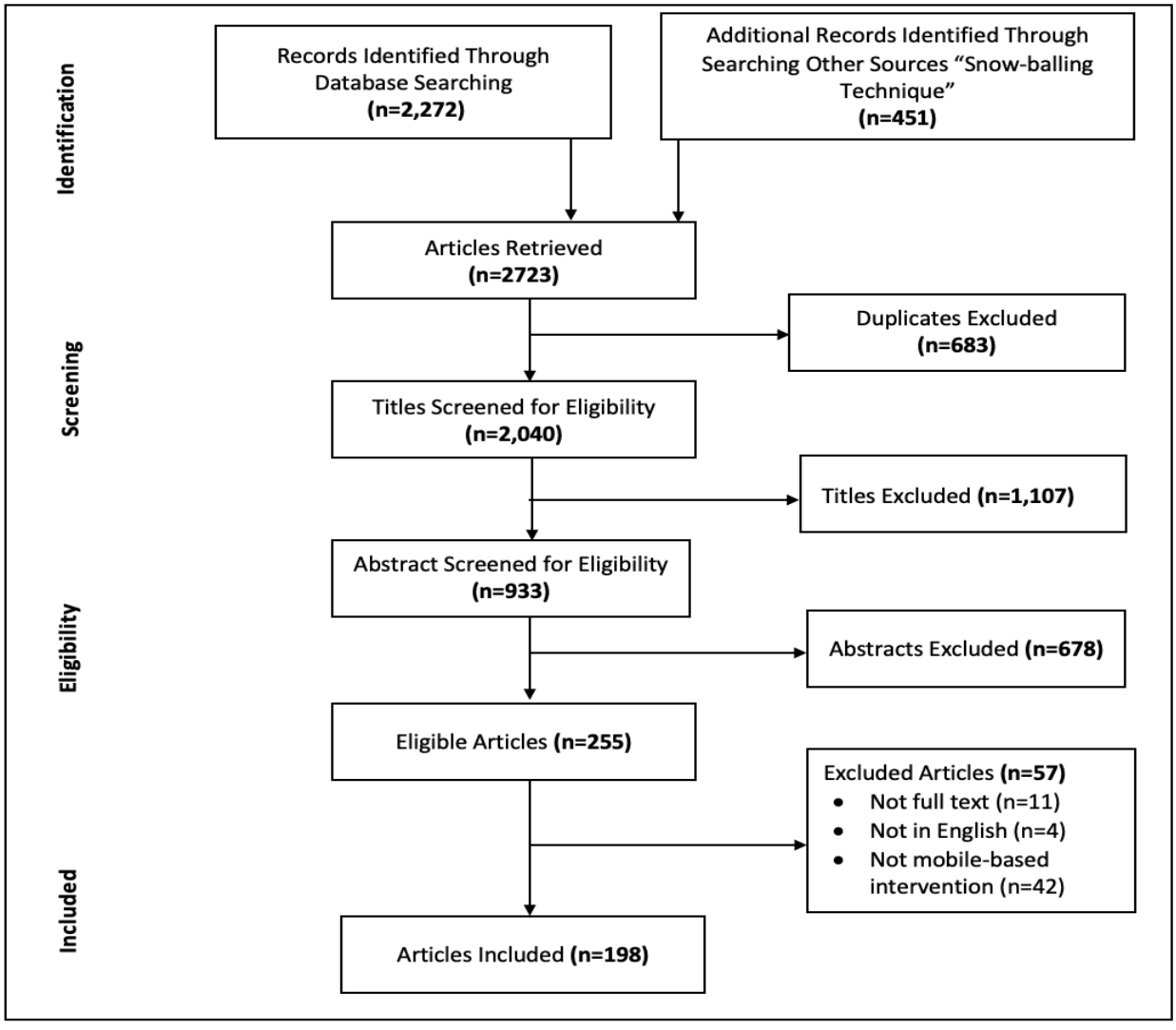


Figure 32: The Study Selection Workflow as a PRISMA Flow Diagram.

5.4.2 Analysis and Coding Scheme

I categorized the articles included in this review study based on different criteria by adapting and extending the coding scheme developed by Orji and Moffat [206] and validated by Almutari and Orji [15], Alqahtani et al. [18], and Aldenaini et al. [9]. I used some classifications of the coding scheme, which are summarized in Table 3.

Table 3: Coding Scheme Classifications.

#	**Coding Scheme Classifications**
1	The study author(s)

2	Title of article
3	Year of publication
4	Targeted health domain
5	The technology employed (e.g., social networking sites (SNSs), games, web, activity trackers, desktop.)
6	Persuasive strategies employed
7	Findings
8	Country of the study

I summarized the coding sheet of the reviewed articles. I also created different coding sheets to extract and determine the different ways of implementing each persuasive strategy. Thus, I extracted, sorted, classified, and named the implementations of each persuasive strategy based on the way they were implemented in the review articles. Moreover, I used the PSD model [123] to analyze the persuasive strategies from the review articles.

5.5 Results and Findings

The analysis of mobile-based PT interventions for promoting PA and decreasing SB shows significant and valuable findings. I delivered and presented our findings across various aspects, including the year and country of the study, and investigated the persuasive strategies employed and their different forms of implementation.

5.5.1 Persuasive Technologies for Physical Activity and Sedentary Behavior Trends by Year and Country

Figure 33 shows an increase in the number of studies on mobile-based PTs starting from 2012. The figure shows some fluctuations in the number of papers published after 2012 and before 2011, while the number peaked in 2020 with 61 studies. The year 2021 seems to have a lower number of published articles compared to 2020. This is because I conducted our review study in the third quarter of 2021 when some of the papers were still yet to be published.

Figure 34 shows that the studies were developed in 32 different countries. Most of the studies were conducted in the USA with a total of 63 studies, followed by the UK, Netherlands, Germany, Canada,

and Australia with a total of twenty, fourteen, twelve, nine, and eight studies, respectively. Portugal, South Korea, and Sweden are in the seventh place, with six studies for each. Italy, Switzerland, Ireland and Brazil are in the eighth place, with five studies for each.

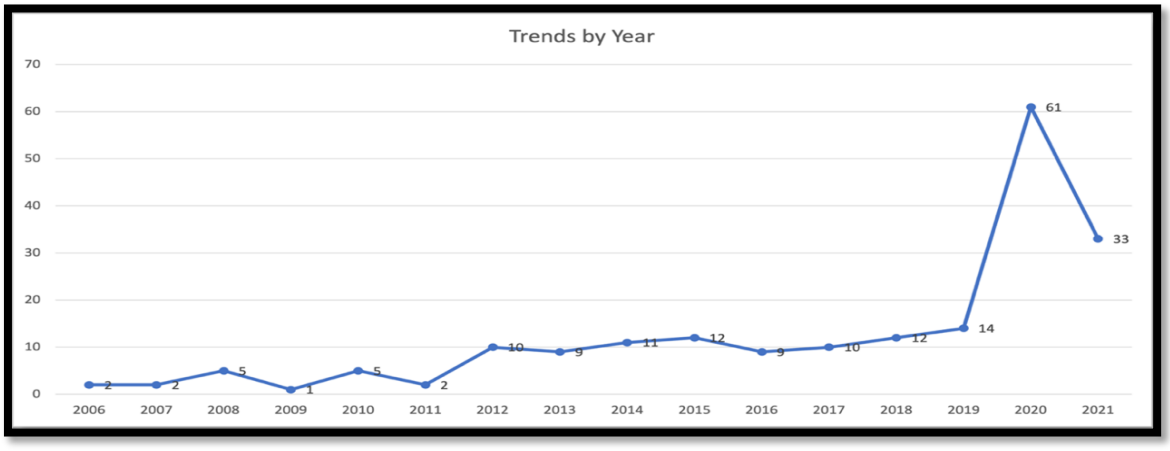


Figure 33: Studies Distribution Based on Year.

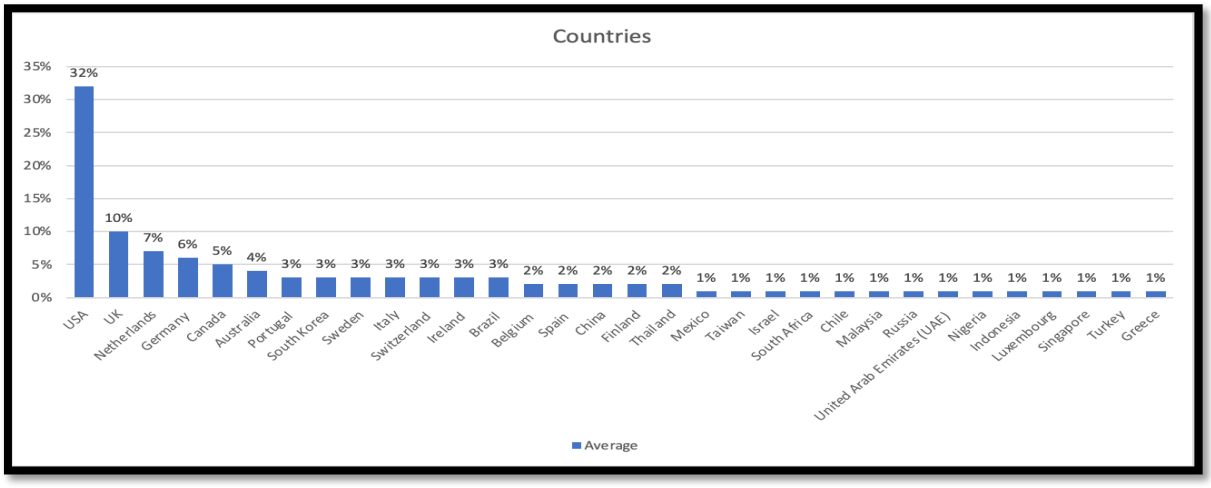


Figure 34: Studies Distribution Based on Country.

5.5.2 Persuasive Strategies and the Frequency of Use

The most frequently and commonly employed persuasive strategies in the reviewed articles are displayed in Figure 35. Our findings show that the tracking/self-monitoring strategy was employed in 192 articles reviewed (97%). The second most employed persuasive strategy was the goal-setting strategy with 90 studies (45%). This is followed by the reminder strategy, reward strategy, and personalization strategy, with a total of 87 studies (44%), 82 studies (41%), and 77 studies (39%),

respectively. A praise strategy ranked sixth with 61 studies (31%), followed by a tailoring strategy, reduction strategy, and tunnelling strategy, with a total of 47 studies (24%), 46 studies (23%), and 43 studies (22%), respectively. A social competition strategy is in the tenth position with 37 studies (19%), followed by a suggestion strategy with 35 studies (18%). Figure 35 also shows that the least employed persuasive strategies are the real-world feel strategy with 4 studies (2%), similarity strategy and social facilitation strategy with 2 studies (1%) for each, and rehearsal strategy with one study (1%).

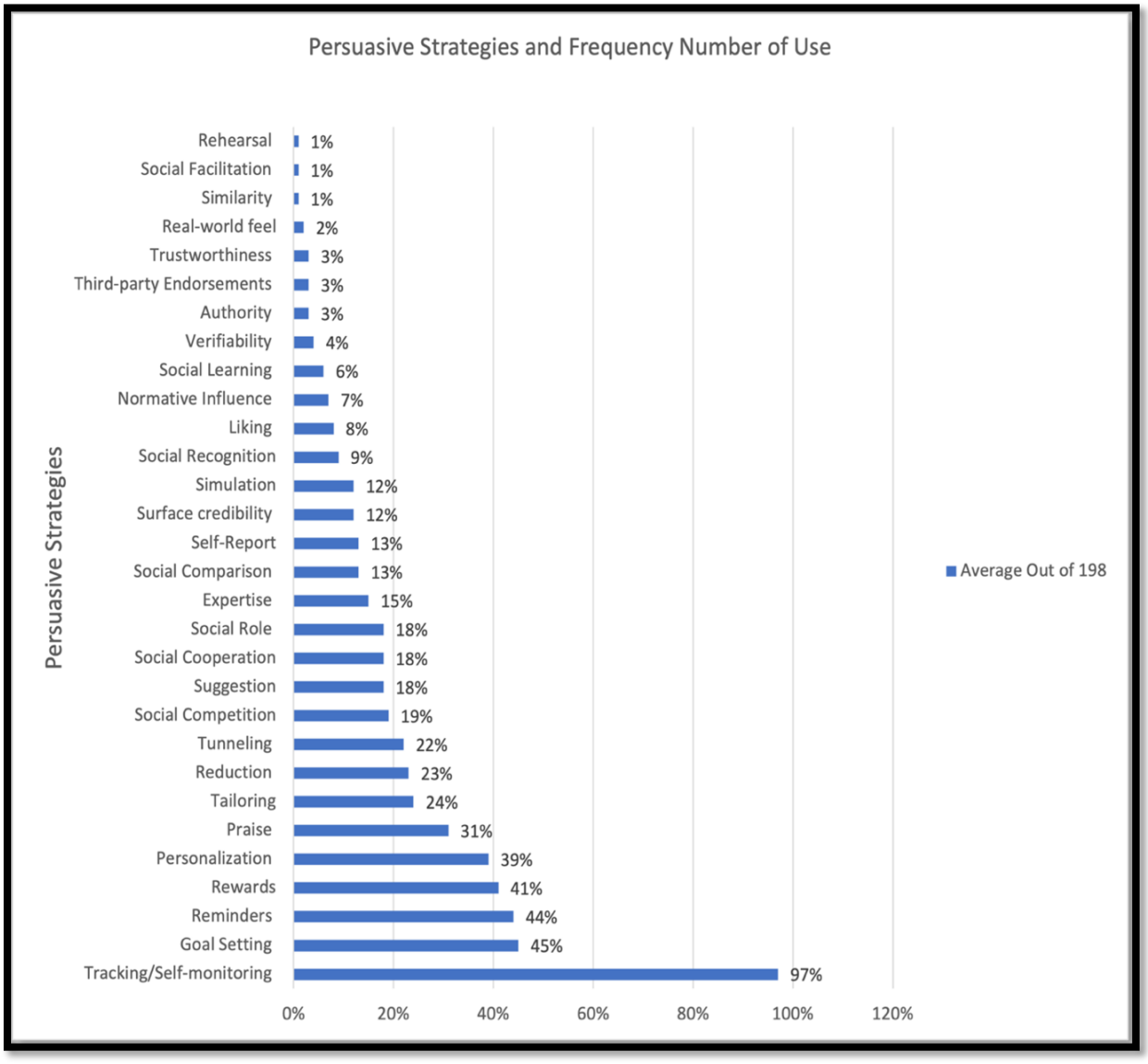


Figure 35: Persuasive Strategies and their Average of Use.

5.5.3 Persuasive Strategies and Their Implementations

In the following sub-sections, I provide a detailed description of the twelve most common persuasive strategies used in the domain of PA, as identified in the reviewed articles. These strategies are self-monitoring, goal-setting, reminders, rewards, personalization, praise, tailoring, reduction, tunneling, social competition, suggestion, and social cooperation, and explanations of how they are implemented in the reviewed articles are provided. Additionally, I present the frequency of implementation for each persuasive strategy.

5.5.3.1 Self-Monitoring Strategy

Figure 35 shows the employment of a self-monitoring strategy in the mobile-based PT interventions in the reviewed articles. The self-monitoring strategy was applied in 192 articles (97%). I think this is due to the importance of tracking a user's PA performance, monitoring the time spent sedentary and the PA levels and progress towards their target behavior goal. Thus, I found that the dominant factors in inspiring users in maintaining or increasing their PA levels were providing them with precise feedback, measurements (e.g., step counts, duration of walking, progress towards goals, calories burned), and notifications of their activities and sedentariness through the use of activity tracker devices and software [9].

The self-monitoring strategy in the mobile-based PT interventions was implemented in many ways. Figure 36 shows the various ways the self-monitoring strategy was implemented in the PA and SB area, along with the most and least frequent forms of implementation. Figure 37 shows more details and examples of the different ways of implementing the self-monitoring strategy.

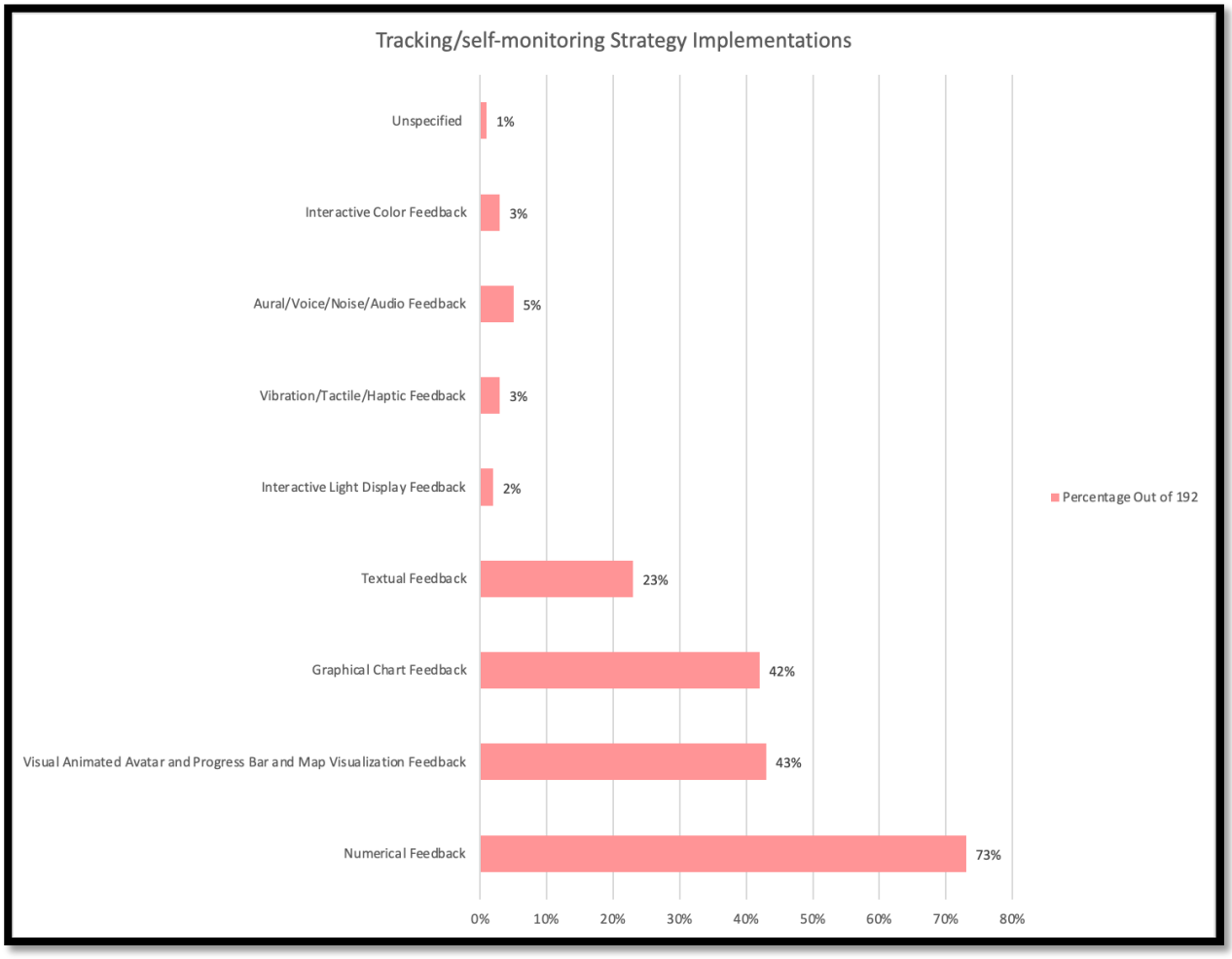


Figure 36: Self-monitoring Implementations in the Reviewed Articles.

The self-monitoring strategy implementations are as follows:

- **Numerical Feedback:**

  Numerical feedback is shown when a system or an application provides and displays numerical measurements of the user's performance, such as step counts, heart rate, calories burned, distance, or speed. For example, the step count is shown as 7543 steps, while the calories burned is displayed as 69.6 kcal as numerical feedback examples. I found that the most frequently employed form of a self-monitoring strategy is numerical feedback with 140 studies (73%) of the 192 articles that employed a self-monitoring strategy.

- **Visual Feedback (Visually Animated Avatar, Progress Bar, and Map Visualization Feedback):**

The visual feedback of a self-monitoring strategy in the reviewed articles came in different forms, including visually animated avatars or animated characters, progress bars, and maps or paths or locations visualization. The visual feedback implementation ranked as the second most frequent form of self-monitoring strategy employed with 82 studies (43%).

- **Graphical Chart Feedback:**
  Graphical chart feedback is the third most employed form of self-monitoring strategy with 80 studies (42%). The examples of graphical feedback include bar chats, line charts, and pie or circle charts.

- **Textual Feedback:**
  Textual feedback refers to when a system provides feedback to users in a text format, whether it includes numbers or not, such as text messages, emails, and textual notifications. In the self-monitoring strategy, textual feedback delivers a text to users that reflects their PA progress and sometimes provides a textual summary of their overall performance. Textual feedback came in fourth place as the most frequently employed form of self-monitoring strategy in the domain of PA and SD with 44 studies (23%).

- **Aural, Voice, Noise, or Audio Feedback:**
  The fifth most common form of self-monitoring strategy implementation is aural, voice, noise, or audio feedback with nine studies (5%).

- **Vibration, Tactile, or Haptic Feedback:**
  Vibration, tactile, or haptic feedback also ranked as the sixth most common form of self-monitoring strategy implementation with six studies (3%).

- **Interactive Color Feedback:**
  Interactive color feedback is one form of providing self-monitoring and tracking to the user that reflects their PA and SB performance by displaying different colors that match their level of activity. Interactive color feedback also ranked as the sixth most common form of self-monitoring strategy implementation with six studies (3%).

- **Interactive Light Display Feedback:**

Interactive light display feedback provides different ambient light intensities and colors to reflect users' PA and SB performance. This type of self-monitoring strategy ranked as the seventh most common form of implementation with four studies (2%).

- **Unspecified:**
  Only one study (1%) did not specify the form of implementation of their self-monitoring strategy.

Figure 37 shows more details and examples of the different ways of implementing self-monitoring strategies. It shows the frequency of each type of self-monitoring strategy implementation in the reviewed articles. It is worth mentioning that most of the articles included employ more than one type of self-monitoring strategy (e.g., numerical feedback and visual feedback). Thus, I present each implementation example separately regardless of any other type of self-monitoring implementation. The self-monitoring implementation examples are as follows:

- **Numerical Feedback:**
  The most frequently employed type of self-monitoring strategy is numerical feedback with 140 studies (73%). Here, I just include the articles that present numerical feedback separately from textual feedback; therefore, I excluded any study that employed numerical feedback in a textual format such as text messages or textual notifications.
- **Bar Charts:**
  The second most employed type of self-monitoring strategy is bar charts with 50 studies (26%).
- **Textual Feedback:**
  The third most frequently employed type of self-monitoring strategy is textual feedback with 44 studies (23%).
- **Line Charts:**
  Line charts came in fourth place as the most frequently employed type of self-monitoring strategy with 31 studies (16%).
- **Progress Bars:**

Progress bars came in fifth place as the most frequently employed type of self-monitoring strategy with 30 studies (16%).

- **Avatars/Animated Characters:**
  Avatars or animated characters ranked as the sixth most frequently employed type of self-monitoring strategy with 29 studies (15%).
- **Pie Charts:**
  Pie charts came in seventh place as the most frequently employed type of self-monitoring strategy with 26 studies (14%).
- **Metaphors and Other Image Visualization:**
  The eighth most frequently employed type of self-monitoring strategy is metaphors and other image visualization with 22 studies (11%). Metaphors came in different forms including an aquarium, garden, gym, city town, and other gamified feedback. Other forms of image visualization included the display of gardens, flowers, butterflies, fuel, bubbles, balloons, calendars, etc.
- **Maps, Paths, Location Visualization:**
  The ninth most commonly employed type of self-monitoring strategy is a map, path, or location visualization with 15 studies (8%).
- **Voice, Aural, or Audio Feedback:**
  Voice, aural, or audio feedback took tenth place as the most frequently employed type of self-monitoring strategy with eight studies (4%).
- **Vibration or Tactile Feedback:**
  Vibration or tactile feedback took eleventh place as the most frequently employed type of self-monitoring strategy with six studies (3%).
- **Color Changing:**
  Color-changing feedback ranked eleventh as the most frequently employed type of self-monitoring strategy with six studies (3%).
- **Light Displays:**

Light displays took twelfth place as the most frequently employed type of self-monitoring strategy with four studies (2%).

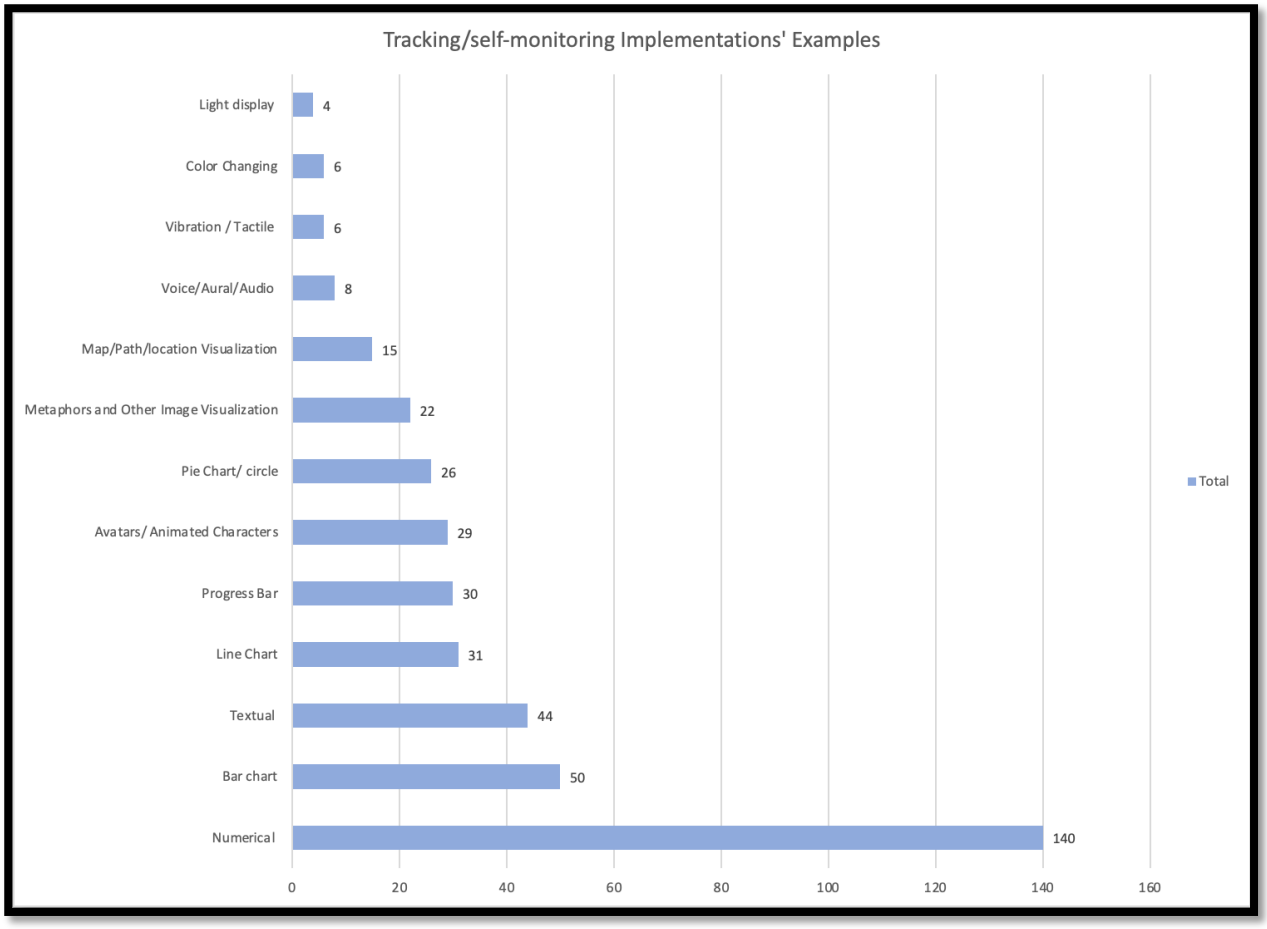


Figure 37: Self-Monitoring Strategy Implementation Examples in the Reviewed Articles.

5.5.3.2 Goal-Setting Strategy

A goal-setting strategy does not belong to the PSD model's principles or strategies; however, I included the goal-setting strategy in this review due to the importance of this persuasive strategy in persuading users to change their unhealthy behaviors such as prolonged time spent sitting and encouraging them to engage in more PA. Another reason for including a goal-setting strategy is the number of articles that employed this strategy, 90 studies (45%), which is close to half of the 198 reviewed articles. Figure 35 shows the employment of a goal-setting strategy in the mobile-based PT interventions in the reviewed articles on PA and SB.

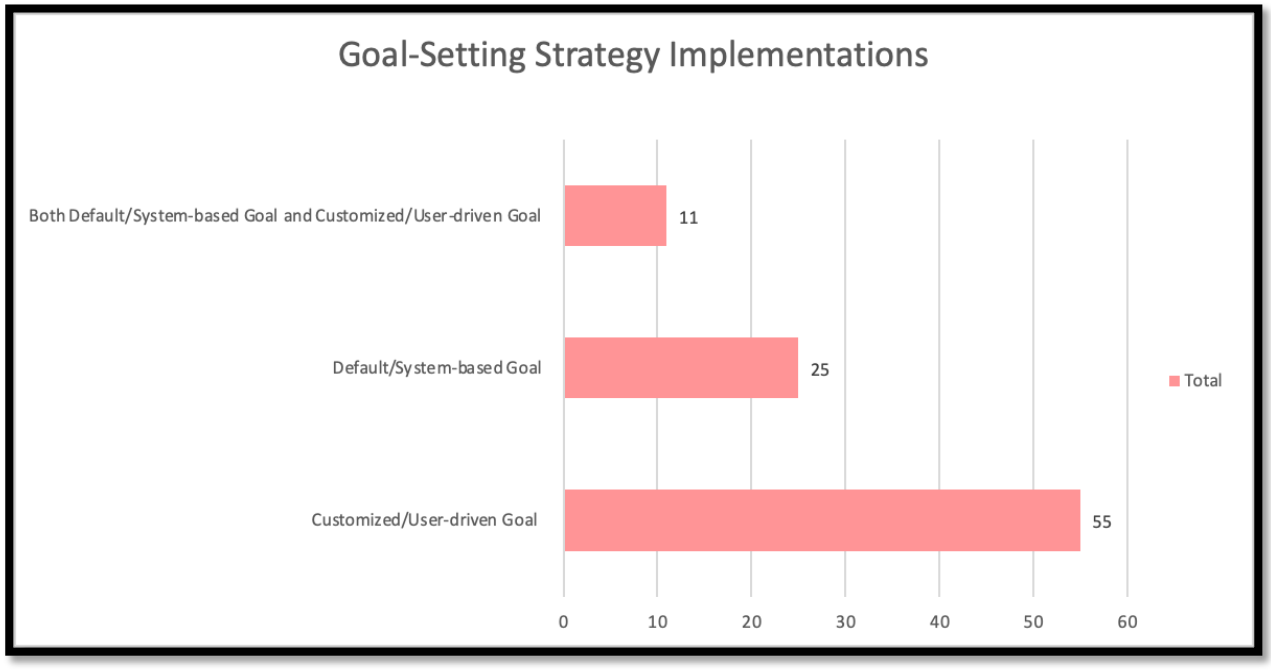


Figure 38**: Goal-Setting Strategy Implementations in the Reviewed Articles.**

Based on our findings in reviewing the mobile-based PT interventions in PA and SB, there are two types of goal-setting strategies: (1) User-driven goals, which allow the user to have control in setting their own PA goals and customize them as they prefer, and (2) default or system-based goals, which mean the system is responsible for setting suitable and automatic PA goals. Some of the reviewed articles included both types of goal-setting strategies, and other articles employed only one type.

Figure 38 shows the number of articles that employed each type of goal-setting strategy. Out of the 90 articles that employed a goal-setting strategy, customized or user-driven goal setting was employed in 55 studies (61%), default or system-based goal setting was employed in 25 studies (28%), and only 11 studies (12%) employed both types of goal-setting strategies.

5.5.3.3 Reminder Strategy

Based on our findings, a reminder strategy is considered one of the main persuasive strategies employed in mobile-based PT interventions to encourage PA and decrease SB. Figure 35 shows that a reminder strategy was employed in 87 studies (44%) of the total 198 reviewed articles.

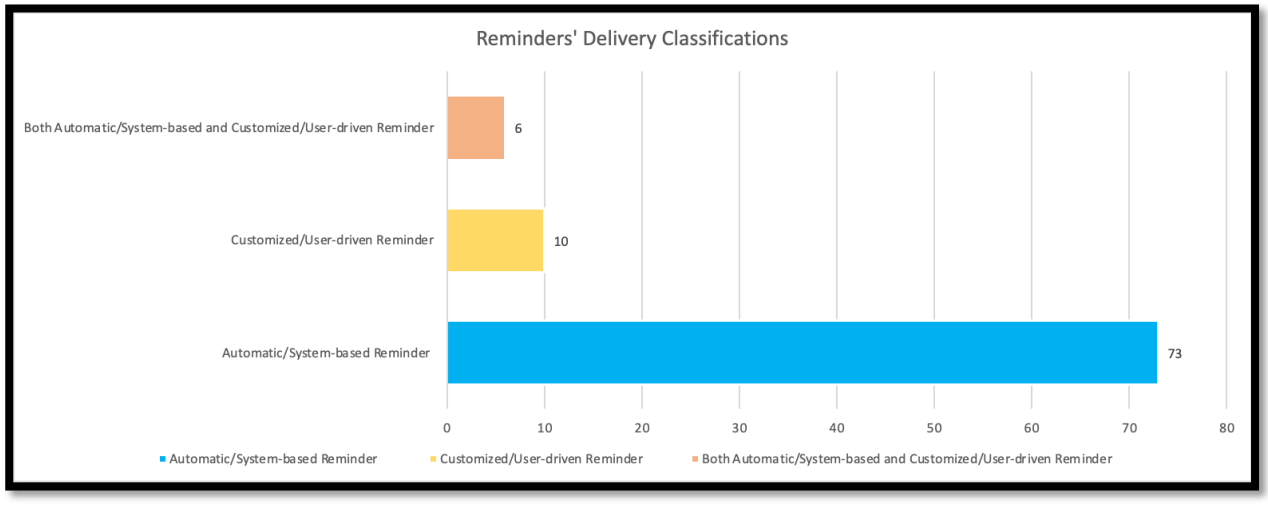


Figure 39: Reminder Strategy Delivery Classifications.

In the reviewed studies, a reminder strategy was delivered to the users of mobile-based persuasive systems in two main ways; thus, I classified the delivery of a reminder strategy as automatic or system-based reminders and customized or user-driven reminders. Automatic or system-based reminders (push reminders) are usually issued from a system to the users based on tracking of their PA performance and SB status. Thus, system-based reminders are delivered to the users randomly and are not scheduled. On the other hand, customized or user-driven reminders (pop-up reminders) are set by the users of a persuasive system according to their suitable times and availability. Figure 39 shows that out of the 87 studies that employed a reminder strategy, 73 studies (85%) employed automatic or system-based reminders, ten studies (10%) employed customized or user-driven reminders, and just six studies employed both types of reminders (system-based and user-driven).

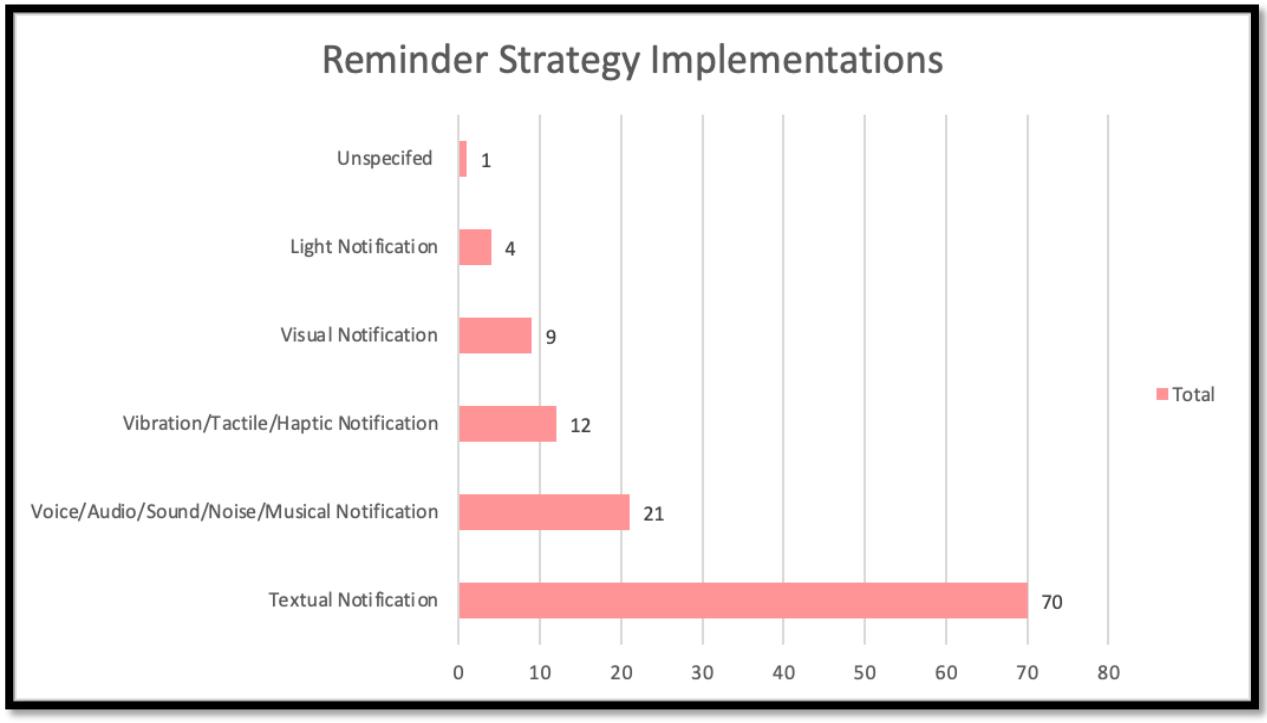


Figure 40: Reminder Strategy Implementations in the Reviewed Articles.

The reminder strategy in the mobile-based PT interventions was implemented in many ways. Figure 40 shows the various ways the reminder strategy was implemented, along with the most and least frequent forms of implementation. The reminder strategy implementations are as follows:

- **Textual Reminder Notifications:**

  The textual reminder notification was the most frequently employed form of reminder strategy implementation with 70 studies (80%) of the 87 articles that employed a reminder strategy. The textual reminder notifications include textual pop-up messages, textual automatic push notifications, textual emails, and text messages.

- **Voice Reminder Notifications (Voice, Audio, Sound, Noise, Music):**

  The voice reminder notification strategy in the reviewed articles ranked as the second most frequent form of reminder strategy implementation with 21 studies (24%).

- **Vibration Reminder Notifications (Vibration, Tactile, Haptic):**

  The vibration reminder notification strategy was the third most employed form of reminder strategy with 12 studies (14%).

- **Visual Reminder Notifications:**

The visual reminder notification strategy was the fourth most employed form of reminder strategy with only nine studies (10%). Visual reminder notifications include, for example, an interactive virtual pet or a green garden with flowers and butterflies.

- **Light Reminder Notifications:**

  The light reminder notification strategy ranked as the fifth most employed form of reminder strategy with four studies (5%). The light reminder notifications include, for instance, a flashing LED screen and a light display with different intensities.

- **Unspecified:**

  Only one study did not specify the form of reminder strategy implemented.

5.5.3.4 Reward Strategy

As mentioned in Section 5.4.2, a reward strategy was employed in 82 studies (41%) out of the 198 reviewed articles. The reward strategy in the mobile-based PT interventions was implemented in many ways. Figure 41 shows the various ways the reward strategy was implemented, along with the most and least frequent forms of implementation.

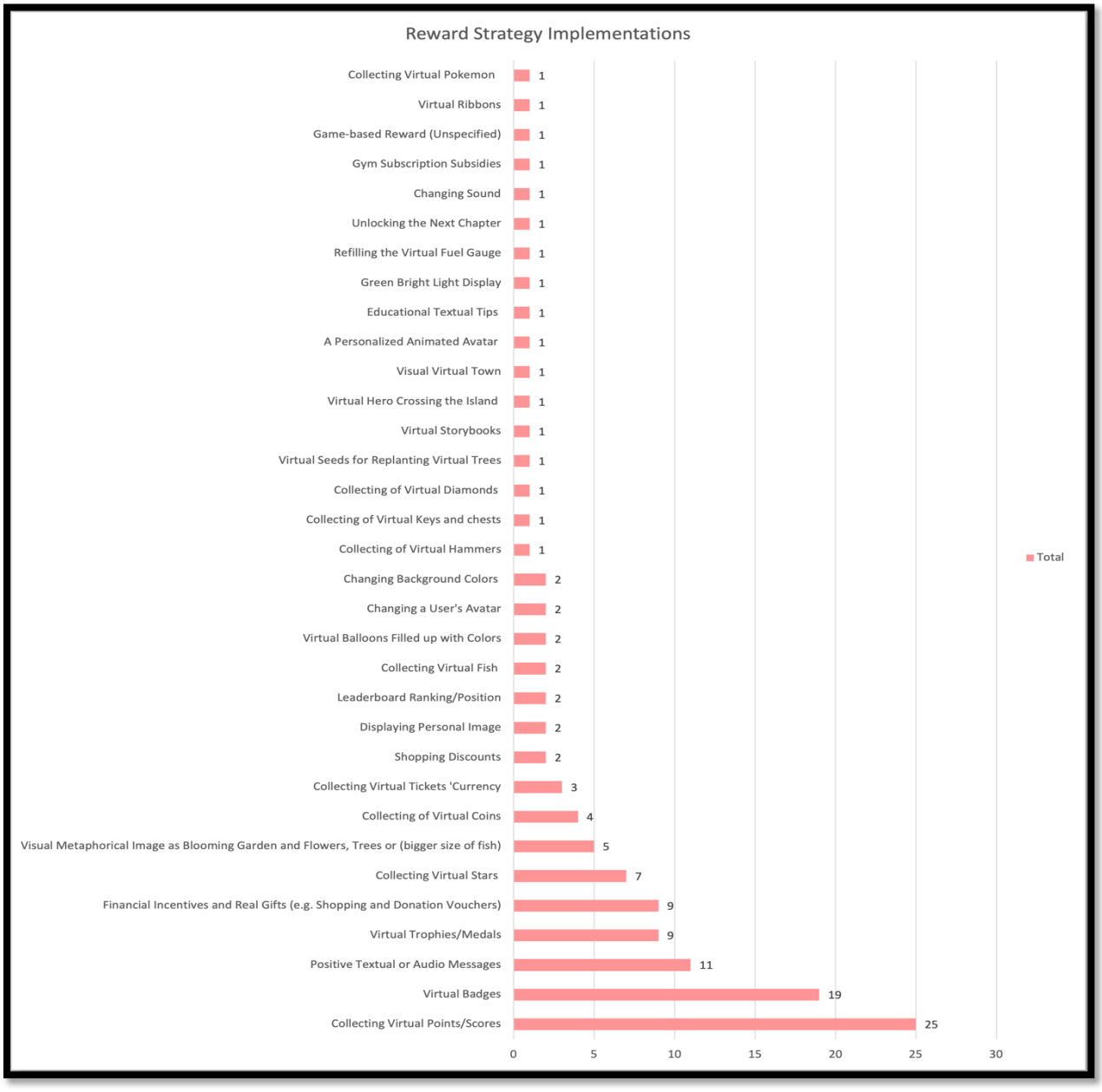


Figure 41: Reward Strategy Implementations in the Reviewed Articles.

Figure 42 shows the general classifications of reward strategy-based implementations in the mobile-based PT interventions in the reviewed articles for promoting PA and reducing SB. The most frequent form of reward strategy was the collecting of virtual objects or items not usable in the real world with 56 studies (68%) out of the 82 studies that employed a reward strategy. Providing positive textual or audio messages ranked as the second most frequent way to reward users with 11 studies (13%). The

collecting of virtual items usable in the real world (e.g., financial incentives and real gifts) also ranked as the second most frequent form of implementing a reward strategy with 11 studies (13%), followed by the displaying of vital metaphorical images with seven studies (9%), and changing a user's avatar, sound, and background colors with three studies (4%). Each reward of shopping discounts, leaderboard rankings or position, unlocking the next chapter, virtual storybooks, displaying balloons and heroes, and displaying personal images ranked as the fifth most frequent forms of implementing a reward strategy with two studies (2%) for each.

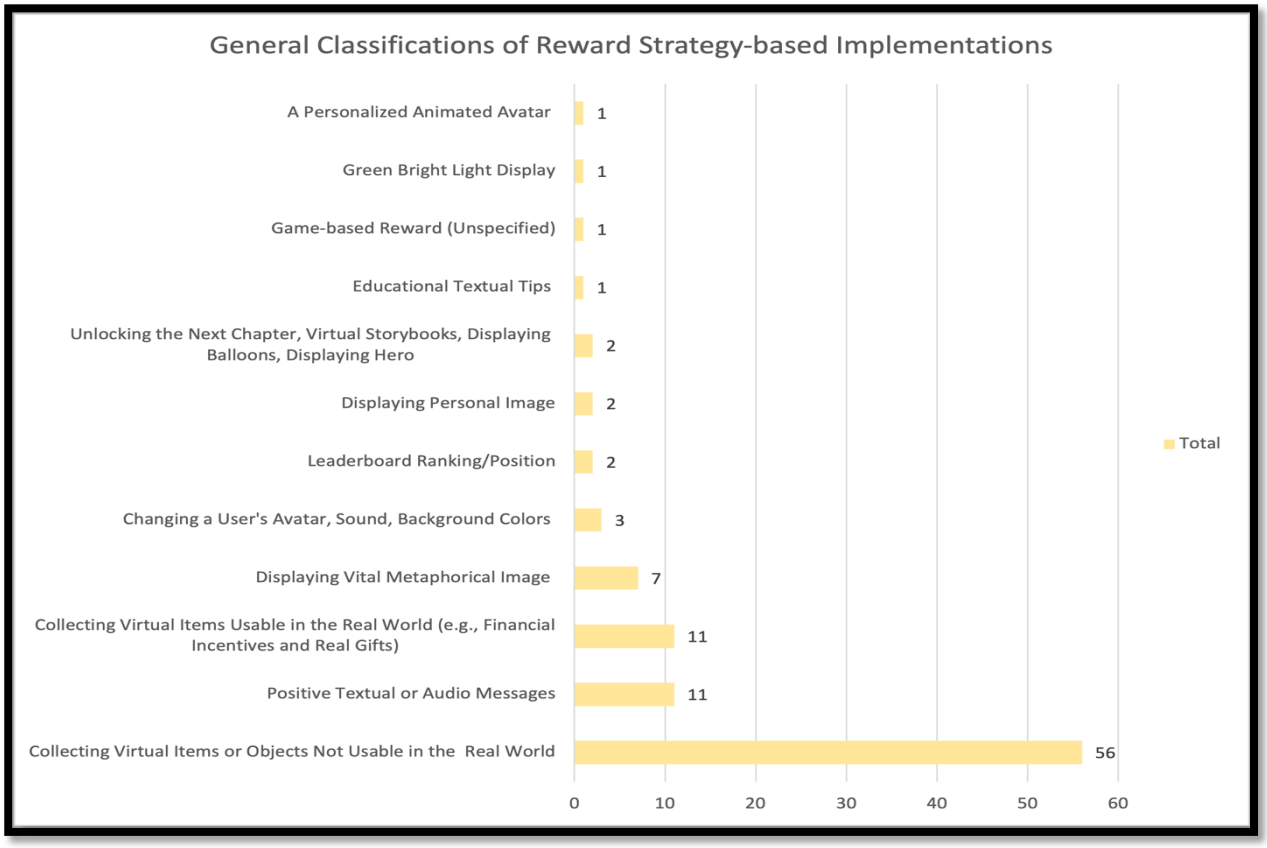


Figure 42: General Classifications of Reward Strategy-based Implementations in the Reviewed Articles.

5.5.3.5 Personalization Strategy

I adopted the same personalization classifications used by Ghanvatkar et al. [101]: personalized motivational content, personalized educational content, personalized activity recommendations, personalized goal recommendations, personalized fitness partner recommendations, and personalized intervention timing. I also noticed that some of the included articles described a customization feature

in their systems or applications. Customization is achieved when a user can modify, edit, or change something in the application or system to suit their needs, desires, or tasks (e.g., from application settings) [294]. Thus, personalization is typically a system-based feature, while customization is a user-driven feature [294]. In this section, I only included the personalization strategy regardless of the customization feature. Figure 35 shows the employment of a personalization strategy in the mobile-based PT interventions in the reviewed articles. A personalization strategy was employed in 77 articles (39%). As I mentioned previously, the fifth most commonly employed persuasive strategy in the reviewed articles is personalization. Table 4 shows the types of personalization and their meanings [101].

Table 4: Types of Personalization (adapted from [101]**).**

Type of Personalization	Meaning/Definition
Personalized Goal Recommendations	• Quantified goals such as step count, floor count, duration of exercise, or calorie burn rate.
Personalized Activity Recommendations	• Recommending a specific type of PA or behavior such as standing, walking, running, or cycling.
Personalized Fitness Partner Recommendations	• Matching a user of a system to other users who are similar and have the same target goals to motivate them to maintain or increase their PA levels.
Personalized Educational Content	• Increasing users' knowledge and awareness by sending personalized feedback about the health benefits of PA or some techniques and tips for improving PA.
Personalized Motivational Content	• Motivating users to improve their PA by sending personalized motivational feedback and reinforcement messages.
Personalized Intervention Timing	• Finding a suitable time to send recommendations or feedback to the user such as sending a notification reminder to a user at suitable times and opportune moments.

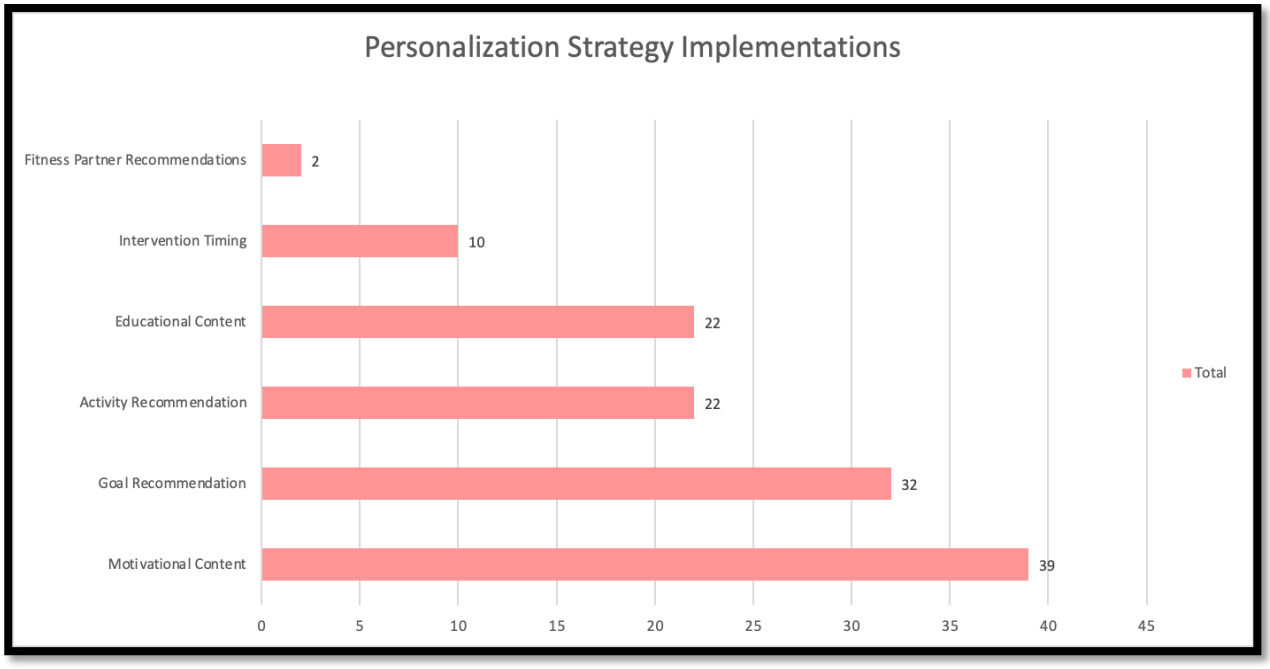


Figure 43: Personalization Strategy Implementations in the Reviewed Articles.

The personalized goal recommendations may look closely related to the system-based goals' implementation of the goal-setting strategy (Section 5.4.4.2). However, the two concepts are different in that the system-based goal indicates that the system is responsible for setting suitable PA goals for the user. On the other hand, personalized goal recommendation means providing personalized goal recommendations (e.g., 30 mins of walking) based on the user's PA performance to achieve the desired goal, which is either set by the system or the user. The difference is that system-based goals focus on setting suitable goals in a predefined or automatic way while taking the user's ability into consideration, while personalized goal recommendations focus on providing recommendations to achieve the already-set goal according to the user's PA progress (e.g., walk for 30 mins to work instead of driving to achieve your step count goal). Thus, a user's permission is needed to accept or reject a suggested personalized goal recommendation.

Figure 43 shows personalization strategy implementations in mobile-based PT interventions in the PA and SB area. The figure displays the most and least frequent forms of implementation. The most commonly employed form of personalization strategy in the reviewed articles is personalized

motivational content with 39 studies (51%) out of 77 articles that employed a personalization strategy. Personalized goal recommendations ranked as the second most frequently employed form of personalization strategy with 32 studies (42%). Personalized activity recommendations and personalized educational content came in third place, with 22 studies (29%) for each. Personalized intervention timing ranked as the fourth most frequently employed personalization strategy with ten studies (13%). The least frequently employed form of personalization strategy was personalized fitness partner recommendations with only two studies (3%).

5.5.3.6 Praise Strategy

A praise strategy is one of the essential persuasive strategies used to motivate users to engage more in PA. Praise or compliments can be offered to users in different formats such as symbols, words, images, and sounds [123]. Figure 35 shows that a praise strategy was employed in 61 studies (31%) of the 198 reviewed articles.

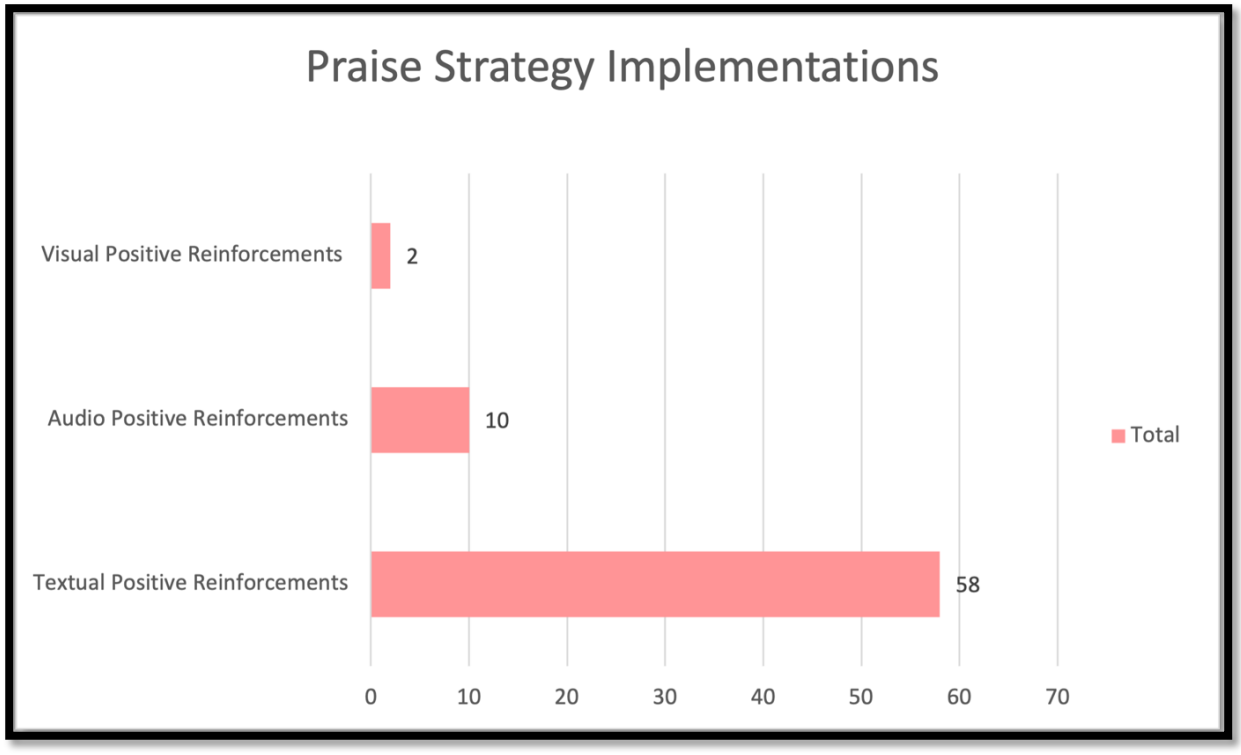


Figure 44: Praise Strategy Implementations in the Reviewed Articles.

A praise strategy in the mobile-based PT interventions was implemented in many ways. Figure 44 shows the various ways a praise strategy was implemented in the PA and SB area along with a display

of the most and least frequent forms of implementation. The praise strategy implementations are as follows:

- **Textual Positive Reinforcements:**

  The textual positive reinforcements were the most frequently employed form of praise strategy with 58 studies (95%) of 61 articles that employed a praise strategy. The textual positive reinforcements included textual pop-up messages, textual push messages, and text messages.

- **Audio Positive Reinforcements:**

  The implementation of positive audio reinforcements as a praise strategy in the reviewed articles ranked as the second most frequent form of praise strategy implementation with ten studies (16%).

- **Visual Positive Reinforcements:**

  Positive visual reinforcement ranked third, and it was the least employed form of praise strategy implementation with only two studies (3%) of 61 studies that employed a praise strategy in their PT system designs.

5.5.3.7 Tailoring Strategy

Figure 35 shows that a tailoring strategy was employed in 47 studies (24%) of 198 reviewed articles. Tailoring and personalization strategies are both concerned with acknowledging the differences between users. The main difference is that tailoring is applied at a group level (e.g., adapting the system to different groups of users such as people of the same age, gender, personality type, and health condition), while personalization is at the individual level.

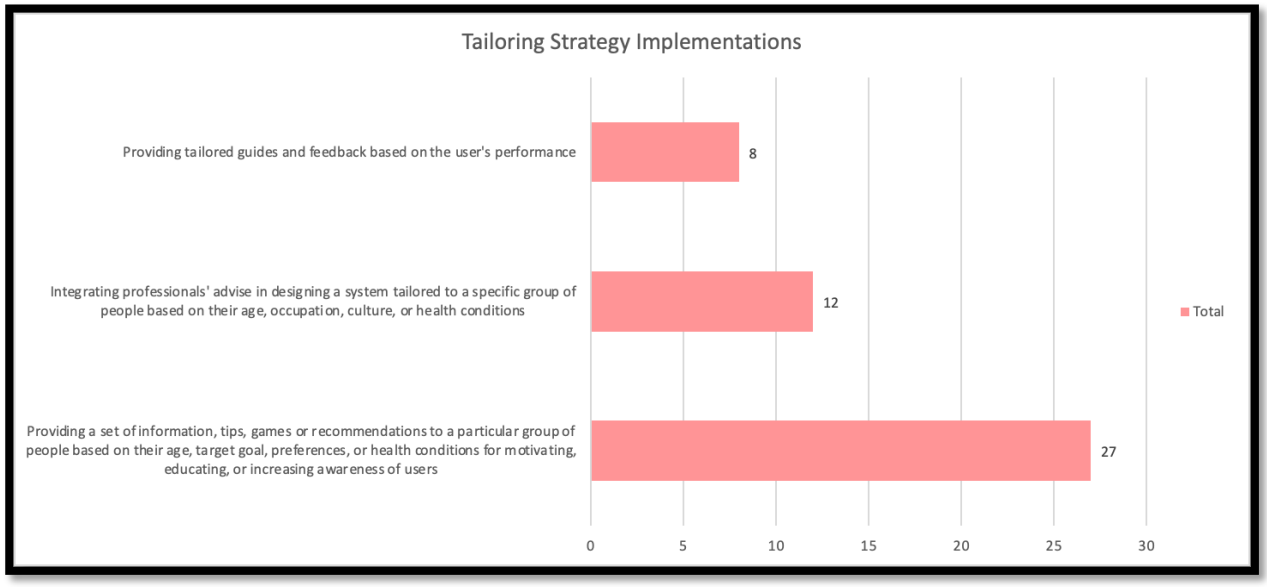


Figure 45: Tailoring Strategy Implementations in the Reviewed Articles.

The tailoring strategy in the mobile-based PT interventions was implemented in many ways. Figure 45 shows the various ways the tailoring strategy was implemented, along with the most and least frequent forms of implementation. The tailoring strategy implementations are as follows:

- **Providing a Set of Information, Tips, Games or Recommendations to a Particular Group of People Based on Their Age, Target Goal, Preferences, or Health Conditions for Motivating, Educating, or Increasing the Awareness of Users:**

  Of 47 studies that employed a tailoring strategy, twenty-seven studies (57%) employed this form of tailoring strategy implementation. This implementation is considered the most frequent way used to employ a tailoring strategy.

- **Integrating Professionals' Advice in Designing a System Tailored to a Specific Group of People Based on Their Age, Occupation, Culture, or Health Conditions:**

  This implementation is considered the second most frequently employed form of tailoring strategy in the reviewed studies with 12 studies (26%).

- **Providing Tailored Guides and Feedback Based on the User's Performance:**

  This implementation of a tailoring strategy is the least employed, with eight studies (17%) of 47 studies that employed a tailoring strategy.

5.5.3.8 Reduction Strategy

To incorporate a reduction strategy into a persuasive system, the system has to reduce the efforts and burdens that users may experience when using the system and performing their target behaviors. Figure 35 shows the employment of a reduction strategy in the mobile-based PT interventions in the reviewed articles. The reduction strategy was applied in 46 studies (23%) of the 198 articles included in our review study.

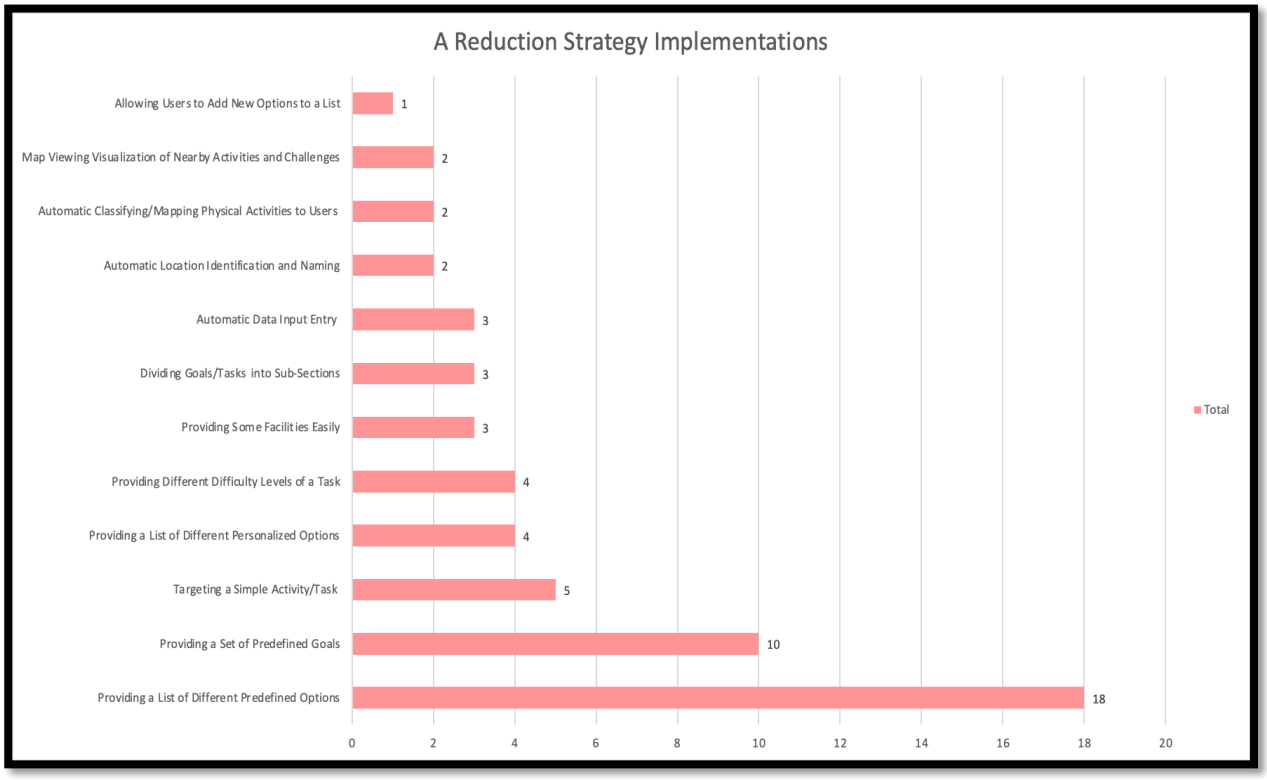


Figure 46: Reduction Strategy Implementations in the Reviewed Articles.

Reduction strategies in the mobile-based PT interventions were implemented in many ways. Figure 46 shows the various ways reduction strategies were implemented, along with the most and least frequent forms of implementation. The following shows the reduction strategy implementations (in order from the most frequently employed implementations on the top to the least frequently employed on the bottom):

- **Providing a List of Different Predefined Options, Choices or Suggestions:**

Out of the 46 studies that employed a reduction strategy, 18 studies (39%) implemented a reduction strategy by providing a list of different predefined options to users. Thus, this form of reduction implementation was the most frequently employed in the reviewed studies.

- **Providing a Set of Predefined Goals, Plans, or Programs:**

  Providing a set of predefined goals or plans or programs to reduce a user's effort in creating a new plan for their PA goals ranked as the second most common form of reduction strategy implemented with ten studies (22%) out of the 46 studies that employed a reduction strategy.

- **Targeting a Simple Activity or Task:**

  Targeting a simple activity or task ranked as the third most employed form of reduction strategy with five studies (11%).

- **Providing a List of Different Personalized Options, Choices or Suggestions:**

  Providing a list of different personalized options also placed as the fourth most common way of implementing a reduction strategy with four studies (9%).

- **Providing Different Difficulty Levels of a Task:**

  Providing different difficulty levels of a task ranked as the fourth most common way of implementing a reduction strategy with four studies (9%).

- **Easily Providing Some Facilities:**

  Easily providing some facilities ranked as the fifth most common way of implementing a reduction strategy with three studies (7%).

- **Dividing Goals or Tasks into Sub-sections:**

  Dividing goals or tasks into sub-sections also ranked as the fifth most frequent way of implementing a reduction strategy with three studies (7%).

- **Automatic Data Input Entry:**

Automatic data input entry also ranked as the fifth most frequent way of implementing a reduction strategy with three studies (7%).

- **Automatic Location Identification and Naming:**

  Two (4%) of the reviewed studies employed a reduction strategy by providing automatic location identification and naming to users, which ranked sixth.

- **Automatic Classifying and Mapping of Physical Activities to Users:**

  The automatic classifying and mapping of physical activities to users also ranked as the sixth most common way of implementing a reduction strategy with two studies (4%).

- **Map-Viewing Visualization of Nearby Activities and Challenges:**

  The map-viewing visualization of nearby activities and challenges ranked as the sixth most common way of implementing a reduction strategy with two studies (4%).

- **Allowing Users to Add New Options to a List:**

  Allowing users to add new options to a list ranked as the sixth and the least common way of implementing a reduction strategy in the reviewed studies with only one study (2%).

5.5.3.9 Tunneling Strategy

Figure 35 shows that a tunneling strategy was employed in 43 studies (22%) of the 198 reviewed articles. The tunneling strategy in the mobile-based PT interventions was implemented in many ways. Figure 47 shows the various ways the tunneling strategy was implemented in the PA and SB area, along with the most and least frequent forms of implementation.

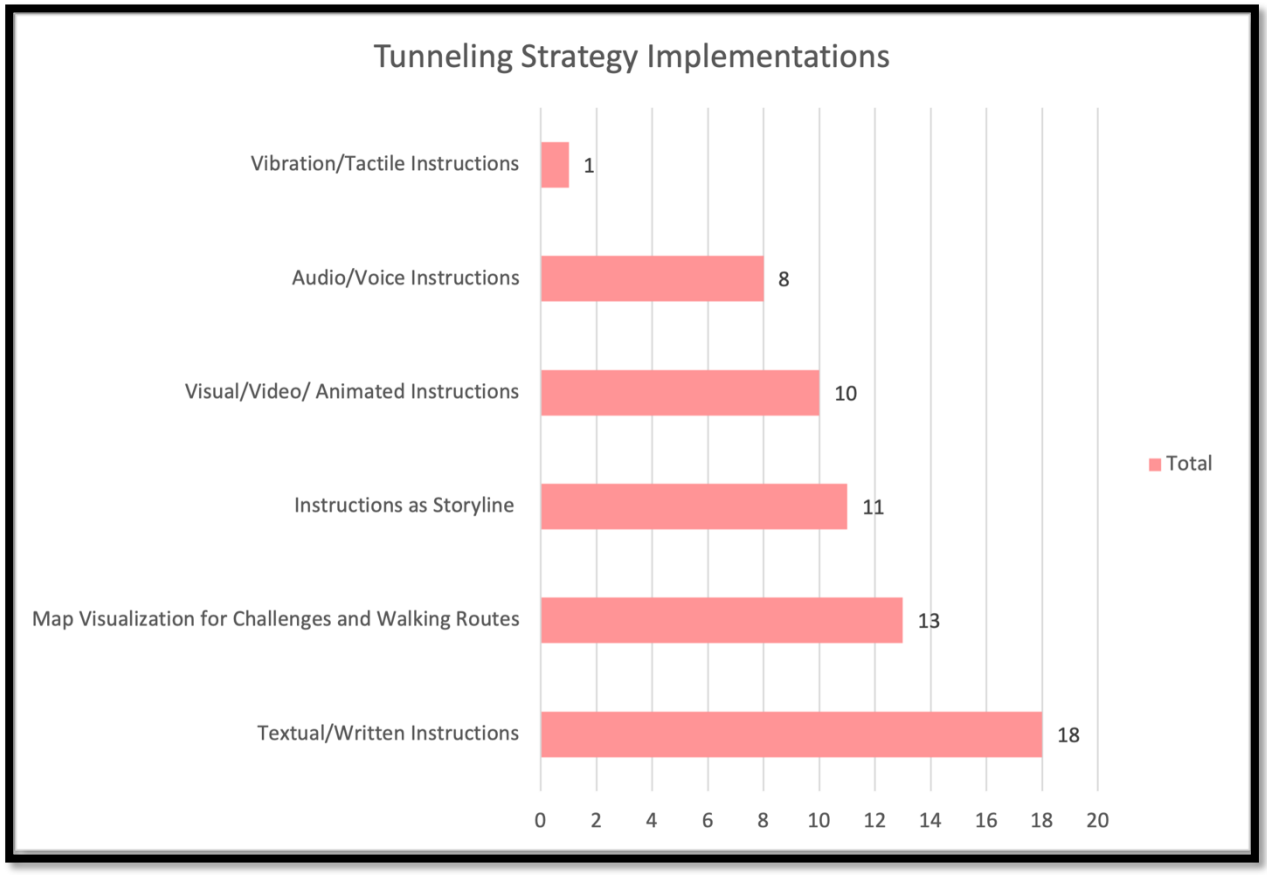


Figure 47: Tunneling Strategy Implementations in the Reviewed Articles.

The tunneling strategy implementations are as follows:

- **Textual or Written Instructions:**

  The textual or written instructions were the most frequently employed form of tunneling strategy with 18 studies (42%) out of 43 articles that employed a tunneling strategy.

- **Map Visualization for Challenges and Walking Routes:**

  Implementing a map visualization for challenges and walking routes as a tunneling strategy in the reviewed articles ranked as the second most common tunneling strategy implementations with 13 studies (30%).

- **Instructions as Storylines:**

Providing instructions as storylines came in third place out of the most common ways of implementing a tunneling strategy with 11 studies (26%).

- **Visual, Video or Animated Instructions:**

  Visual, video or animated instructions ranked as the fourth most frequently employed form of tunneling strategy with ten studies (23%) of 43 studies that employed a tunneling strategy.

- **Audio or Voice Instructions:**

  Implementing audio or voice instructions as a tunneling strategy in the reviewed studies ranked fifth with eight studies (19%) of 43 studies that employed a tunneling strategy.

- **Vibration or Tactile Instructions:**

  Only one study (2%) implemented vibration or tactile instructions as a tunneling strategy in the reviewed articles.

5.5.3.10 Social Competition Strategy

The social competition strategy is one of the most important persuasive strategies employed to motivate users to adopt a target PA behavior. Figure 35 shows that 37 studies (19%) of the 198 reviewed articles employed a social competition strategy.

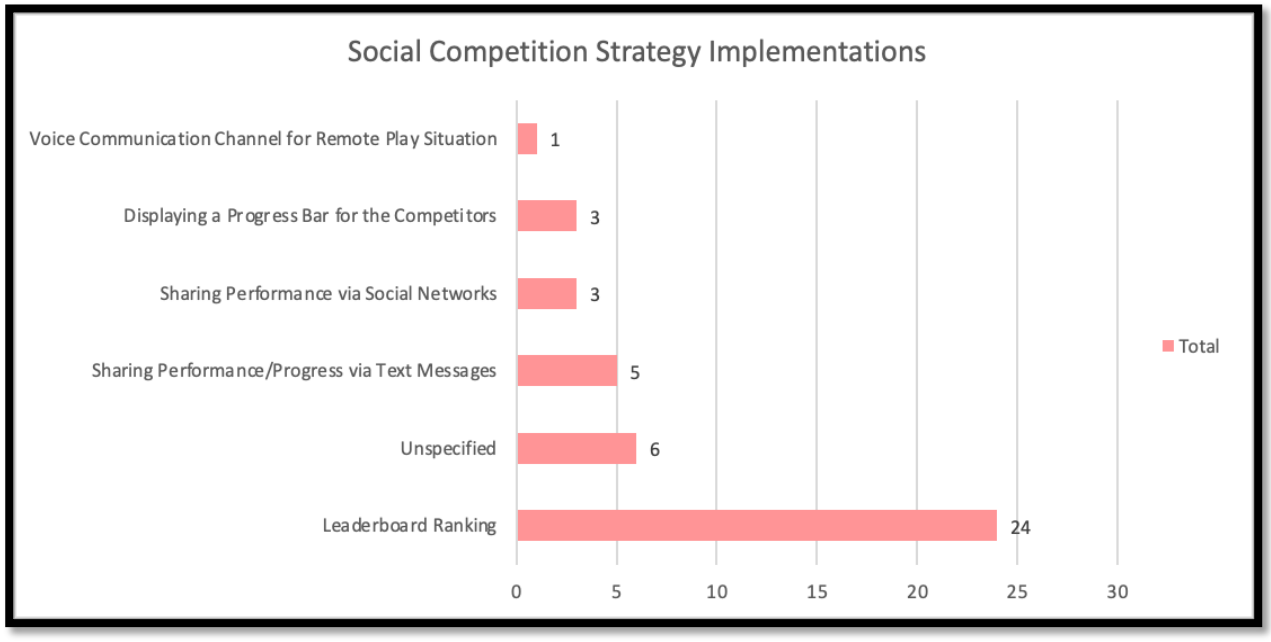


Figure 48: Social Competition Strategy Implementations in the Reviewed Articles.

The social competition strategy in the mobile-based PT interventions was implemented in many ways. Figure 48 shows the various ways the social competition strategy was implemented in the PA and SB area, along with the most and least frequent forms of implementation. The social competition strategy implementations are as follows:

- **Leaderboard Ranking:**

  A leaderboard ranking was the most employed form of social competition strategy implementation with 24 studies (65%) of the 37 articles that employed a social competition strategy.

- **Unspecified:**

  Six studies (16%) out of 37 studies that employed a social competition strategy did not specify their ways of implementing a social competition strategy.

- **Sharing Performance or Progress via Text Messages:**

  Five studies (14%) considered sharing PA performance or progress via text messages as a way of employing a social competition strategy. This consideration is not completely accurate because sharing PA performance or progress with other people can be considered

as a social learning strategy or social comparison strategy, not as a social competition strategy; however, according to the authors' point of view in the reviewed articles, I present sharing performance or progress in the social competition strategy.

- **Sharing Performance via Social Networks:**

  Three studies (8%) classified the sharing of PA performance or progress via social networks as a social competition strategy. As mentioned previously, this classification is not very accurate, but I still present it based on the research's classification in the included reviewed articles.

- **Displaying a Progress Bar for Competitors:**

  Displaying a progress bar for competitors ranked as the fourth most frequently employed form of a social competition strategy with three studies (8%).

- **Voice Communication Channel for Remote Play Situations:**

  Implementing a voice communication channel for remote play situations to provide a social competition strategy was employed only once (3%).

5.5.3.11 Suggestion Strategy

Figure 35 shows that a suggestion strategy was employed in 35 studies (18%) of the 198 reviewed articles. The suggestion strategy in the mobile-based PT interventions was implemented in many ways. Figure 49 shows the various ways the suggestion strategy was implemented, along with the most and least frequent forms of implementation.

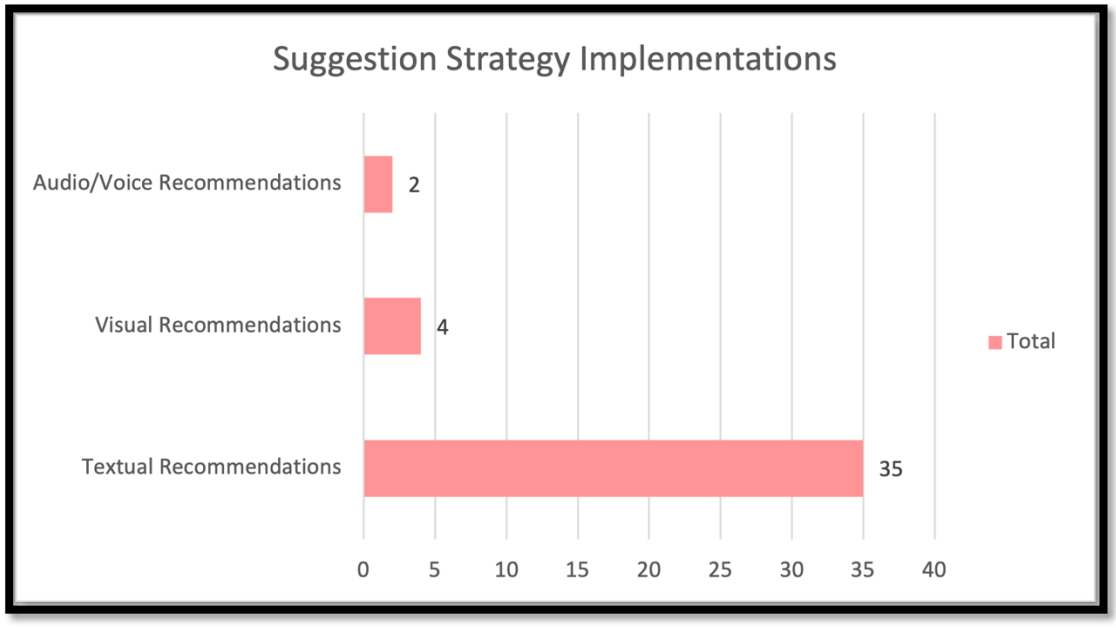


Figure 49: Suggestion Strategy Implementations in the Reviewed Articles.

The suggestion strategy implementations are as follows:

- **Textual Recommendations:**

  The textual recommendations were the most employed form of suggestion strategy with 35 studies (100%) out of 35 articles that employed a suggestion strategy. The textual recommendations include text messages, textual pop-up notifications, textual push notifications, etc.

- **Visual Recommendations:**

  Implementing visual recommendations as a suggestion strategy in the reviewed articles ranked as the second most frequent form of suggestion strategy implementation with four studies (11%).

- **Audio or Voice Recommendations:**

  Audio or voice recommendations ranked third. It was the least employed form of suggestion strategy with only two studies (6%) of 35 studies that employed a suggestion strategy in their PT system designs.

5.5.3.12 Social Cooperation Strategy

Figure 35 shows the employment of a social cooperation strategy in the mobile-based PT interventions in the reviewed articles. The social cooperation strategy was employed in 36 studies (18%) of the 198 articles included in our review study to promote PA and reduce SB.

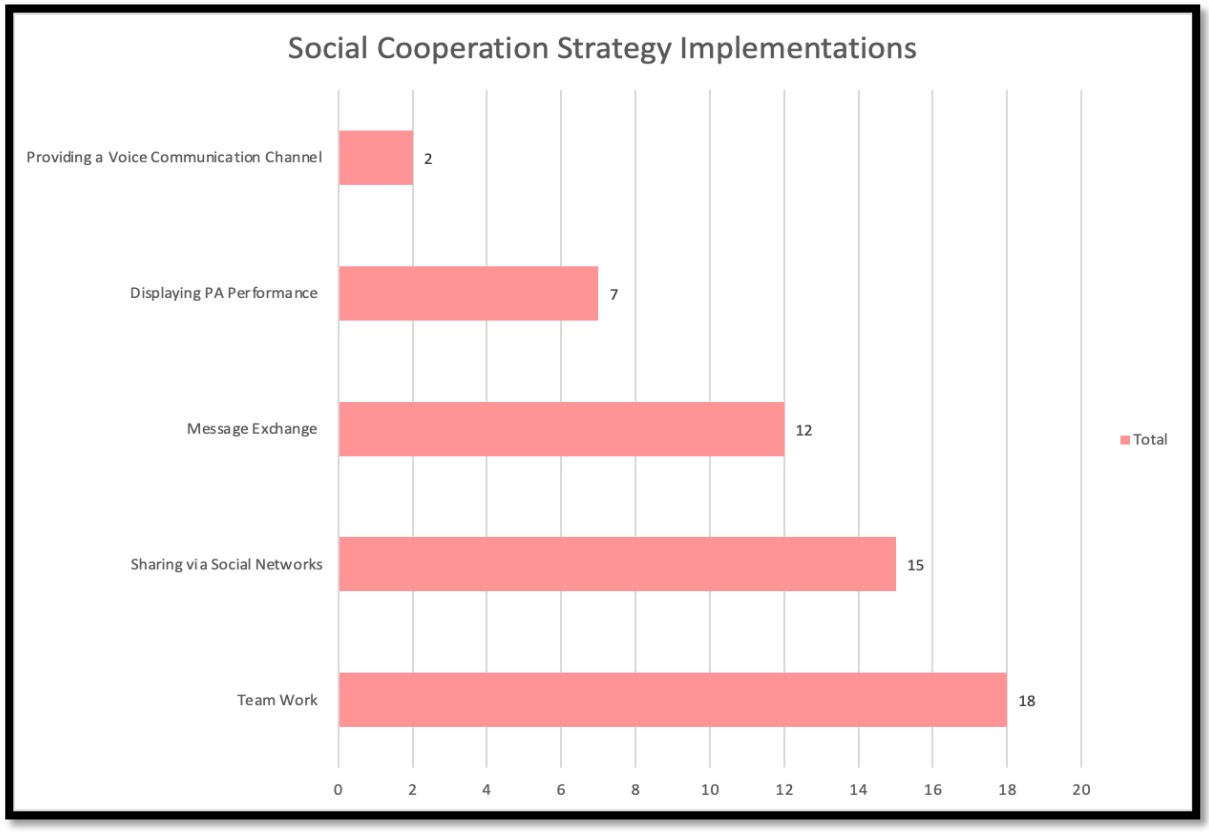


Figure 50: Social Cooperation Strategy Implementations in the Reviewed Articles.

The social cooperation strategy in the mobile-based PT interventions was implemented in many ways. Figure 50 shows the various ways the social cooperation strategy was implemented in the PA and SB area, along with the most and least frequent forms of implementation. The social cooperation strategy implementations are as follows:

- **Teamwork:**

  Teamwork or working together as a team was the most frequently employed form of social cooperation strategy with 18 studies (50%) of 36 studies that employed a social cooperation strategy.

- **Sharing via Social Networks:**

Sharing PA performance and progress via social networks was the second most frequently employed form of social cooperation strategy with 15 studies (42%) out of 36 articles that employed a social cooperation strategy.

- **Message Exchange:**

  The implementation of message exchange for encouraging feedback, chatting, comments, or planning for contributing to a fitness exercise as a social cooperation strategy in the reviewed articles ranked as the third most common social cooperation strategy implementation with 12 studies (33%).

- **Displaying PA Performance:**

  Displaying PA performance and progress ranked as the fourth most frequently employed form of social cooperation strategy with seven studies (19%) of 36 studies that employed a social cooperation strategy.

- **Providing a Voice Communication Channel**

  Implementing a voice communication channel as a social cooperation strategy was the least frequently employed form of social cooperation strategy, with only two studies (6%).

5.6 Discussion

This chapter focuses on delivering a systematic review of the persuasive strategies used in mobile-based PT interventions for supporting PA and decreasing SB. This study aims to (1) investigate and provide a comparison of the different ways of implementing persuasive strategies on mobile-based PT interventions that aim to motivate users to increase their PA and reduce their time spent sedentary, (2) show the different classification-based implementations for each persuasive strategy, (3) show the weaknesses and strengths of the intervention-based strategies and implementations, (4) highlight the limitations and pitfalls of the existing research and PT interventions, and (5) give recommendations and directions for future research.

5.6.1 Persuasive Strategies and their Implementations

Our findings (presented in Section 5.4.3) show that the ten most frequently employed persuasive strategies on mobile-based PTs for PA and SB domains, ordered from the most to the least frequently

employed, were tracking/self-monitoring, goal-setting, reminders, rewards, personalization, praise, tailoring, reduction, tunneling, and social competition. On the other hand, the least frequently used strategy is rehearsal, followed by social facilitation and similarity. Figure 35 summarizes these results. In regard to the implementation of each persuasive strategy, most of the reviewed studies employed more than one strategy in their mobile-based PT designs to realize the targeted PA behavioral change goal. Each strategy is implemented in multiple ways across the literature. For example, the cooperation strategy was implemented in five different ways, and the reduction strategy was implemented in 12 different ways. Section 5.4.3 shows the results regarding the different forms of implementation.

5.6.2 The Relationship Between the Persuasive Strategies Implementation Type and Effectiveness of Mobile-based Persuasive Technologies

This study sheds light on the different ways of implementing each persuasive strategy. The effectiveness of each study is often related to various factors and aspects such as the target population (e.g., age, health condition, occupation, gender, sample size), the objective of the study, domain, environment (e.g., weather, location), technology platforms, and persuasive strategies employed. It is not easy to accurately state and measure the effectiveness of each persuasive strategy and its implementation because most of the reviewed studies employed more than one persuasive strategy, and each strategy can be implemented in different ways. Thus, it is almost impossible to measure the effectiveness of each persuasive strategy and its implementations. The following are the most important observations and findings from this study:

1. The majority of the reviewed studies employ more than one persuasive strategy, and each persuasive strategy was employed in one or more different ways.
2. A single type of implementation can be considered as a way of implementing multiple strategies. For example, delivering textual messages to the user in the "*Alert Me*" application by Fahim et al. [85] regarding their PA performance and sedentary behavior can be considered a self-monitoring, personalization, and reminder strategy.
3. It is impossible to know exactly the most and least effective persuasive strategies and ways of implementing each persuasive strategy by comparing the available studies because most of the articles employed more than one persuasive strategy, and each persuasive strategy can be implemented in different ways. Thus, I invite researchers to explore this direction by

conducting lab or field studies and comparing participants' responses to different strategies. For example, thematic analysis can be used to get more detailed insights into the effectiveness of each strategy. Beyond just reporting on the overall performance of the app with respect to promoting the target behavior, researchers could dig deeper (through qualitative studies, for example) to determine what made the app work or not.

4. I classified some persuasive strategies based on how they are delivered to users (e.g., textual, visual), and I classified other persuasive strategies as system-based or user-driven strategies.
5. It was not easy to extract, name, and classify the different persuasive strategies employed in the reviewed studies, and I needed to study each article in-depth (read, extract, sort, analyze).
6. I recommend that each article describe the persuasive strategies they employed and link each strategy with an existing example from their system design (what, how, where) in a table or list.
7. Some articles did not specify exactly how to implement each persuasive strategy, while others provided examples (the form of implementation) without mentioning the persuasive strategy itself.
8. It was also difficult to find the different types of each persuasive strategy implementation. It was not easy to classify them into groups, name them, or differentiate between the general classification and the examples (they were confusing).
9. Giving brief names as titles for each persuasive strategy implementation was sometimes extremely difficult.
10. Some examples of the implementations were provided only once as an example, so I could not categorize them clearly.
11. The ways of implementing, naming, and classifying the persuasive strategies were mostly based on the authors' points of view.
12. I used the PSD model to classify the persuasive strategies employed in the reviewed articles; however, this model was not comprehensive enough as I found other strategies that do not belong to the PSD (e.g., goal setting, self-reporting).

13. The definitions of persuasive strategies in the PSD model were sometimes overlapping and confusing, especially for the social support strategies (e.g., learning, comparison, recognition, and competition).
14. Most of the reviewed articles provide some figures showing the persuasive strategies employed while ignoring others or not informing the readers about how they employed other persuasive strategies; therefore, more organized tables and figures would be helpful (visualization, if applicable).
15. More information is needed about users' reviews, feedback, comments, and opinions regarding the persuasive strategy they like the most and the least as well as their views regarding the form of implementation they like or dislike the most and the least.

5.6.3 Observations and Recommendations for Future Research

This section addresses some observations and limitations of the reviewed studies. It also provides some recommendations to inform future research. These observations are supported by other reviewed articles such as [206], [9]:

1. There is a lack of a comparison between the effectiveness of mobile-based PTs applying a single persuasive strategy and those applying multiple persuasive strategies.
2. There is no clear guideline for evaluating the effectiveness of persuasive strategies and their implementations.
3. There is a need to provide an inclusive PT design framework that considers all the essential aspects such as target populations, technology platforms, persuasive strategies employed and their implementations, domain, and other aspects.
4. It is essential to consider publishing studies that have both positive and negative outcomes so they can help other researchers avoid ineffective approaches and only follow correct and verifiable ones.
5. There is a need to precisely name the persuasive strategies employed in the PT interventions along with their forms of implementation and examples. This could be shown in a table, list, or figure. The reviewed articles showed that most of the reviewed studies did not clearly specify the persuasive strategies employed in their PT design and did not show how exactly they employed each strategy in their designs. The reader needs to read

the whole article and sometimes dig in depth to extract the persuasive strategies employed and their implementations. Thus, I recommend that future researchers provide a clear way of displaying each strategy and how it is employed in their PT system design (e.g., by providing a table showing the persuasive strategies employed, the type of implementation, an example of each implementation in the PT design, and an image or a diagram of the implementation (such as a user interface, icon, prototype, or avatar).

5.7 Conclusion and Future Work

This study introduces a rich, comprehensive, and valuable systematic review of mobile-based PTs in the PA and SB domains. Based on our analysis of 198 articles, this study sheds light on the persuasive strategies used in designing mobile-based PTs for PA and SB while showing how persuasive strategies were implemented differently in designing mobile-based PTs for PA and SB; highlights the gaps, pitfalls, and limitations in the present literature on mobile-based PTs for PA and SB; and provides directions and recommendations for the future of mobile-based PT research.

Future research should clearly describe the persuasive strategies employed and their implementations. There is also a need for more review papers that address different implementations of each persuasive strategy in the PA and SB domains and other domains (e.g., healthy diet, smoking cessation, mental health). Future systematic reviews should also address the persuasive strategies' implementations based on different technology platforms, not only for mobile-based PTs. It is important to provide a standard measurement for the effectiveness of each persuasive strategy and each implementation. Future research should also provide clear and unified classifications for each persuasive strategy's implementation with possible examples. Thus, our systematic review study can be considered a reference source of knowledge for such a purpose in the PA and SB domains for mobile-based PTs. Finally, I noticed that persuasive strategies were implemented in multiple ways, but the literature lacks a clear view of the most effective strategies or combination of strategies that will yield the best results. Thus, future work should investigate this direction to fill this gap.

6 CHAPTER 6: TAILORING PERSUASIVE AND BEHAVIOUR CHANGE SYSTEMS FOR PROMOTING PHYSICAL ACTIVITY

This chapter represents the fourth stage of the five main stages in this dissertation. This stage involves designing and conducting the user study based on the previous stages in addition to offering practical guidelines for app design. In this chapter, the employment of the user study using an online survey is demonstrated. It outlines the study's objectives, research questions, background, related work, evaluation methodology, and presents and discusses the results. Additionally, guidance is provided on developing a tailored persuasive system to encourage physical activity (PA) based on the user-study assessments of the persuasiveness of various persuasive strategies and their implementations while taking into consideration participants' needs, preferences, and recommendations.

6.1 Introduction

Physical inactivity is a significant health hazard for different non-communicable diseases such as diabetes, obesity, cancer, high cholesterol, and heart disease [49]. Evidence demonstrates that a lack of regular PA is one of the most significant hazards contributing to death worldwide [309]. Health research shows that a quarter (25%) of the global adult population is considered sedentary or physically inactive [309]. The number of inactive adults continues to grow due to various factors, including the progression of technology. Promoting PA is not easy due to the interdependencies and relationships between PA and other factors such as demographic, social, psychological, behavioral, and biological factors. Research has shown that persuasive technology (PT) interventions for promoting PA are among the most effective approaches to encouraging individuals to be physically active [222].

PTs, including persuasive and behavior change systems, employ different persuasive strategies to encourage behavioral change, and research has demonstrated the effectiveness of these persuasive interventions [117], [206]. Thus, researchers on human-computer interaction (HCI) have employed persuasive strategies to improve their PT system designs to encourage users to change their behaviors and adopt more desirable ones (e.g., being physically active). For example, PTs in the health field are designed to promote healthy behaviors and discourage or mitigate unhealthy behaviors [147], [213], [207]. Thus, PTs have supported people to improve their general health and well-being, including through PA, healthy eating, weight management, and smoking cessation [28], [65], [121], [139], [218],

[170], [238]. Furthermore, PTs have helped people overcome addictive and risky behaviors (e.g., substance abuse, drinking alcohol) [47] [154] [193] [237] [258], manage diseases [245] [256], and deal with mental health problems (e.g., anxiety, depression, stress, panic attacks, low mood) [27], [34], [96], [154], [19].

Despite the widespread use of persuasive interventions in persuading people to adopt desirable healthy behaviors and avoid risky ones, most of these PTs are designed using a "one-size-fits-all" or non-tailored method [35], [210]. This "one-size-fits-all" approach might be ineffective because different individuals might be motivated and persuaded by various persuasive strategies [195] [214] [213] [207]. Therefore, different people or groups of people might not be motivated or encouraged to change their undesirable behaviors via the same persuasive strategy [46] [144] [213] [210] [219]. Consequently, there is increasing interest in tailoring PT interventions, especially in health domains that aim to change people's behaviors based on their user characteristics [213], [284]. Research has shown that tailoring PT interventions can increase their effectiveness in promoting desired and healthy behaviors more than non-tailored systems [214]. Research reveals that user characteristics, including age and gender [2] [223], gamer type [162] [205], personality type [140] [207], and gamification user type [210], are beneficial factors to take into consideration for tailoring persuasive and behavior change systems.

Limited research has been carried out on how PT interventions can be tailored to people in various stages of behavior change. The Transtheoretical Model (TTM) of behavior change explains that people's progress occurs via six stages of change (SoC) for adopting healthy behaviors. Hence, PT interventions need to be tailored to motivate people at each stage of behavior change [233], [235]. Some health and HCI researchers have employed the TTM in designing their PT interventions in different domains such as PA [88], stress management [81] [131], healthy eating [105] [165], sustainable energy [125], and substance use [81]. However, there is a lack of information on how PTs should be tailored to people at separate stages of behavior change by modifying the persuasive strategies used in the PT systems. Research revealed that PT systems could be successfully tailored by modifying the persuasive strategies used in the system [147], [144], [204].

Most of the persuasive applications (apps) designed to promote PA are developed using a "one-size-fits-all" approach that disregards tailoring behavior theories (e.g., the TTM and its SoC) and persuasive strategies to user groups based on different aspects (e.g., cultural variances) [30], [91], [171], [145], [202]. Though sedentary behavior (SB) and physical inactivity remain a global challenge that impacts different cultures, most PT intervention studies have been conducted on developed countries, including European, Canadian, Australian, and American cultures [202], [150]. Accordingly, the existing PT interventions for encouraging PA might not be effective nor meet the requirements and needs of users from Arabic populations, which emphasizes the need to examine how to tailor PT interventions for promoting PA to individuals from Arabic cultures. Cultural variances have been shown to influence and affect different dimensions of human lives, such as people's motivations, beliefs, thoughts, decisions, and interactions with technological systems [151], [242], [190]. Cultural and contextual aspects must be considered in designing PT interventions that aim to motivate healthy behavior change to improve the effectiveness of the persuasive systems [16].

Despite extensive evidence on the need to consider people's cultural differences in informing and designing PT systems, the effects of culture on the design of PA persuasive and behavior change systems have mostly been neglected [279]. In this study, I investigate whether people from Arabic or non-Arabic cultures are motivated by different persuasive strategies and their implementations for promoting PA and at different states of users' behavior changes. To achieve this, 1) I compare the persuasiveness of strategies for Arabic and non-Arabic populations, 2) I identify most and least preferable strategies in each population, 3) I analyze variations in persuasiveness for distinct strategy implementations, 4) I investigate factors influencing implementation choices in each population, 5) I examine differences in persuasiveness between various implementations and their alignment with ARCS motivational constructs at different SoC for Arabic and non-Arabic populations, 6) I gather and analyze participants' perspectives and recommendations in each population, and 7) I use participants' insights to inform future app design for enhanced user satisfaction and engagement.

I provide applicable culturally based guidelines for designing tailored persuasive PA mobile systems to Arabic and non-Arabic populations. I investigated the participants' current stage of behavior change (*precontemplation, contemplation, preparation, action, and maintenance*) [233]–[235], perceived persuasiveness [76], and motivational appeal dimensions (*attention, relevance, confidence, and*

satisfaction) [148] of the twelve persuasive strategies (*self-monitoring, personalization, goal-setting, suggestion, reminders, praise, rewards, reduction, tunneling, social competition, social cooperation, and simulation*) and their different forms of implementation (each implementation is represented as a feature) included in the prototypes of the online survey. I generated the guidelines based on a large-scale comparative study (N = 1100) of the PA behavior of people from Arabic and non-Arabic populations. I used a mixed-method approach involving quantitative (using the structural equation modeling (SEM) technique [112]) and qualitative (based on the participants' feedback and comments) research and analysis approaches to develop models. To collect data from participants, I developed and presented two implementations as features (high-fidelity prototypes) for each of the 12 persuasive strategies included in the online survey for promoting PA, followed by validated scales for evaluating perceived persuasiveness [76] and motivational appeals [209]. I conducted an assessment and comparison of the overall persuasiveness of persuasive strategies among Arabic and non-Arabic populations. This involved identifying and ranking the most and least preferable persuasive strategies in each population. Additionally, I analyzed and compared the persuasiveness and effectiveness of distinct implementations of each persuasive strategy within both Arabic and non-Arabic populations. To better understand the factors and reasons influencing the implementation choices of these strategies, I conducted an investigation in each population. Furthermore, I conducted a comparative analysis to explore the relationships between different motivational levels and the effectiveness of persuasive PA behavior for both Arabic and non-Arabic populations across various stages of behavior change. To gain valuable insights into future app design, I separately collected and analyzed the perspectives, preferences, opinions, and recommendations of Arabic and non-Arabic participants. I utilized the insights gathered from participants in each population to inform the app design process, with the ultimate goal of enhancing user satisfaction and engagement. Consequently, this study provides valuable guidelines for the design of persuasive PA mobile systems that cater to both Arabic and non-Arabic audiences.

I employed the classification of Arabic and non-Arabic populations in this dissertation as a stepping stone to investigate the specific characteristics of Arabic populations compared to others. To maintain simplicity and clarity, I avoided multiple classifications of other cultures, focusing instead on a broad comparison. This approach aims to facilitate future investigations and comparisons of different

cultures worldwide, both including and excluding Arabic populations. Furthermore, in future work, I plan to investigate cultures by geographical region, political stability, weather conditions, living conditions, and their influence on populations' adaptation to or maintenance of PA.

This study provides eleven main contributions:

1. This study compares the overall persuasiveness of persuasive strategies for Arabic and non-Arabic populations, identifying the most and least preferable persuasive strategies within each population.

2. It explores distinct implementations of each persuasive strategy and highlights the importance of selecting suitable implementations to enhance the effectiveness and persuasiveness of persuasive systems.

3. It offers insights from the thematic analysis of participants' qualitative feedback within each population (Arabic and non-Arabic) to gain an understanding of the reasons behind their implementation preferences.

4. It emphasizes the importance of tailoring PT systems and employing appropriate tailored persuasive strategies based on different stages of behavior change.

5. It compares the persuasiveness of the persuasive strategies in terms of their effectiveness in persuading and motivating health behavior change (e.g., promoting PA).

6. It investigates how persuasive systems motivate individuals' behavior changes by applying the ARCS motivational model.

7. It provides qualitative insights based on participants' comments regarding the adoption of healthy and desirable PA behaviors at different stages of change. I map participants' comments concerning their motivational appeals to the ARCS motivation constructs: Attention, Relevance, Confidence, and Satisfaction.

8. The study investigates the effectiveness of persuasive strategies based on their implementations. Each persuasive strategy can be implemented in several ways, which might affect the persuasiveness and motivational appeals of the users. For example, a self-monitoring strategy can be presented as textual or visual (graphs/charts) feedback on the user's progress and performance.

9. The study offers design guidelines for persuasive systems for promoting PA that appeal to both a broad audience (non-Arabic populations) and a specific group (Arabic populations) based on their implementation choices and preferences.

10. The study provides insights and visualizations for the future design of our PA app, which is specifically tailored to Arabic and non-Arabic users, as detailed in Chapter 7.

11. To the best of our knowledge, this is the first study designed to offer a comprehensive comparison, both quantitively and qualitatively, of large populations of Arabic and non-Arabic participants aimed at tailoring PA apps based on the effectiveness of persuasive strategies, implementations of strategies, stages of behavior change, and understanding of participants' preferences, needs, and recommendations.

6.1.1 Research Objective

In spite of the widespread employment of persuasive strategies in persuasive and behavior change intervention systems designed in different domains such as education and health, there is still a need for further knowledge and comprehension about the role and effectiveness of discrete strategies [218], along with their various implementations. The objectives of this study are summarized as follows:

- **Objective 1:** To determine and compare the overall persuasiveness of strategies between Arabic and non-Arabic populations and to identify the strategies ranked as the most and least preferable in each population.

- **Objective 2:** To assess and analyze how persuasiveness ratings vary for distinct implementations of each strategy between Arabic and non-Arabic populations and to

investigate the factors or reasons that influence the choice of specific implementations of persuasive strategies in each population.

- **Objective 3:** To examine the differences in persuasiveness between various implementations of each strategy and how they align with the ARCS motivational constructs (Attention, Relevance, Confidence, Satisfaction) at different stages of change for both Arabic and non-Arabic populations and to provide recommendations for selecting persuasive strategy implementations at various stages of change among Arabic and non-Arabic populations.

- **Objective 4:** To gather and analyze the perspectives, preferences, opinions, and recommendations of Arabic and non-Arabic participants regarding the future app design and to use the insights from participants to inform the design process and enhance user satisfaction and engagement in the future app.

6.1.2 Research Questions

I have summarized the overarching research questions of this study as follows:

1. **Research Question 1 (RQ1):** What are the differences in the overall persuasiveness of strategies between Arabic and non-Arabic populations, and which strategies are ranked as the most and least preferable in each population?

2. **Research Question 2 (RQ2):** How do the persuasiveness ratings of distinct implementations of each strategy vary between Arabic and non-Arabic populations, and what factors or reasons influence their implementation choices?

3. **Research Question 3 (RQ3):** What are the differences in persuasiveness between various implementations of each strategy, and how do these implementations align with the ARCS motivational constructs (Attention, Relevance, Confidence, Satisfaction) at different stages of change for both Arabic and non-Arabic populations?

4. **Research Question 4 (RQ4):** What are the perspectives, preferences, opinions, and recommendations of Arabic and non-Arabic participants regarding the future app design, and how can these insights inform the design process to enhance user satisfaction and engagement?

6.2 Background and Related Work

This section introduces a review of the persuasive strategies and their implementations in the ARCS motivational model and TTM of behavior change and their relations to the HCI field. The section also presents some literature on the "explicit" versus "implicit" method of tailoring PTs and cultural variances.

6.2.1 Persuasive Strategies and their Implementations

The previous chapters covered the persuasive system design (PSD) model and the definitions of persuasive strategies (see Table 1) [123]. However, the implementations of each persuasive strategy for promoting PA and reducing SB have been comprehensively illustrated in Chapter 5 [10]. The twelve persuasive strategies included in designing the prototypes of our online survey are *self-monitoring, personalization, goal-setting, suggestion, reminders, praise, rewards, reduction, tunneling, social competition, social cooperation, and simulation* (see Table 5 and Table 8) [123], [10].

Table 5: Definitions of the Twelve Strategies Employed in the Online Survey.

#	Persuasive Strategy	Definition / Meaning	Some Forms of Implementation
1	Self-Monitoring	Tracking the user's performance, status, behavior changes, and progress to encourage the user to obtain his or her target goals.	• Numerical Feedback • Textual Feedback • Visual Feedback • Graphical Feedback (e.g., Bar Chart, Line Chart) • Audio Feedback • Vibration Feedback
2	Personalization	Delivering personalized services or content to users.	• Personalized Goal Recommendations

			• Personalized Activity Recommendations • Personalized Fitness Partner Recommendations • Personalized Educational Content • Personalized Motivational Content • Personalized Intervention Timing
3	Goal Setting	Goal setting is a robust way of assisting users in planning their goals ahead and achieving their target objective [138].	• Customized or user-driven • Default or system-based
4	Suggestion	Offering appropriate suggestions for users to perform a target behavior.	• Textual Recommendations • Visual Recommendations • Audio or Voice Recommendations
5	Reminder	Reminding users of their target behavior goals will increase their opportunities to achieve their desirable behavior goals.	• Automatic or System-based Reminders (Push Reminders) • Customized or User-driven Reminders (Pop-up Reminders) These reminders can be as follows: • Textual Reminder Notifications • Voice Reminder Notifications • Vibration Reminder Notifications • Visual Reminder Notifications • Light Reminder Notifications
6	Praise	The system can use praise via words, images, symbols, or sounds as a way to provide user feedback information based on the user's behaviors.	• Textual Positive Reinforcements • Audio Positive Reinforcements

			• Visual Positive Reinforcements
7	Rewards	The system gives credits and provides virtual rewards to users for their performance and progress in their target behavior.	• Collecting Virtual Items or Objects Not Usable in the Real World (e.g., Badges and Points) • Collecting Virtual Items that are Usable in the Real World (e.g., Financial Incentives and Real Gifts)
8	Reduction	Reducing a complex behavior to simple and easy tasks to assist users in performing the target behavior change.	• Providing a List of Different Predefined Options or Choices or Suggestions • Dividing Goals or Tasks into Sub-sections • Automatic Classifying and Mapping of Physical Activities to Users
9	Tunneling	Providing means and instructions to guide users through a process to perform a targeted behavior.	• Textual or Written Instructions • Map Visualization for Challenges and Walking Routes • Visual or Video or Animated Instructions • Instructions as a Storyline • Audio or Voice Instructions • Vibration or Tactile Instructions
10	Social Competition	Influence users and drive them by having them compete with other users to win a challenge.	• Leaderboard Ranking • Displaying a Progress Bar for the Competitors
11	Social Cooperation	System provides a means for users to cooperate and work together to adopt a target attitude or behavior.	• Teamwork • Sharing via Social Networks
12	Simulation	Let the users immediately observe the cause-effect connection regarding their behavior or attitude.	• User's Physical Movement Interactions in the Real World to Simulate and Control the Virtual Objects, Avatars or Metaphors of a

			Mobile Application and Represent the User's Progress

6.2.2 Stages of Behavior Change and HCI

The TTM is one of the most commonly employed theories in health behavior change, such as in promoting PA [82], [81], [88], [132], [141], [165]. The TTM provides a dynamic process to use to model an individual's behavior change and progress through different SoC. The TTM intends to change individuals' unhealthy and undesirable behaviors to healthy ones. The TTM's five main SoC are *Precontemplation, Contemplation, Preparation, Action, and Maintenance*. However, most studies of PA interventions showed that the majority of commercial persuasive and behavior change technologies or systems were designed in a "one-size-fits-all" or non-tailored approach, as all users receive similar feedback regardless of their current stage of change [35] [210]. This approach might be considered ineffective because diverse individuals are motivated by various persuasive strategies [195], [203], [2], [207]. Thus, various people or groups of people might not be motivated by the same persuasive strategy [46], [144], [213], [210], [219]. Therefore, HCI researchers have employed the TTM to develop or assess persuasive behavior change systems or technologies while considering users' present stage of change in designing the PT interventions [81], [132], [141]. Table 6 summarizes the TTM SoC (adapted from [234]) in the context of PA behavior.

According to the definitions of each stage of behavior change (precontemplation, contemplation, preparation, action, maintenance) from the TTM model, individuals' statuses vary at each stage, influencing their awareness, confidence, readiness to adopt healthy behaviors or quit risky ones, true intention to engage in healthy behavior, and satisfaction with sustaining healthy behavior over an extended period (e.g., six months or more). Consequently, the stage of behavior change plays a significant role in an individual's persuasion and motivation to adopt healthy behaviors (e.g., practicing PA). Additionally, research has demonstrated that a 'one-size-fits-all' approach may be ineffective, as different individuals may be motivated and persuaded by diverse persuasive strategies [195] [214] [213] [207].

Table 6: TTM Stages of Change for PA.

Stage	Definition

Precontemplation	An individual at this stage is currently not exercising (not engaging in regular PA exercise) and has no intention to start exercising within the next six months.
Contemplation	A contemplator is not currently exercising but is planning to start engaging in PA within the next six months.
Preparation	An individual at the preparation stage has decided to start engaging in PA and has taken some steps to achieve this goal.
Action	A person at the action stage has been consistently engaging in PA for six months.
Maintenance	An individual at the maintenance stage has been engaging in PA for more than six months.

6.2.3 ARCS Motivational Constructs and HCI

Keller [148] developed the well-known ARCS motivational model, building on other studies on the psychology of human motivations, then identified four main aspects that support people in becoming and remaining motivated: attention, relevance, confidence, and satisfaction. Though there are many different motivational theories, such as expectancy-value theory [295] and self-determination theory (SDT) [248], I decided to use the ARCS motivational model for four reasons. First, the ARCS motivational model is a well-designed and widely employed motivational model [186], and the components of the ARCS model were obtained from a study on human motivation [1]. Second, the ARCS model is a straightforward and robust macro-theory that contains a wide range of prominent motivational theories, including expectancy-value theory, social learning theory (SLT), self-efficacy theory (SET), reinforcement theory, and cognitive evaluation theory [70], [148], [186]. Third, the ARCS model has been successfully verified to be correlated with behavior and behavior change [104]. Fourth, HCI researchers have used the ARCS motivational model to support the design or assessment of behavior change systems or technologies.

For instance, the ARCS model is commonly used in assessing the motivational appeal of different persuasive and behavior change interventions in various domains, including health [8] [270], education [51] [66] [120] [252], and persuasive games [69], [301]. For example, Abdessettar [1] employed the ARCS motivation model to inform the design of a persuasive education smart mobile system for schoolchildren. Other HCI researchers and persuasive system designers applied one or

more motivational constructs of the ARCS model to improve their PSD. For instance, Stockdale et al. [270] adapted the confidence construct of the ARCS model to develop a PT intervention intended to encourage breastfeeding among first-time mothers by supporting them in developing confidence in their capability to breastfeed. Yusoff and Kamsin [304] utilized the attention construct to enhance the motivational attraction of the persuasive components employed in their persuasive game. Table 7 presents the four constructs of the ARCS motivational model, as adapted from [209].

Table 7: Constructs of the ARCS Model of Motivation (adapted from [209]**).**

Construct	Definition
Attention	"For a system to motivate users, it should arouse and sustain their *attention*."
Relevance	"To motivate users, a system should reflect user's interests and goals. A system that is perceived as helpful and useful with respect to helping users accomplish their goals is more likely to motivate the user. To be *relevant*, a system must be goal oriented, motive matching, and make use of familiar concepts."
Confidence	"People do not like taking on a task with little or no probability of success. Although success is never guaranteed, and people like to be challenged, a challenge that is beyond a user's capability could demotivate them. Users' *confidence* levels are often correlated with their motivation and the amount of effort put forth towards achieving an objective."
Satisfaction	"To motivate and sustain users' motivation, they should derive some *satisfaction* and reward for their effort."

6.2.4 Explicit versus Implicit Approach to Tailoring Persuasive Technologies

Different theories, including the theory of reasoned action (TRA) [114] and theory of planned behavior (TPB) [7] emphasize that attitude is a predictor of behavior. HCI researchers consider perceptions or attitudes as a forerunner of an actual behavior and its effectiveness. Thus, perception can inform and assist in persuasive interventions' design decisions (in user-centered design) and predict actual behavior [218]. For instance, a PT designed by employing models according to user perceptions was shown to be more effective than a generic one [204], [213]. In actual behavior change, the effectiveness of the self-report-driven personalization of different persuasive interventions has been explored in other domains such as PA, eCommerce, and snacking [147], [146].

In the field of PTs, it is broadly recognized and validated that both explicit and implicit measures are effective methods for tailoring PTs. The explicit approach refers to users' perceptions, tendencies, and self-assessments/reports to obey particular persuasive strategies, while the implicit approach refers to users' actual responses [146]. The prominent research done by Kaptein et al. [146] emphasized that "such an explicit approach could be used to tailor persuasive applications: if we have a questionnaire that elicits the tendencies of individual users to comply with distinct influence principles, we would be able to measure these tendencies a priori, and adapt the interaction with the user according to the obtained estimates." Furthermore, many other HCI studies have provided practical design guidelines and instructions according to users' perceptions [13], [140], [194], [205], [207], [210], [217], [218], [220], [221]. Accordingly, I followed a similar methodology and considered user perceptions as a forerunner (precursor) of actual behavior.

6.2.5 Culture and Human Behavior

Culture is a notoriously challenging term to define [265]. Triandis and Hofstede [279] define culture as "the collective programming of the mind which distinguishes the members of one group or category of people from another". Matsumoto [178] defines culture as "the set of attitudes, values, beliefs, and behaviors shared by a group of people, but different for each individual, communicated from one generation to the next". Spencer-Oatey defines [266] [265] culture as "a fuzzy set of basic assumptions and values, orientations to life, beliefs, policies, procedures and behavioural conventions that are shared by a group of people, and that influence (but do not determine) each member's behaviour and his/her interpretations of the 'meaning' of other people's behaviour." Thus, culture is transmitted and obtained from one generation to another; it is a set of values, beliefs, attitudes, behaviors, knowledge, awareness, skills, and policies shared by a group of people that significantly influence and affect these group members. Hence, culture distinguishes particular groups from one another. Culture affects most aspects of people's lives, including their thoughts, opinions, behaviors, interactions, and communications with technology [211], [291]. In this study, I focus on investigating two populations with distinct cultures: Arabic and non-Arabic populations.

6.2.6 Culturally Relevant Persuasive Technologies

Existing research has emphasized the need for making computer applications in general and PTs, in particular culturally relevant PTs [151], [190], [242]. PT aims to change or reinforce attitudes or behaviors without applying deception or coercion [93]. Thus, PT needs to be designed in an unobtrusive manner to be integrated into the user's daily life [61]. As previously illustrated, culture plays an essential role in forming people's attitudes, beliefs, and behaviors. Consequently, the comprehensive merging of PTs into human life cannot be accomplished without considering different cultural variances and aspects [16].

The study of Grimes and Grinter [106] shows that cultural relevance requires understanding the values, needs, norms, beliefs, and behaviors of a target audience, which should all be taken into account when designing a culturally tailored PT intervention for a particular group of people. Therefore, PTs, which are usually involved in applying behavioral theories and their related determinants, can be culturally relevant by employing the essential behavioral theories, persuasive strategies, and determinants to the cultural needs, beliefs, norms, and behaviors of the target population. Nevertheless, it is worth mentioning that if a PT intervention adapts to cultural aspects and characteristics, it does not necessarily mean it will be effective and successful. PT interventions that adapt to cultural aspects will increase their potential of being culturally influential to the target population, which may increase the intervention's effectiveness [106], [16].

Research studies on designing culturally relevant PT interventions are limited, as only a few studies have been done in this field. Among these studies, Khaled et al.[151] examined the effects of cultural variances on the effectiveness of different persuasive strategies. They showed that the persuasive strategies frequently implemented in designing PT systems are more appropriate for individualist than collectivist cultures. The researchers provided five collectivist-focused persuasive strategies: *group customization, group opinion, deviation monitoring, group surveillance, and disapproval conditioning*. However, these proposed persuasive strategies for collectivist cultures are not behavioral theory-based nor developed based on a large-scale study.

The study by [153] introduced a persuasive game called "Smoke?" in the smoking cessation domain. The game was developed for both individualist and collectivist cultures. The design of "Smoke?" was supported by a set of collectivist-focused persuasive strategies: *group opinion, harmony, team*

performance, monitoring, and disestablishing. The resulting outcomes of the game revealed that culturally matched persuasive strategies are more persuasive.

In the PA domain, Almutari et al.[16] conducted a large-scale study of 430 participants targeting both collectivist and individualist cultures. Their study focused on targeting Saudi Arabia as a collectivist culture and Canada as an individualist culture. They aimed to identify if and how behavior determines whether the extended Health Belief Model (HBM) can be effectively tailored in PT interventions that target different cultures to promote PA. Their research also investigated the effects of the age and gender of the target audience. Their evaluation results showed that the HBM determinants *Cue to Action, Perceived Severity,* and *Social Influence* are the most significant determinants of PA in the Saudi adult population. In the Canadian adult population, the HBM determinants *Self-Efficacy, Social Influence,* and *Cue to Action* are the most significant. Their study offers design guidelines for PT interventions suitable for general and specific groups of populations based on their cultural differences, age, and gender.

Culturally relevant PT designs have been applied in different health domains. For example, Orji and Mandryk [202] examined culturally relevant dimensions in the healthy eating domain. They delivered culturally relevant design methods for tailoring PT systems to individualist and collectivist cultures. The outcomes of their large-scale study illustrated some variations among different cultural groups and sub-groups. Accordingly, the researchers present two methods for designing culturally relevant PT applications.

Despite the presence of the above-mentioned studies on culturally relevant persuasive strategies, the process of adapting strategies from one domain to another is not straightforward. Thus, persuasive strategies that work properly in one domain (e.g., healthy eating) might not be directly applicable to another domain (e.g., PA system design) [202]. Adapting and transferring persuasive strategies from one domain to another is challenging due to each domain's special characteristics. According to Almutari [16], eating is a daily behavior that is important for everyone's life, while practicing PA is not necessarily a daily activity regardless of the importance of PA for health. Furthermore, for individuals to be physically active, they might need specific exercise equipment, time, and effort, making it more challenging to design persuasive PA systems. Hence, there is a need for more research

to investigate the effectiveness of persuasive strategies' implementations, motivational appeals, and persuasiveness with respect to the user's existing stage of behavior change with the aim of developing culturally relevant PT systems in the PA domain.

Most of the HCI studies for promoting PA have targeted behavior changes for users from Western countries, resulting in a lack of studies and a huge gap in research on persuasive systems' ability to change users' behavior in non-Western countries. Most of the existing studies focus on Western populations (e.g., American, Australian, European, Canadian) [16]. Our findings from the previous systematic reviews showed that most of the articles included in these literature reviews on PT interventions for promoting PA were conducted in Western countries [9], [12], [11], [10]. Our results show that out of 170 articles included in the systematic review in Chapter 3, 154 studies (91%) were conducted in Western countries and only 16 studies (8%) were performed in non-Western countries (only 1 study was conducted in an Arabic country, the UAE) [9]. Of the 80 studies included in Chapter 4, 67 studies (84%) were conducted in Western countries, and just 13 studies (16%) were carried out in non-Western countries [12]. Out of the 38 studies in our article [11], 34 studies (89%) were conducted in Western countries and four studies (11%) were carried out in non-Western countries. Of the 198 studies included in the literature review of Chapter 5, 171 studies (86%) were conducted in Western countries, and 27 studies (14%) were carried out in non-Western countries [10]. Accordingly, this study investigates the possible cultural differences between Arabic populations and non-Arabic populations in the effectiveness of providing a tailored persuasive system for encouraging PA that meets peoples' implementation's choices, motivational appeals, current stage of behavior change, and perceived persuasiveness.

6.3 Methodology

I followed the methodological process illustrated in Figure 51, which has been used and validated in other research [210], [218]. I went through several important steps to gather information and insights:

- **Selecting Persuasive Strategies and Implementations:** Initially, I collected information from prior studies, specifically Chapter 5 of the research. Additionally, I consulted with 16 experts in the fields of HCI and PT in our Persuasive Computing lab. Moreover, another researcher and I conducted a thorough examination and comparison of the findings from a comprehensive

literature review and insights from HCI researchers and experts. This analysis plays a crucial role in guiding the final decision-making process for the selection of persuasive strategies and their implementations. Drawing from their expertise, I identified specific persuasive strategies and their corresponding implementations.

- **Creating Prototypes:** Once the strategies and implementations were chosen, I proceeded to design detailed high-fidelity prototypes. These prototypes served as practical examples, illustrating how each strategy could be effectively applied in real-life scenarios.

- **Getting Feedback:** To gather diverse perspectives, I conducted a large-scale online survey. This survey included both closed-ended questions with predefined answers and open-ended questions. This allowed participants to articulate their thoughts and feelings regarding our prototypes.

- **Analyzing the Results:** Subsequently, I analyzed the information I had collected. Employing a variety of tools and techniques, I examined the data from both quantitative (utilizing numerical data and statistics) and qualitative (evaluating descriptions and opinions) perspectives. This analysis aided in comprehending the perceptions of participants regarding the prototypes and persuasive strategies.

Accordingly, the design process for Implementation 1 and Implementation 2 of each persuasive strategy in our user study followed an inclusive methodological approach and a face validation process [84]. This involved a comprehensive literature review, iterative discussions, and feedback from 16 HCI and PT experts. Low-fidelity prototypes of the visual features for each persuasive strategy were presented to these experts. The HCI and PT experts reviewed the implementations for each strategy (prototypes) and provided detailed feedback, ensuring that the implementations accurately reflect the corresponding strategies. Finally, the designs were subjected to a thorough inspection by two researchers. This approach ensured that both implementations were clear, specific to each of the twelve persuasive strategies included in our study (e.g., self-monitoring, praise, reward, etc.), and easily comprehended by the participants.

In summary, this research involved a methodical approach, including the selection of persuasive strategies and their corresponding implementations, the development of practical exemplars, the collection of feedback from a diverse audience, and a thorough examination of the results. This comprehensive methodology ensures the robustness and significance of our findings within the fields of HCI and PT research.

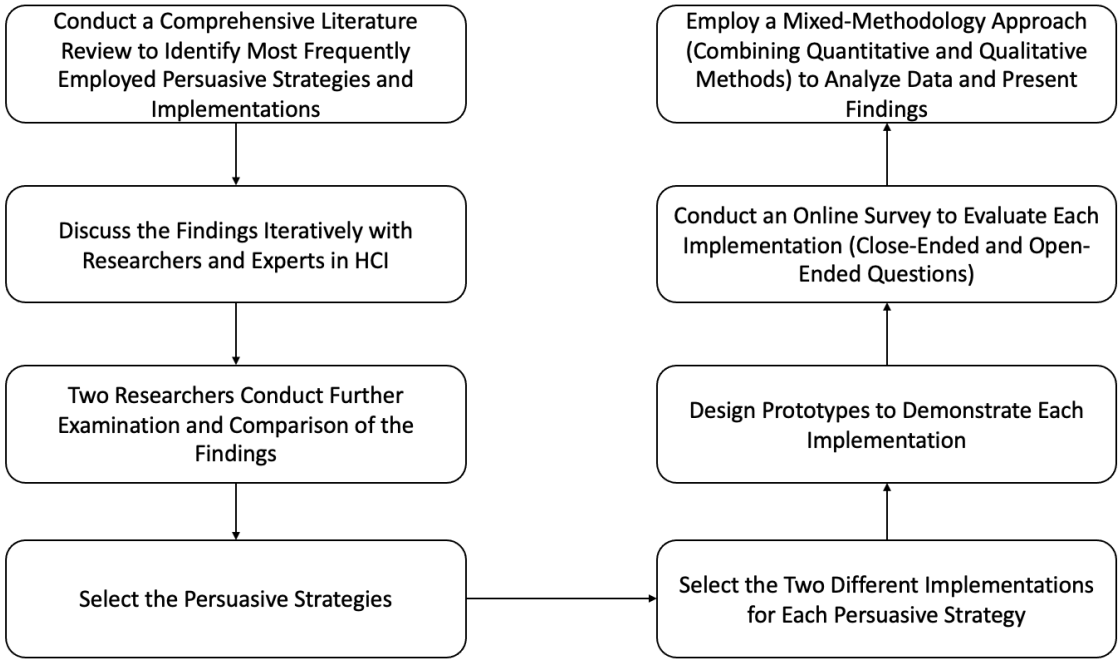


Figure 51: Methodological Plan.

The user study design was developed through four main stages. In the first stage, I conducted a systematic review of 170 articles on PTs for promoting PA and reducing SB and found that *mobile and handheld devices* were the most frequently employed technology platform in the reviewed articles [9].

In the second stage, I conducted a systematic review of 80 articles on a *mobile phone-based technology* platform for promoting PA and reducing SB [12]. I found that the most frequently employed technology platforms used in conjunction with mobile phone-based PTs are wearable activity trackers and sensors, followed by mobile phone-based PTs along with/without embedded (built-in) sensors and cameras. Furthermore, I found that the twelve most frequently employed strategies were *self-*

monitoring, personalization, reminders, goal-setting, rewards, praise, reduction, social competition, suggestion, social comparison, tunneling, and simulation.

In the third stage, I conducted a comprehensive systematic review of 198 articles (from 2006 to 2021) on mobile-based PT interventions exploring the most and least employed persuasive strategies and presenting the different ways of implementing each strategy and their effectiveness [10]. The findings revealed that the twelve most frequently employed strategies were *self-monitoring, goal-setting, reminders, rewards, personalization, praise, tailoring, reduction, tunneling, social competition, suggestion, and social cooperation.*

In the fourth stage, building on the results from the previous stages, I conducted a large-scale user study (online survey) of 550 participants for each population (non-Arabic and Arabic). I considered the most frequently employed technology platform (*mobile and handheld devices*) and implemented the most common strategies from these stages in the persuasive mobile app prototypes for promoting PA in the online survey. I designed and presented twenty-four high-fidelity prototypes operationalizing each persuasive strategy's implementation for promoting PA. Each strategy is designed and employed *two different forms of implementation* (one, two, or three screen design "interfaces" per strategy implementation) based on the third systematic review (stage three) and the iterative evaluations and suggestions from 16 experts in HCI and PT. The aim is to compare the two implementations of each strategy according to participants' opinions. The systematic reviews' results and experts' evaluations indicate that the common strategies that need to be evaluated by users in PA mobile apps are *self-monitoring, personalization, goal-setting, suggestion, reminders, praise, rewards, reduction, tunneling, social competition, social cooperation, and simulation*. The definitions of each strategy are shown in Table 1 according to the PSD model [123]. The persuasive strategies and features of a persuasive app prototype included in this online survey and the corresponding descriptions of each strategy interface (implementation) are shown in Table 8 below.

Table 8: Strategy Implementations on the Mobile App Prototypes in the Online Survey.

Strategy	Implementation 1	Implementation 2
Self-monitoring	**Textual and Numerical Feedback**: The first screen allows users to track and see their PA progress for the same day and the day before	**Numerical and Visual Feedback**: The first screen allows users to track and see their PA progress for the same day and the day before

	as *textual and numerical feedback* on the screen. Furthermore, the users can check their weekly summary progress as a *textual and numerical* table as represented in the second screen when tapping on the "Summary Progress Overtime."	as *numerical and visual feedback* (e.g., *pie charts*, *progress bars* for all the parameters such as distance, step counts, stair counts, speed, and calories burned) on the screen. Furthermore, users can check their weekly *progress bar* toward their weekly goal and track the summary progress as *a bar chart* shown on the second screen when tapping on the "Summary Progress Over time."
Personalization	**Personalized Motivational Content**: The users receive *personalized motivational content* based on their step count (PA) progress over the week and based on their PA level and behavior. *Motivational content* refers to providing encouraging feedback to the user [101].	**Personalized Goal Recommendations**: The users receive *personalized goal recommendations* based on the progress of the user's step counts (PA) over the week and based on their PA level and behavior.
Suggestion	**Textual Notifications**: The users receive general walking tips, facts and suggestions as *textual pop-up notifications*.	**Visual Notifications**: The users receive general walking tips, facts and suggestions as *visual pop-up notifications*.
Goal Setting	**Default/System-based Goals:** The application provides a *system-based* step count goal to the user (e.g., the daily step goal is 10,000 steps) according to most fitness trackers and research studies and as recommended by the World Health Organization [309].	**Customized/User-Driven Goals:** The users can *customize* their goals. Thus, users can increase or reduce their daily step count goals as they prefer.

Reminders	**Automatic/System-based Reminders (Push Reminders)**: The users receive *default automatic reminders* based on their PA progress and SB. The users randomly receive *push notification reminders* and based on their tracked walking progress.	**Customized/User-Driven Reminders (Pop-up Reminders):** The users can set reminders based on their preferable scheduled times. The users receive *pop-up window reminders* based on their preferable scheduled times.
Rewards	**Collecting of Virtual Points:** The users earn *virtual points* based on their walking progress.	**Collecting of Virtual Badges:** The users earn *virtual badges* based on their walking progress.
Praise	**Textual Praise:** The users receive *textual* encouragement and congratulatory praise based on their walking progress.	**Audio and Visual Praise:** The users receive *audio and visual praise* when achieving their daily or weekly walking goals (e.g., fireworks sounds and images and hand clapping sounds and images).
Reduction	**Providing a List of Different Predefined Options for Nearby Activities:** The user is provided with a list of nearby walking activity locations along with the estimated duration, walking distance, and directions on Google Maps.	**Providing a Set of Predefined PA Plans/Goals:** The user can choose from predefined walking plans (e.g., a different target walking location daily) by accepting the plan or selecting a different walking location.
Social Competition	**Leaderboard**: Users' walking progress is shown as a ranking *leaderboard* for the winners of the competition along with different virtual rewards (prizes).	**Displaying a Progress Bar for Each Competitor:** Users' walking progress is shown as a *visual progress bar* for each competitor.
Tunneling	**Textual/Written Instructions:** The user is provided with *written textual* descriptions for walking routes.	**Map Visualization for Walking Routes:** The user is provided with a *map visualization* for walking routes.
Social Cooperation	**Message Exchange via Social Networks:** The user can invite other users to walk together by joining a social chat room. The users can plan and agree to walk together in the chat room.	**Teamwork:** The users can invite friends to join them to engage in a walking challenge. The invited user (a friend) can either accept joining the challenge or not. If the team

		successfully completes the challenge, they will earn virtual points.
Simulation	**Users' PA Movements' Interactions in the Real World to Simulate and Present the Users' Progress:** The users are provided with the simulated charging of a battery that simulates the users' movements and walking progress throughout the week based on their walking goal.	**Educational Tips/Images to Realize the Cause and Effect of PA and SB on Health:** The app simulates a current and target goal body shape based on the user's parameters to realize and motivate the cause and effect of being physically active to educate the users and increase their awareness.

I employed a mixed-method research approach to collect different types of data to explore our research questions. The mixed-method research approach employs both qualitative and quantitative methods to explore and expand the comprehension of research problems and avoid the limitations of employing a single method alone. Thus, combining both methodologies would provide more accurate data analysis and more insights into the intended topics and research questions [63].

I needed to learn participants' in-depth points of view, their preferable features and strategies, their concerns, and the reasons behind their opinions in utilizing and designing a persuasive mobile app for promoting PA and reducing SB. This can be accomplished by employing a qualitative approach that usually consists of sentences, quotes, codes, and themes. Therefore, I used a thematic analysis for the qualitative data as recommended by Creswell and Clark [63].

6.3.1 Qualitative Research Approach

Qualitative research is used to collect and analyze non-numerical data (e.g., text, audio, images, or video) for comprehending ideas, experiences, and opinions. Qualitative research is often employed when there is a need to explore and discuss a research problem, gain in-depth insights, or produce new ideas for research [293].

While using quantitative information is appropriate, qualitative research provides more insights and detailed information about the research problem as well as the quantitative data. In a qualitative approach, researchers can communicate with the respondents, who can express their feelings, opinions, and thoughts, which are difficult to recognize by employing quantitative research alone.

Researchers can collect qualitative data through different types of studies, such as focus groups, solicited diaries, interviews, vignettes, visual methods, observations, field research, surveys, action research and secondary sources (e.g., reviews of other articles) [83]. After organizing and coding the collected data, researchers can generate themes or patterns, leading to more insights, detailed answers and solutions to their research questions and problems.

Thematic analysis is a process of analyzing qualitative data that relies on generating and analyzing themes or reporting repeated patterns from non-numerical obtained data [155]. In employing the thematic analysis of qualitative data, six phases should be followed to make appropriate and suitable patterns. The six phases are familiarization with data, producing and generating initial codes, searching for themes among codes, reviewing and revising themes, defining and naming themes, and generating and introducing the final report [196].

6.3.1.1 Phase 1: Familiarization with Data

Researchers become familiar with the collected data through repeated readings and comparisons with original recordings to ensure accuracy and understanding. This phase provides researchers with a solid foundation and simplifies the coding process for the second phase.

6.3.1.2 Phase 2: Producing and Generating Initial Codes

Initial codes are generated from the data, either manually through note-taking or using computer software. This phase involves categorizing and organizing data for further analysis.

6.3.1.3 Phase 3: Searching for Themes Among Codes

Researchers search for themes among the initial codes, organizing related codes into coherent patterns. Visual representations such as mind-maps, charts, and tables or writing descriptive codes may assist in organizing and classifying the codes into different themes and patterns.

6.3.1.4 Phase 4: Reviewing and Revising Themes

Themes generated in the previous phase are reviewed and refined, ensuring relevance and coherence. Data extracts are examined to confirm alignment with themes, and the entire dataset is checked for completeness.

6.3.1.5 Phase 5: Defining and Naming Themes

Themes are defined and named based on their representation of the data and research objectives. Clarity and specificity are emphasized to accurately reflect the content of each theme.

6.3.1.6 Phase 6: Generating and Introducing the Final Report

The final report is written while incorporating findings from the thematic analysis. The report highlights the significance of themes and their contribution to addressing research questions and objectives.

Throughout the process, researchers must be mindful of biases and ensure transparency in their interpretations. The documentation of findings and decisions throughout the process aids in reflexivity and enhances the study's reliability. The sample size is determined based on data saturation and research needs to ensure the adequate representation of themes or patterns [41], [42], [43], [58], [130], [196]. Figure 52 illustrates the six phases of the thematic analysis process.

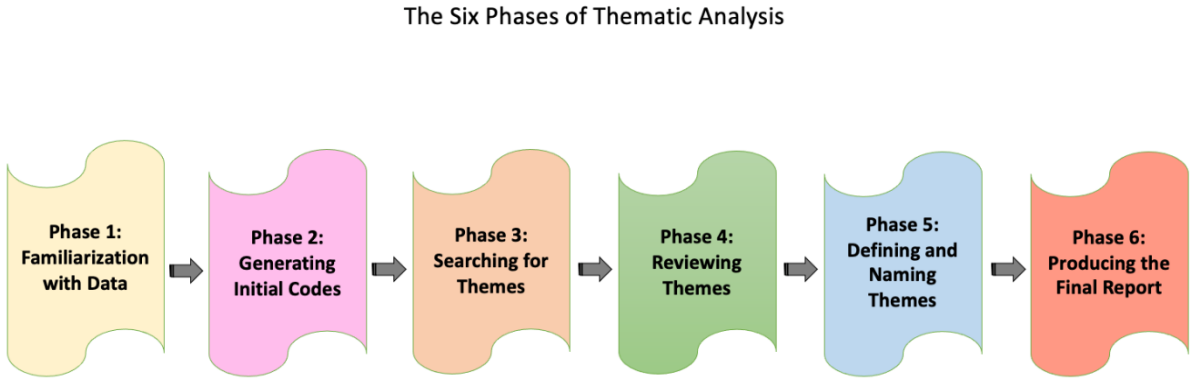


Figure 52: Six-Phase Thematic Analysis Process (Adapted from Braun and Clarke, 2006 and 2021).

6.3.2 Quantitative Research Approach

Quantitative research is used to gather and analyze numerical data for statistical analysis [293]. It counts opinions, behaviors, attitudes, and other variables to either support or disprove a hypothesis [183]. The quantitative research approach can be used to identify averages and patterns, examine relationships and hypotheses, form predictions, and generalize findings to broader populations [293].

There are different methods for collecting data as part of a quantitative approach, including online survey “questionnaires”, paper surveys, longitudinal studies, existing data, and document reviews (e.g., systematic reviews of related works) [183], [72]. Online surveys can target a large number of participants and include either closed-ended questions, open-ended questions, or a combination of both. It is important to create well-defined and easy to comprehend questions for a survey. Surveys can be used to collect quantitative data, qualitative data, or both depending on the type of questions introduced to participants (e.g., closed-ended or open-ended questions) [64], [244], [67], [267], [74].

I aimed to conduct a large-scale user study with a significant number of participants, collecting both quantitative and qualitative data. Online surveys serve this purpose optimally as they can be easily distributed, reaching a wide range of populations. They offer the ability to include both close-ended and open-ended questions, thereby integrating these two types of questions to understand participants' justifications and reasons for their selections and ratings. Additionally, they help to capture participants' desires, needs, feelings, and any recommendations they may have for advancing future research and improving the features and design of the PA app. Thus, employing online surveys suited the needs and objectives of our research aims.

I employed explicit measures, an effective approach for tailoring PTs, which rely on users' perceptions and self-assessments to adapt specific persuasive strategies [146]. Numerous HCI studies have provided practical design guidelines and recommendations based on users' perceptions collected via survey responses [13], [140], [194], [205], [207], [210], [217], [218], [220], [221]. Following a similar methodology, I considered user perceptions as a precursor to actual behavior. Figure 53 shows the research methodologies employed in our study.

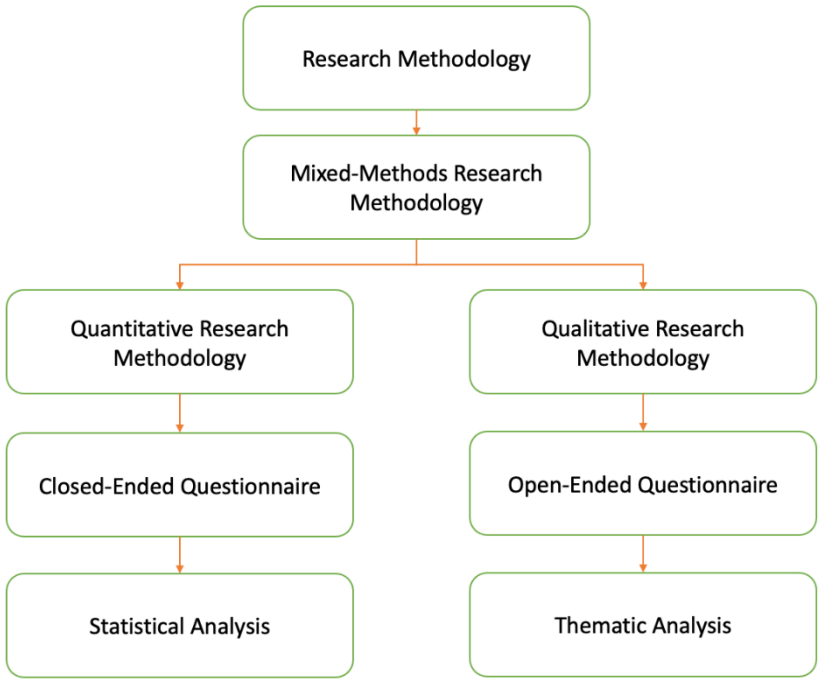


Figure 53: Research Methodologies Employed in Our Study.

6.3.3 Study Instrument

The study consists of the following sections:

1. Demographics and Personal Information:

In the demographic and personal information section, I collected demographic information such as the participants' age, gender, level of education, marital status, occupation, country of residence, country of origin, general health status, level of SB based on self-diagnosis, and experience with PA apps. The following are some of the questions I used in the user study:

- How much time do you usually spend sitting or reclining on a typical day (i.e., total time spent sitting at work, in an office, reading, watching television, using a computer, doing hand crafts like knitting, resting, etc.)?

- Do you currently use a walking or fitness application to track your step counts or your general physical activity progress (e.g., Fitbit Mobile Track, Google Fit)?

- Have you previously used a walking or fitness application to track your step counts or your general physical activity progress (e.g., Fitbit Mobile Track, Google Fit)?

- Could you please inform us about the walking or fitness applications you currently use or previously used? Please, choose all applicable.

2. User Motivational Appeal:

I assessed the motivational appeals of the participants using the ARCS motivational model scale [284] [148]. I adapted the motivational scale questionnaire to the PA context. Each motivational statement was measured using a 5-point Likert scale ranging from "1 = Strongly Disagree" to "5 = Strongly Agree" to assess the level of participants' agreement. Table 9 summarizes the ARCS motivational statements included in the study (adapted from [209]).

Table 9: Statements for Evaluating the ARCS Motivational Model Constructs.

Constructs	Statements
Attention	1. The app would capture and hold my attention. 2. The app has some content that stimulates my curiosity.
Relevance	1. The content of the app would be relevant to me. 2. I can relate with the content of this app. 3. The content of the app makes sense to me. 4. The content of the app would be useful to me.
Confidence	1. It would be easy to understand and use the app. 2. The app would help me control my physical activity. 3. The app would build my confidence in my ability to be physically active.
Satisfaction	1. I would really enjoy using the app. 2. It would be a pleasure to work with an app like this.

	3. The app would help me accomplish my behavior goal.

3. Perceived Persuasiveness:

I used the perceived persuasiveness scale to get participants' feedback on the perceived effectiveness of each implementation of the persuasive strategies. This scale is a validated instrument that has been used in other PT research [76] [213] [210] [207]. I adapted the scale to meet the PA context. Each perceived persuasiveness statement was measured using a 7-point Likert scale ranging from "1 = Strongly Disagree" to "7 = Strongly Agree" to measure participants' agreement. The perceived persuasiveness scale included in the study consists of the following statements:

- The feature would *convince* me to increase my physical activity level (e.g., step count).
- The feature would *influence* me to reduce my time spent sedentary (e.g., sitting).
- The feature would be *personally relevant* for me.
- The feature would make me *reconsider* my physical activity behaviors.
- The feature would *make me or motivate me* to use the app.

4. Stages of Behavior Change:

I examined the participants' readiness or tendency to change their undesirable health behaviors and attitude, such as their lack of PA, by employing five multiple-choice SoC questions in the TTM adapted from [103] [218]. Participants were required to select only one option from the SoC to reveal their current change status. I adapted the SoC questions to fit the context of PA, and they are as follows:

- **Precontemplation:** I do not engage in regular exercise and have no intention to start exercising in the future.
- **Contemplation:** I am not exercising currently, but I am planning to start within six months.

- **Preparation:** I am seriously considering starting to exercise and have taken some steps toward this objective.
- **Action:** I have been exercising consistently for up to six months.
- **Maintenance:** I have maintained an active lifestyle for more than six months.

5. Persuasive Strategies Implementation Preferences and Prototype Development:

I adapted a validated methodology that has been employed by other HCI researchers [207], [210], [213], [284], [19], [218], [140]. Specifically, I provided two different prototype implementations for each persuasive strategy in the design of the PA app. Therefore, I developed two implementations for each of the 12 persuasive strategies included in the online survey totaling 24 prototypes representing the 24 persuasive strategies' implementations. Then, I evaluated the persuasiveness of the 24 implementations by displaying a prototype mobile interface that illustrates each persuasive strategy feature in the survey.

The low-fidelity prototypes underwent a comprehensive testing and iterative evaluation process, during which they were rigorously examined by 16 experts specializing in HCI and PT. The insights and feedback from these experts played a pivotal role in shaping the subsequent revisions made to the low-fidelity prototype of a persuasive mobile PA application. Consequently, I proceeded to enhance and develop the high-fidelity prototypes, which underwent a series of iterative assessments by the same group of experts and underwent pilot evaluations. This process aimed to refine and optimize the mobile PA application prototypes to ensure they were comprehensible to a broad and diverse user base from various backgrounds. Furthermore, two researchers further examine and compare the findings, considering the outcomes from our comprehensive literature review and the perspectives of HCI researchers and experts in our Persuasive Computing lab. This examination guides the final decision-making process for selecting the persuasive strategies and their implementations for the high-fidelity prototypes.

Each prototype implementation of the persuasive strategies included one, two, or three distinct screen designs, each representing specific app features. These designs were curated to facilitate active engagement and interaction among potential users with the proposed PA application functionalities.

Subsequently, the invaluable feedback and comments garnered from the experts and the pilot evaluations were incorporated into the final iterations of the PA application prototypes. This rigorous refinement process was aimed towards ensuring that each prototype implementation remained user-friendly and easily accessible to the intended target audience. To further enhance user understanding, detailed descriptions of the features embedded within each prototype were provided.

Figure 54 displays examples of the prototype implementations of two persuasive strategies (rewards and goal-setting) and two ways of implementing each persuasive strategy. To avoid possible bias due to the order of strategies implementation prototypes in the survey, I employed a Latin square to balance the order presenting the implementations' features. I used the rotation functionality of the Dalhousie (Dal) Opinio software, which changes the order of the implementations automatically for each participant. Dal Opinio is a comprehensive survey software application that allows researchers (e.g., faculty members and students) to create and publish surveys quickly and easily using a typical web browser, which can be operated effectively through various technology platforms such as computers, laptops, mobile phones, and tablets [3].

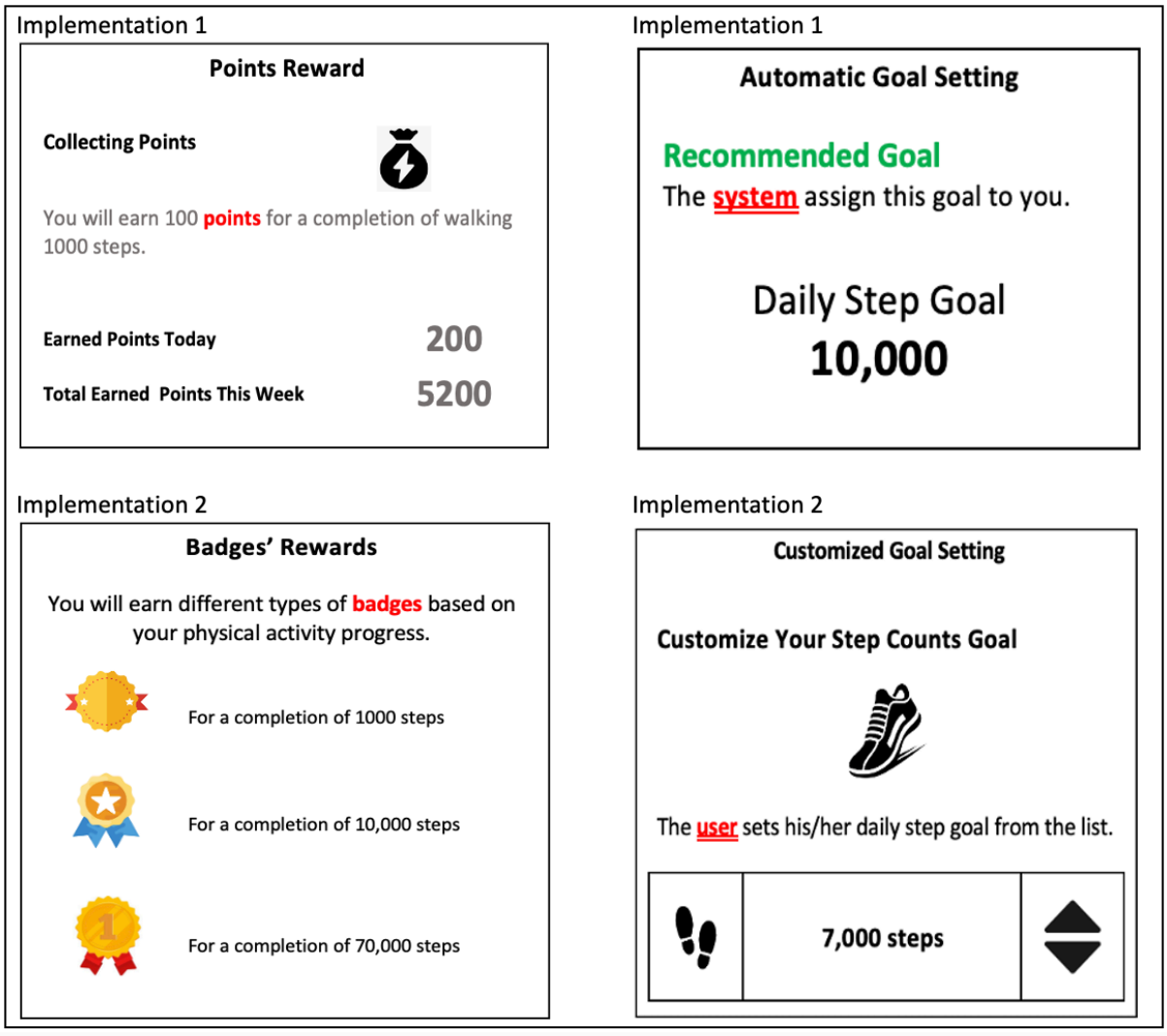


Figure 54: Prototype of the Implementations of Rewards and Goal-setting Strategies.

I included both closed-ended and open-ended questionnaires in the online survey. The open-ended questions allow participants to give their feedback and comments to justify their selections or ratings by expressing their thoughts, recommendations, opinions, and feelings (e.g., which features they like or dislike and why). These open-ended questions not only ensure that participants engage actively with the survey questions, as they also encourage them to take adequate time before making quick or arbitrary decisions regarding each app feature [19].

I provided participants with an online consent form before starting the survey. They filled out and completed the survey anonymously (i.e., no names were collected from participants). I included

attention statements (questions) throughout the survey to ensure that participants would not provide random answers or selections. This was done to encourage them to carefully read and answer all the questions. As a result, if a participant answered the attention questions inaccurately, their response was not included in the data analysis.

6.3.4 Data Collection

To collect data for our research study, I conducted a large-scale online user study including participants (Arabic and non-Arabic) recruited via diverse approaches. I recruited participants through Dalhousie University email announcements (for both academic and non-academic populations) as I posted a recruitment advertisement on today@dal, which is a society newsletter for faculty members, staff, and research students used to post and display university events, highlights, and announcements (e.g., a user study recruitment via an online survey) [277]. The recruitment announcement email was also sent via email groups for graduate and undergraduate computer science students (e.g., cs-jobs@kil-lsv-2its.dal.ca).

I received ethical research approval from the Research Ethics Board at Dalhousie University (see Appendix C). I used Dal Opinio website software to establish the online survey (Arabic and English) versions. Participants were provided with a consent form to read that is located on the first page of the online survey. The consent form included detailed information about the study and informed participants about the type of data that will be collected. I posted the survey link on different platforms, including social networking sites and emails. Thus, all participants had to give their consent before beginning the survey.

Participants had the right to agree or disagree with the consent. Agreement led the participants to begin the study by moving to the next page of the survey, while disagreement stopped them from starting the study, as the first survey page would close. The participants had the choice to withdraw from the study at any time without consequences and with an affirmation of confidentiality and anonymity. I discarded all the surveys the participants partially completed. If participants completed the survey and then chose to withdraw, I would not be able to remove their obtained data due to anonymity unless they had given their email to enter into a draw for gift card compensation. I solely used the participants'

email addresses to send the (gift card) compensation. However, if participants' information has been analyzed or published in international journals or conferences, I will not be able to remove their data.

I also recruited public participants via posting on social networking sites and apps (e.g., Facebook, Twitter/X, Snapchat, WhatsApp, Telegram, LinkedIn). The WhatsApp and Telegram messenger app group and channel members have no personal relations with the lead researcher. I tried to reach some authoritative organizations to participate in our study by posting the survey on their official social media accounts such as the the Dalhousie Kinesiology Society in Canada. Furthermore, I posted the recruitment script on Kijiji, which is an online advertising website that allows people to engage in personal business, find jobs, and exchange services and goods [292].

Besides sharing the online survey through Kijiji and other social media sites, I used the Amazon Mechanical Turk (MTurk) platform to recruit more people and obtain a large volume of data. Amazon MTurk is an online marketplace that assists individuals and businesses in outsourcing their virtual jobs and tasks to be performed by others [271]. MTurk is a practical and effective platform commonly utilized by researchers to recruit participants for their user studies. I chose MTurk for three main reasons. First, MTurk is a reliable and accepted method for collecting data and responses from various populations and has been employed in many HCI studies [140], [210], [19], [218], [207]. Second, MTurk is an ideal platform to use to get a large number of participants from a wide range of populations. Third, MTurk distributes surveys securely and effectively to worldwide populations at a reasonably low cost with a high quality [45], [177].

I distributed the Arabic version of the survey to the Arabic audience by posting it on various Arabic social forums, channels, groups, and authoritative organizations using social networking sites and apps (e.g., Facebook, Twitter/X, WhatsApp, Telegram, LinkedIn, and organizations' official social media accounts). By constructing the online survey in Arabic language and targeting Arab social networks, I ensured that the participants were Arabic individuals.

Specifically, I posted the online Arabic survey on Facebook groups and forums such as Arab Society, The Arabians Fact, Saudia Arab, Arab Business Club, Arab World, Arabi Architects Society (AAS), Arab Socials, The Arabs Group, Arab Marketer Society, Arab Countries, Muslim Groups, Saudi Arabian JOBs, and The Arabs Group in Bahrain. On Telegram, I posted in groups such as KuCoin

Arabic Community, Saudi Universities' Instructors and Lecturers, Ministry of Higher Education Inquiries, Arab Knowledge Ambassadors, Emirates Society, Arabic Students' Association, Group News Egypt, RT Arabic, and Binance Arabic. On Twitter/X, I shared the survey on public accounts such as Arab Best, Arab Science Club, Arabic Special Education, General Science and Culture for Arabic Saudi Electronic University, Saudi Aramco, ArabicLit, and ArabicAdab. Additionally, I posted the survey in LinkedIn groups such as Jobs for Arabic Speakers, Association of Arabic Teachers, Arab Unity School, Job Arabia, and Saudi Arabia Business and Job Opportunities and Technology Initiatives. Furthermore, I reached out to authoritative organizations to participate in our study by posting the survey on their official social media accounts, including the National Center for Social Studies in the Kingdom of Saudi Arabia (KSA), the forum of Teaching Assistants and Lecturers in Saudi Universities, the Imam Abdulrahman Bin Faisal University Society in the KSA, the Cairo University Society in Egypt, and Zayed University in the United Arab Emirates (UAE). I aimed to target Arab individuals living in Arab countries; therefore, I included two questions in our online survey about their country of origin and country of residence to ensure that respondents were Arabs residing in Arabic countries. Despite distributing the Arabic survey across multiple social networking sites and apps, the response rate from the Arabic population was slower compared to the non-Arabic population, which required reposting the survey periodically. Consequently, it took a longer time to collect data from Arabic participants for our user study.

The target populations of the study are Arabic and non-Arabic populations. People who live in various environments and countries will have different cultures and beliefs, which will influence their opinions, PA levels, behaviors, and attitudes. Therefore, to accommodate Arabic participants, I translated the English version of the survey to the Arabic language. I evaluated and validated the translations with the help of native Arabic HCI researchers and Ph.D. holders at Dalhousie University. Thus, I distributed the Arabic version of the survey to the Arabic audience, while the English version was distributed to the non-Arabic audience. Figure 55 shows the flowchart of assigning Arabic and English versions of the online survey.

Before the recruitment for the main study, I conducted two pilot studies to ensure the suitability and clarity of the survey's questions to the participants, avoid any mistakes, and examine the validity of the study instruments. I conducted the first pilot study using the English survey with ten random

students from the university and ten participants from MTurk. The second pilot study using the Arabic survey was conducted on 20 random Arabic students from Dalhousie University. Figure 56 presents the flowchart of participants' recruitment in the user study.

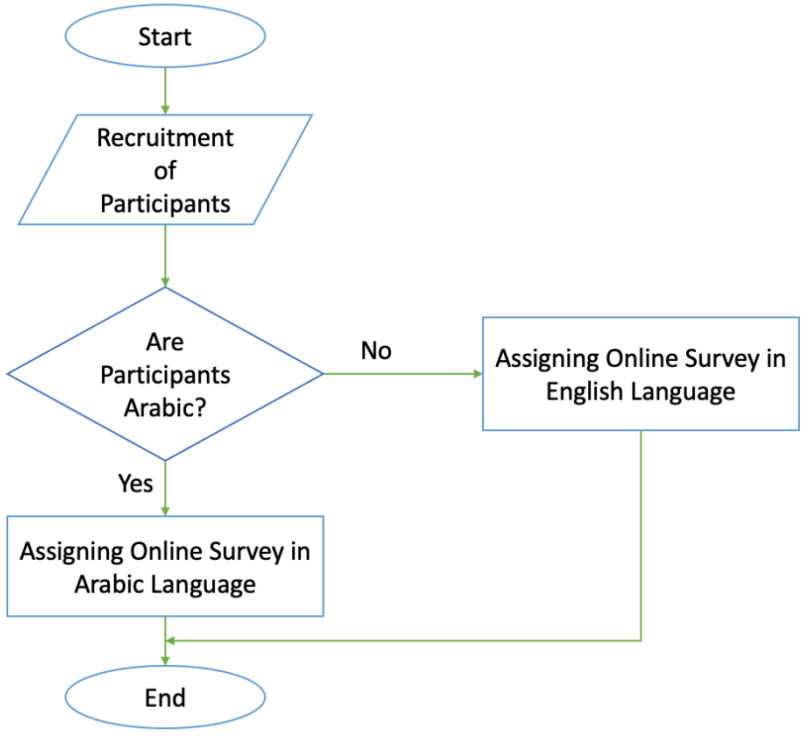


Figure 55: Flowchart of Assigning Arabic and English Versions of the Online Survey.

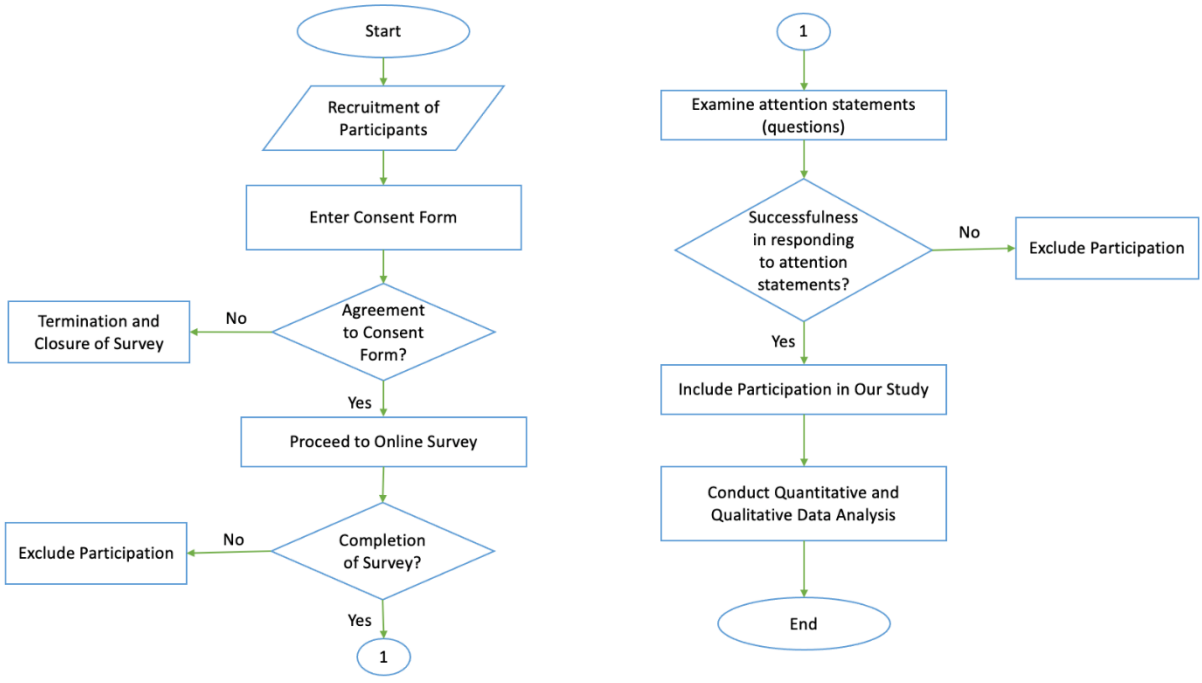


Figure 56: Flowchart of Participants' Recruitment in Our User Study.

I constructed the online survey for our user study using Dal Opinio, a comprehensive survey software application [3]. In designing the online survey for our user study, I employed a within-subject (or repeated measures) study design, where each participant evaluated the two implementations (prototypes) of each of the twelve persuasive strategies included in our study [37]. I structured the user study (an online survey) to enable participants to assess the features of each implementation (presented as a high fidelity prototype) and provide their preferences, opinions, ratings, justifications, and recommendations for future PA app design. Consequently, there is no actual PA app to be downloaded or prototype design link to view. The high-fidelity prototypes were included as screenshots in the survey. To prevent bias from the presentation order (order effect), I varied the order in which the prototypes were presented to participants.

To prevent individuals from submitting the survey multiple times, I set the "Allow Multiple Submissions" option in Dal Opinio to "No," ensuring each participant could submit the survey only once [3]. Additionally, for participants recruited via Amazon MTurk, I created a Qualification Type to

automatically assign to those who have completed the survey, preventing them from participating more than once [271].

To mitigate random submissions, I incorporated attention-check questions into the survey. Participants who failed to respond correctly to at least one of these questions were excluded from the study. Additionally, I addressed monotonous response patterns by analyzing participants' answers to both quantitative (closed-ended) and qualitative (open-ended) questions. Responses that exhibited repetitive patterns or consistent answer styles were also excluded from the study. Furthermore, the average time participants need to complete the survey is about 30 to 40 minutes. To further ensure data quality, I investigated and checked the time each participant spent completing the survey. If the time was too short (e.g., 10 minutes or less), those responses were excluded from our user study.

For the data collection process involving Arabic participants, I received a total of 707 responses. Out of these, 157 participants were excluded based on data quality checks. Specifically, 83 participants did not complete the survey, 52 participants failed the attention-check questions, 13 participants submitted the survey in a short time (e.g., less than 10 minutes), and 9 participants exhibited monotonous response patterns (e.g., repetitive answering or using the same selection style in multiple-choice questions). Consequently, 550 participants from the Arabic population were included in our user study.

During the data collection process for non-Arabic participants, a total of 825 responses were obtained. After conducting data quality checks, 275 responses were excluded. The exclusions included 108 participants who did not complete the survey, 87 who failed attention-check questions, 37 who finished the survey too quickly (e.g., less than 10 minutes), and 43 who showed repetitive or monotonous response patterns. As a result, 550 non-Arabic participants were included in the final study.

6.3.5 Participant Demographic Information

The target participants are from two populations: Arabic and non-Arabic. I included a total of (n=1100) participants, with half of that number from each population. I needed to recruit a large number of participants to ensure the participation of a wide range of populations in terms of age and gender variances, interests and hobbies, perceived persuasiveness, SoC, motivational affordances, and

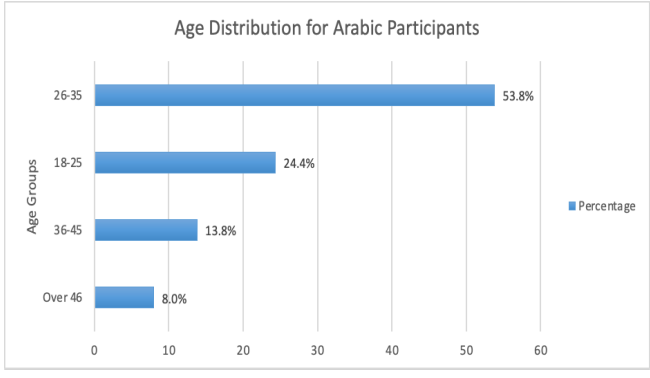
expertise and background with technologies (e.g., mobile PA apps). I included the responses in our analysis after filtering out incorrect and incomplete ones according to the attention-check questions [177].

I created Arabic and English versions of our online survey because one of our study's main objectives is to assess the comparative appeal of the designated persuasive strategies and their implementations of a PA mobile app across Arabic and non-Arabic populations and examine cultural variations within the Arabic populations. Our inclusion criterion for Arabic and non-Arabic populations is that they must be adults (18 years or older). I provided the English version of the online survey to the eligible participant residents in non-Arabic countries (e.g., USA, Canada, Australia) who are proficient in the English language. For the Arabic survey, I distributed it to the Arabic participant residents in Arabic countries (e.g., Oman, Qatar, KSA, Bahrain, UAE) who are proficient in the Arabic language. Demographically, our participants from both the Arabic and non-Arabic populations showed diversity across various factors including age, gender, marital status, educational level, employment status, and their current stages of behavior change, as displayed in Table 10 and Table 11.

For the Arabic population, our demographic findings reveal that 53.6% were male, 46.4% were female, and 0.0% were of 'other' gender. Furthermore, our findings show that the most frequently represented age group was individuals aged 26 to 35 years, with 53.8%, while the least frequently represented age group was above 46 years (8.0%). Most Arabic participants were married (69.1%), while (29.1%) were single. Additionally, 80.4% of the participants have a full-time job, while only 6.5% were not working or seeking employment. Moreover, most of our Arabic participants were educated, with 59.3% having a bachelor's degree, 24.0% having a master's degree, and only 1.1% having less than a high school degree. Most of the Arabic participants were from Saudi Arabia (32.0%), followed by Qatar (10.7%), UAE (10.5%), Bahrain (9.5%), Kuwait (8.7%), Oman (4.7%), Yemen (4.5%), Egypt (4.4%), Jordan (3.6%), and Sudan (2.4%). Furthermore, among the Arabic participants, the majority were in the Preparation stage of behavior change (28.4%), followed by the Contemplation stage (23.1%), the Precontemplation stage (19.5%), the Action stage (17.8%), and the Maintenance stage (11.3%) (see Figure 57).

Table 10: Demographic Information of the Arabic Participants.

Demographic Characteristics	Outcomes
Age	18–25 (24.4%), 26–35 (53.8%), 36–45 (13.8%), Over 46 (8.0%)
Gender	Male (53.6%), Female (46.4%), Other (0.0%)
Marital Status	Single (29.1%), Married (69.1%), Widowed (0.2%), Divorced (1.3%), Separated (0.2%), Other (0.2%)
Education Level	Less than High School (1.1%), High School or equivalent (8.9%), College diploma (3.6%), Bachelor's degree (59.3%), Master's degree (24.0%), Doctoral degree (2.5%), Other (0.5%)
Employment Status	Employed (Full-time job) (80.4%), Employed (Part-time job) (5.8%), Not working, seeking employment (7.3%), Not working, Not seeking employment (6.5%)
Stage of Change	Precontemplation (19.5%), Contemplation (23.1%), Preparation (28.4%), Action (17.8%), Maintenance (11.3%)



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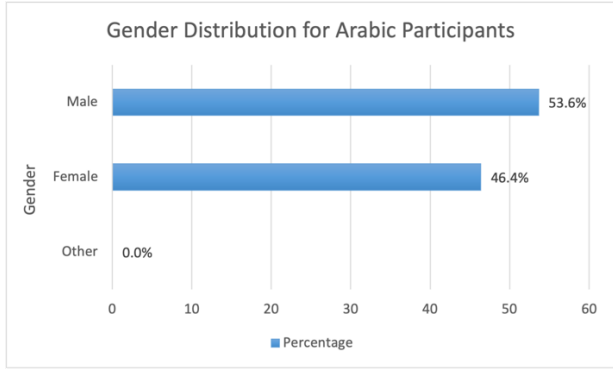

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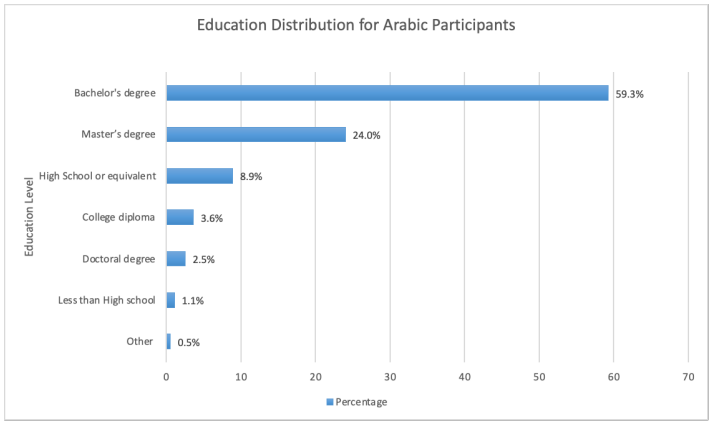
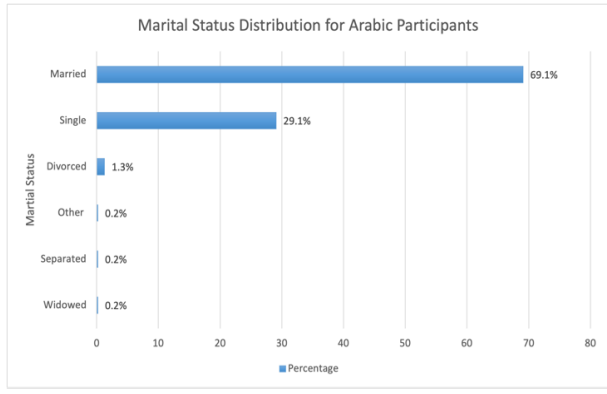
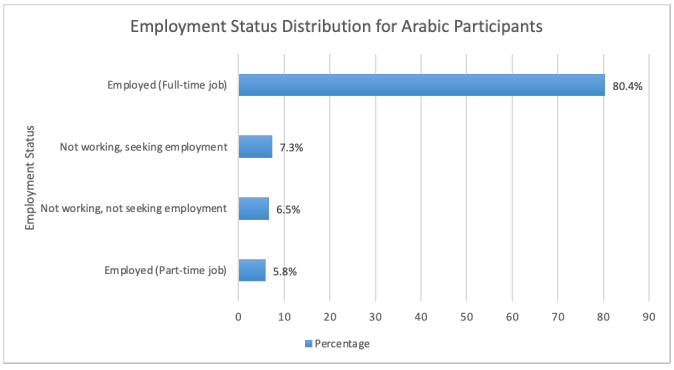

Education Distribution for Arabic Participants
Education Level
Bachelor's degree
Master's degree
High School or equivalent
College diploma
Doctoral degree
Less than High school
Other
59.3%
24.0%
8.9%
3.6%
2.5%
1.1%
0.5%
0
10
20
30
40
50
60
70
Percentage

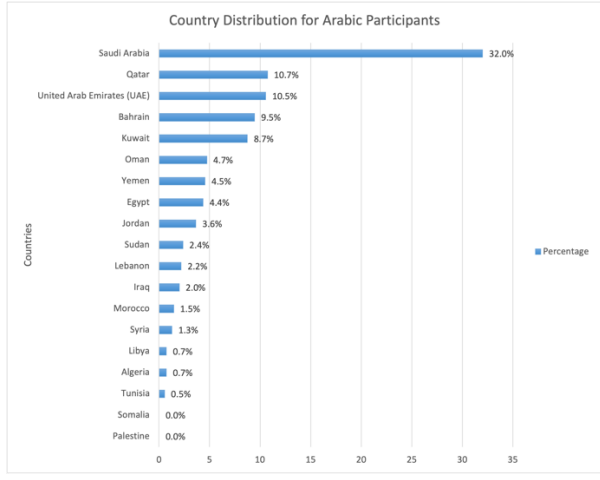
C


Marital Status Distribution for Arabic Participants
Martial Status
Married
Single
Divorced
Other
Separated
Widowed
69.1%
29.1%
1.3%
0.2%
0.2%
0.2%
0
10
20
30
40
50
60
70
80
Percentage

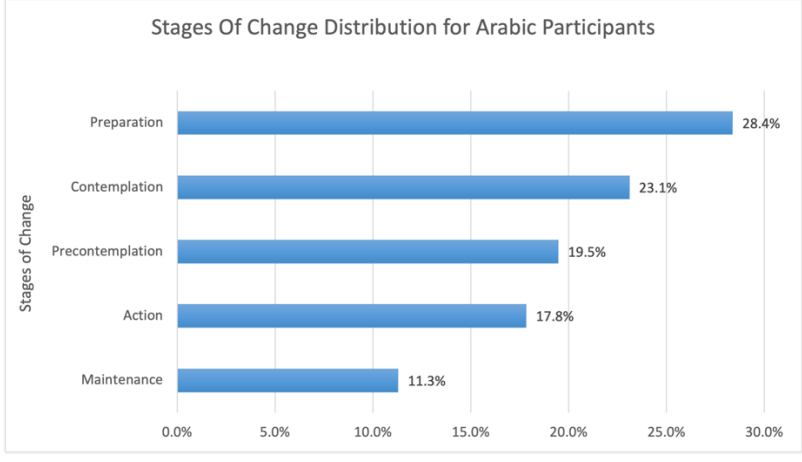
D


Employment Status Distribution for Arabic Participants
Employment Status
Employed (Full-time job)
Not working, seeking employment
Not working, not seeking employment
Employed (Part-time job)
80.4%
7.3%
6.5%
5.8%
0
10
20
30
40
50
60
70
80
90
Percentage

E


Country Distribution for Arabic Participants
Countries
Saudi Arabia
Qatar
United Arab Emirates (UAE)
Bahrain
Kuwait
Oman
Yemen
Egypt
Jordan
Sudan
Lebanon
Iraq
Morocco
Syria
Libya
Algeria
Tunisia
Somalia
Palestine
32.0%
10.7%
10.5%
9.5%
8.7%
4.7%
4.5%
4.4%
3.6%
2.4%
2.2%
2.0%
1.5%
1.3%
0.7%
0.7%
0.5%
0.0%
0.0%
0
5
10
15
20
25
30
35
Percentage

F


Stages Of Change Distribution for Arabic Participants
Stages of Change
Preparation
Contemplation
Precontemplation
Action
Maintenance
28.4%
23.1%
19.5%
17.8%
11.3%
0.0%
5.0%
10.0%
15.0%
20.0%
25.0%
30.0%

G

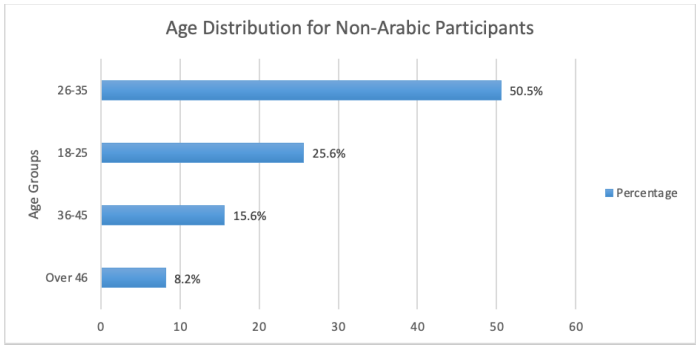
Figure 57: Demographic Information of the Arabic Participants. A) Age Distribution, B) Gender Distribution, C) Education Distribution, D) Marital Status Distribution, E) Employment Status Distribution, F) Country Distribution, and G) Stages of Change Distribution

Based on our findings, the demographics for the non-Arabic population are as follows: 60.4% were male, 39.5% were female, and 0.2% identified as 'other' gender. The majority fell within the 26 to 35 age group (50.5%), while the lowest group was aged above 46 years (8.2%). Concerning marital status, 57.8% were married, and 39.5% were single. For employment status, 73.8% held full-time jobs, while only 1.5% were not employed or were seeking jobs. Regarding education, 49.8% had a bachelor's degree, 17.3% held a master's degree, and none of the non-Arabic participants (0.0%) had less than a high school degree. Most of the non-Arabic participants were from USA (49.6%), followed by India (19.5%), Canada (14.9%), UK (9.1%), and Australia (2.4%). Furthermore, among the non-Arabic participants, the majority were in the Action stage of behavior change (30%), followed by the Preparation stage (24%), the Maintenance stage (18.9%), the Precontemplation stage (14.9%), and the least in the Contemplation stage (12.2%) (see Figure 58).

Table 11: Demographic Information of the Non-Arabic Participants.

Demographic Characteristics	Outcomes
Age	18–25 (25.6%), 26–35 (50.5%), 36–45 (15.6%), Over 46 (8.2%)
Gender	Male (60.4%), Female (39.5%), Other (0.2%)
Martial Status	Single (39.5%), Married (57.8%), Widowed (0.4%), Divorced (1.8%), Separated (0.2%), Other (0.4%)
Education Level	Less than High school (0.0%), High School or equivalent (9.3%), College diploma (21.5%), Bachelor's degree (49.8%), Master’s degree (17.3%), Doctoral degree (1.5%), Other (0.7%)
Employment Status	Employed (Full-time job) (73.8%), Employed (Part-time job) (21.3%), Not working, seeking employment (3.5%), Not working, Not seeking employment (1.5%)

Stage of Change	Precontemplation (14.9%), Contemplation (12.2%), Preparation (24%), Action (30%), Maintenance (18.9%)



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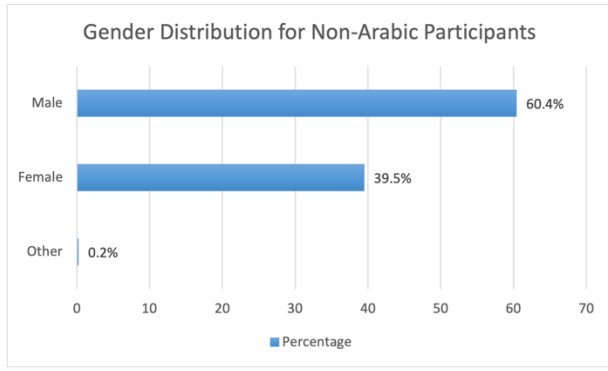

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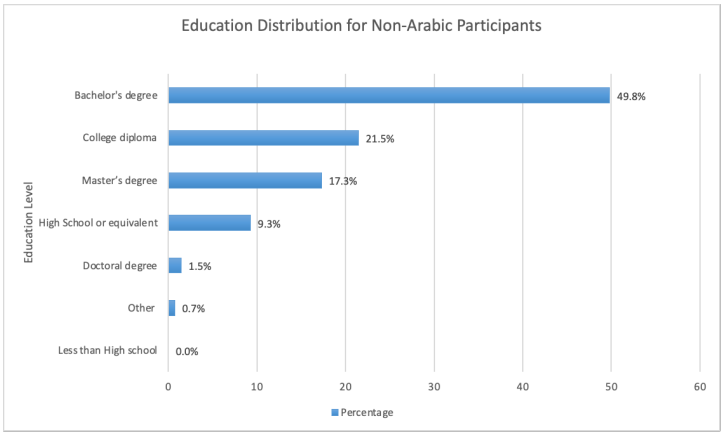

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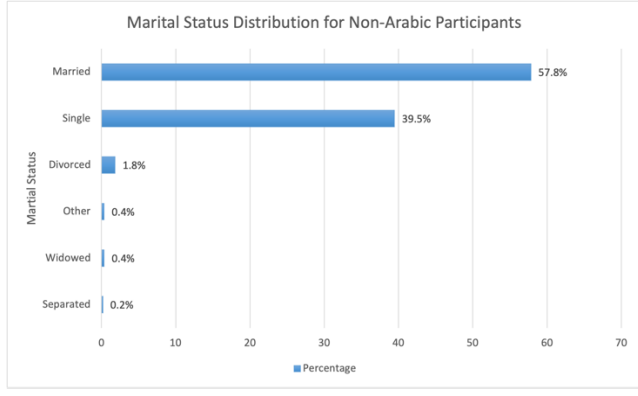

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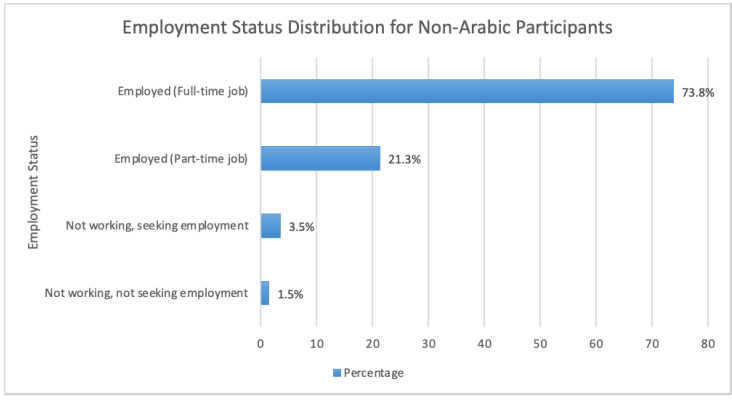

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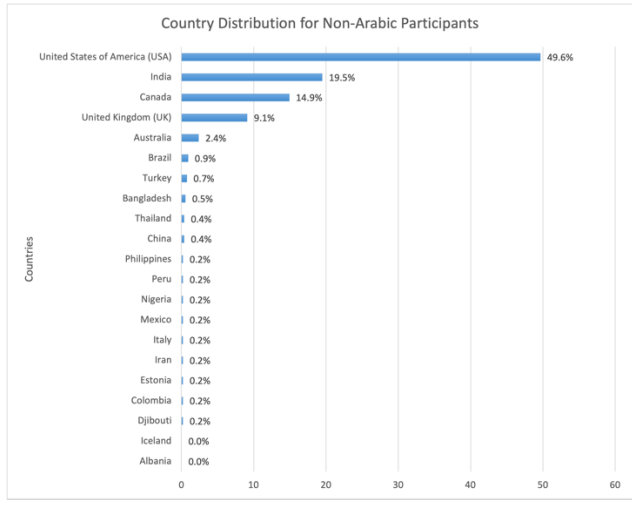

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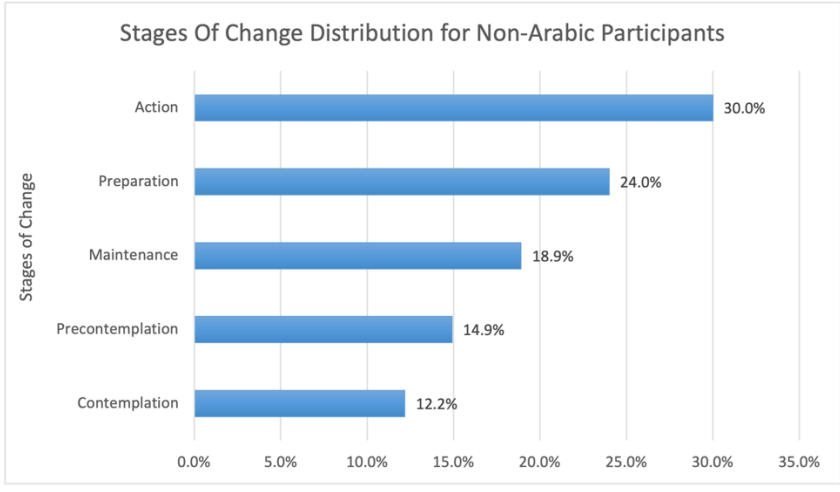

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Figure 58: Demographic Information of the Non-Arabic Participants. A) Age Distribution, B) Gender Distribution, C) Education Distribution, D) Marital Status Distribution, E) Employment Status Distribution, F) Country Distribution, and G) Stages of Change Distribution.

6.3.6 Data Analysis

To analyze the data, I employed reliable and popular analytical tools, procedures, and techniques that have been used in different research studies [207], [19], [218]. Below, I summarize the various steps I took to analyze the data.

1. I computed the statistical findings (quantitative data) for demographic variables.
2. I determined the suitability of the data for the analysis by employing Kaiser-Meyer-Olkin (KMO) sampling adequacies and the Bartlett Test of Sphericity [143] using SPSS software. These examinations will test the whole data's sufficiency and the redundancy between the data variables. Suitable factor-analytic data must have a KMO measure of at least 0.8, while the recommended KMO value should not be less than 0.6 [143]. It is essential to employ these examinations before conducting detailed data analysis, specifically in multi-variable models.
3. To inspect and compare the persuasiveness of the strategies overall across the two implementations for each population (Arabic and non-Arabic), I computed the average score for each strategy used. Consequently, I performed a repeated measure ANOVA (RM-ANOVA) of variance analysis followed by pairwise comparison [137], [243] after ensuring the validation for the ANOVA assumptions using SPSS.
4. I employed a one-sample t-test [200], [281] to determine the persuasiveness of distinct implementations using a midpoint rating of 4.0 as the check value. Thus, I computed the average rating of the five perceived persuasiveness questionnaire items on a 7-point Likert scale for each population (Arabic and non-Arabic) to identify the persuasiveness score for each implementation of a strategy and the overall persuasiveness score of each persuasive strategy.
5. I employed a two-way mixed ANOVA [136], [280], [306] for the between-subject comparison between Arabic and non-Arabic populations, examining both overall strategies and the two implementations of each persuasive strategy used in the user study.
6. I employed partial least squares (PLS) structural equation modeling (SEM) (PLS-SEM) [253] to create models presenting the relationships between the persuasiveness of the strategies' implementations and the ARCS motivational constructs with respect to the individuals' SoC. PLS-SEM is a well-known approach for structural equations modeling that estimates path models and discovers complex inter-relationships between variables [253]. I decided to use the PLS-SEM approach rather than others (e.g., covarying-based) because PLS-SEM is exceptionally applicable and recommended for complex predictive models [158], and many HCI researchers have successfully used it to estimate the relationships between variables in

their studies [25], [76], [210], [205]. I used the SmartPLS 4 tool for SEM, as it is a reliable approach for developing models and finding modeling relationships between variables [236].

7. I employed multigroup comparison using the multigroup analysis function in SmartPLS to discover the differences through models for participants at various SoC and likelihoods for tailoring a persuasive PA mobile app to people's SoC [236], [254]. Before evaluating and comparing the models, I performed measurement invariance through the five SoC and determine model reliability and validity checks [110], [128], an approach that has been employed by other HCI researchers [205], [218].
8. I employed thematic analysis [42], [43], [196], [293] to recognize and analyze the qualitative data such as feedback, recommendations, and comments given by participants to justify their quantitative selections and ratings.

I elaborate further on the analysis in Sections 6.3.7 and 6.3.8.

6.3.7 Measurement Validation

As mentioned in Section 6.3.6, we assessed the suitability of our data for factor analysis using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and the Bartlett Test of Sphericity. Our findings, derived from the Arabic and non-Arabic populations, revealed KMO values of 0.976 and 0.980, respectively. These values exceeded the recommended threshold of 0.6. Additionally, the Bartlett Test of Sphericity produced statistically significant results for both the Arabic and non-Arabic populations: $\chi 2(7260) = 98512.746$, $p < .0001$, and $\chi 2(7260) = 100788.625$, $p < .0001$, respectively. These test results collectively provide evidence that our datasets are well-suited for factor analysis, as documented by Orji et al. 2013 [212].

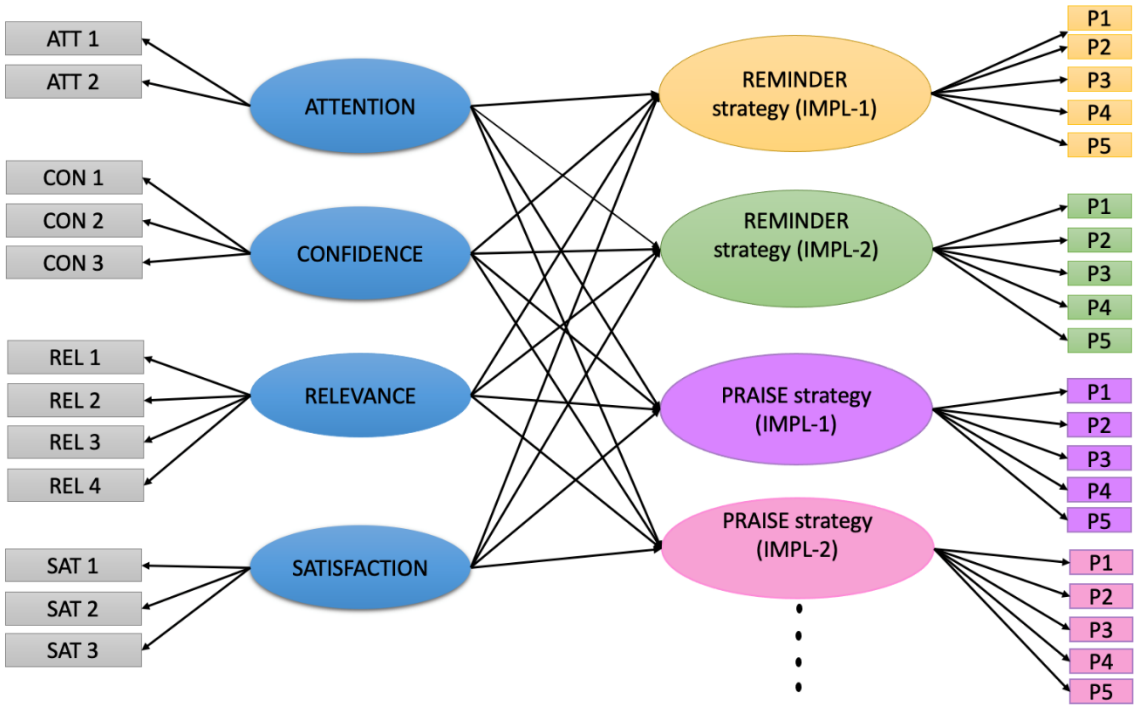


Figure 59: PLS-SEM structural model showing the relationship between the ARCS motivational constructs and the two implementations of the Reminder and Praise strategies.

After assessing the appropriateness of our data, I employed the PLS-SEM methodology to construct models demonstrating the relationships between the ARCS motivational constructs and the persuasiveness and effectiveness of each strategy's implementation for people at various stages of change. Figure 59 shows a model illustrating two implementations of the reminder and praise strategies. PLS-SEM is a recommended approach for modeling relationships among variables (Kupek 2006) [158]. As highlighted by Hair et al. (2019) [113], PLS-SEM emerges as the preferred methodology 'when the structural model is intricate, involving numerous constructs, indicators, and/or interconnections.' Adhering to established guidelines, I took steps to validate the measurement model before moving forward with estimating the structural paths for evaluating the relationships between the variables utilizing the well-defined criteria for assessing the validity and reliability of PLS-SEM models (Hair et al. 2021) [111]. Precisely, I carried out PLS-SEM model validity and reliability examinations by employing a standard set of criteria provided below.

Particularly, I examined the attributes of scales by considering three aspects: (i) indicator reliability, assessed through the use of Cronbach's alpha and composite reliability; (ii) convergent reliability,

evaluated using the average variance extracted (AVE); and (iii) discriminant validity, which was assessed using the heterotrait-monotrait (HTMT) ratio of correlations. Across all models, both Cronbach's alpha and composite reliability, which evaluate the internal consistency and the robustness of indicators and their correlations with latent variables, exceeded the recommended limit of 0.7 (Chin 1998) [54]. Additionally, I determined convergent reliability as the AVE values, which indicate the variance obtained by the latent variable from its indicators, surpassed the recommended value of 0.5 (Chin 1998) [54] (refer to Table 12). Finally, I determined discriminant validity by ensuring that the HTMT ratio of correlations, utilized to evaluate discriminant validity, remained below the recommended value of 0.9 (Henseler, Ringle, and Sarstedt 2015) [127]. In brief, our measurement models produced satisfactory values across all indices for validating and ensuring the reliability of the PLS model (see Table 13).

Table 12: Cronbach's alpha, composite reliability, and AVE values of the ARCS motivational constructs and the persuasiveness of one implementation of the Praise strategy.

Variables	Cronbach's alpha *(threshold:≥ 0.7)*	Composite reliability *(threshold:≥ 0.7)*	Average variance extracted (AVE) *(threshold:≥ 0.5)*
Attention	0.705	0.871	0.772
Confidence	0.767	0.865	0.682
Relevance	0.822	0.882	0.652
Satisfaction	0.792	0.878	0.706
Persuasiveness	0.916	0.937	0.749

Table 13: Heterotrait-monotrait (HTMT) values of the ARCS motivational constructs and the persuasiveness of one implementation of the Reward strategy.

	Attention	Confidence	Relevance	Satisfaction	Persuasiveness
Attention	0.804				
Confidence	0.834	0.835			
Relevance	0.812	0.860	0.858		
Satisfaction	0.849	0.804	0.819	0.861	
Persuasiveness	0.681	0.884	0.718	0.743	0.884

Before investigating the significant variances in persuasiveness scores (path coefficients) among groups, I proactively ensured the establishment of measurement invariance to guarantee the comparability of these groups, thereby avoiding comparisons between disparate groups. I accomplished this by employing a three-step procedure structured for PLS-SEM (Henseler, Ringle, and Sarstedt 2016) [128]. Initially, I employed component-based confirmatory factor analysis (CFA) within SmartPLS 4 to perform factor analysis for each data group, retaining items with factor loadings of at least 0.5 (Hair, Ringle, and Sarstedt 2011) [112] across all groups, thereby initiating configural invariance. Next, following the established PLS-SEM technique, I initiated compositional invariance (i.e., equivalent indicator weights) and the equivalence of composite mean values and variances across groups (Henseler, Ringle, and Sarstedt 2016) [128].

Finally, to measure significant variances in path coefficients (β) between the two implementations of each strategy, I applied a methodology highlighted by Clogg, Petkova, and Haritou (1995) [59] and Gastón Sánchez (2009) [99], which has also been employed in other studies, including the work of Orji et al. (2013) [212]. After conducting measurement invariance, I executed the PLS algorithm and bootstrapping and captured the standard error (SE) and β values for each construct. These values were then utilized to compute pairwise t-statistics and the corresponding p-values to examine for significant variances in β utilizing a pairwise comparison procedure (Clogg, Petkova, and Haritou in 1995, and Gastón Sánchez in 2009) followed by a Bonferroni adjustment. A significant p-value illustrates a substantial variance in β across the implementations.

6.3.8 The Structural Model

I formed the relationships between the ARCS motivational constructs and each strategy's implementations using structural models of SmartPLS 4. This approach enabled us to assess and uncover the variances in how individuals at various stages of change perceive the different implementations of each of the twelve strategies for each population (Arabic and non-Arabic) separately (see Figure 59). Subsequently, I examined significant structural variances between the models for each stage of change by utilizing the multi-group analysis tool and approach in SmartPLS 4 (Sarstedt, Henseler, and Ringle 2011 [254] ; SmartPLS GmbH [236]). Consequently, I computed the path coefficient (β) level and the significance (p) of the path coefficient (Hair, Ringle, and Sarstedt

2011) [112]. Path coefficients determine the effect of one variable on another. In Table 22 and Table 23, I displayed the individual path coefficients (β) and their corresponding significance level (p) attained from our structural models for each stage of change of the Arabic and non-Arabic populations separately.

6.4 Results

In this section, I present the results of our data analysis based on four key aspects:

1. I compared the persuasiveness of all strategies for both Arabic and non-Arabic populations to identify the most and least preferable strategies.

2. I analyzed the persuasiveness of distinct implementations of each strategy for both Arabic and non-Arabic populations and aimed to understand the reasons behind their choices.

3. I assessed the persuasiveness of different implementations of each strategy in relation to the four ARCS motivational constructs (Attention, Relevance, Confidence, and Satisfaction) across various stages of change for both Arabic and non-Arabic populations.

4. I explored the perspectives, preferences, opinions, and recommendations of Arabic and non-Arabic participants regarding future app design.

Figure 60 shows the four main phases of the analysis for the user-study based on the research questions. Additionally, brief introductions to the four phases are provided below:

Phase 1: Overall Persuasiveness of Strategies

In this section, I employed a repeated measures analysis of variance (RM-ANOVA), treating strategies and implementations as within-subject factors. The results of the RM-ANOVA, conducted for both Arabic and non-Arabic populations, revealed significant main effects related to strategy type and implementation type, along with a noteworthy interaction between implementation and strategy. These findings indicate substantial variations in persuasiveness effects among different strategies within each population, irrespective of specific implementations. Moreover, significant distinctions emerged among the implementations themselves, emphasizing the significant interplay between implementation and strategy. Following the significant main effect and interaction, I conducted

pairwise comparisons to determine whether the implementations of each strategy differ significantly. I also conducted a two-way mixed ANOVA for a between-subject comparison of the overall effectiveness of the strategies between Arabic and non-Arabic populations.

Phase 2: Persuasiveness of Individual Implementations

In the second section, I present the results of the individual implementations of each strategy within the Arabic and non-Arabic populations. Utilizing the one-sample t-test, I observed that persuasiveness scores for different implementations significantly exceeded the midpoint rating of 4 ($p < .0001$), as determined by the 7-point Likert scale employed to assess perceived persuasiveness. This confirms that both Arabic and non-Arabic participants found the implementations to be persuasive. However, the persuasiveness levels varied between the first implementation (IMPL-1) and the second implementation (IMPL-2) within each strategy, as illustrated in Figure 66 and Figure 67. Additionally, I conducted an RM-ANOVA to evaluate whether the two implementations significantly differed in persuasiveness for each distinct persuasive strategy, with Table 17 outlining the implementation types (IMPL-1 and IMPL-2) for each individual strategy within each population. I also conducted a two-way mixed ANOVA for a between-subject comparison of the effectiveness of the implementation types (IMPL-1 and IMPL-2) for each strategy between Arabic and non-Arabic populations.

Phase 3: ARCS Motivational Constructs and Stages of Change

Moving on to the third section, I present the results of our analysis exploring the connection between various implementations of each strategy and the four ARCS motivational constructs (Attention, Relevance, Confidence, and Satisfaction) for individuals at various stages of change. Our findings highlight the significant variations in motivational appeal associated with different strategies based on implementation types observed in both Arabic and non-Arabic populations.

Phase 4: Participants' Perspectives and Recommendations for Future App Design

In the fourth section, I explore the valuable insights gathered from Arabic and non-Arabic participants. The objective here is to comprehensively understand their perspectives, preferences, opinions, and recommendations concerning the design of future iterations of the app. By exploring these user-driven insights, I aim to inform and guide the app's development to maximize user engagement, satisfaction, and overall effectiveness.

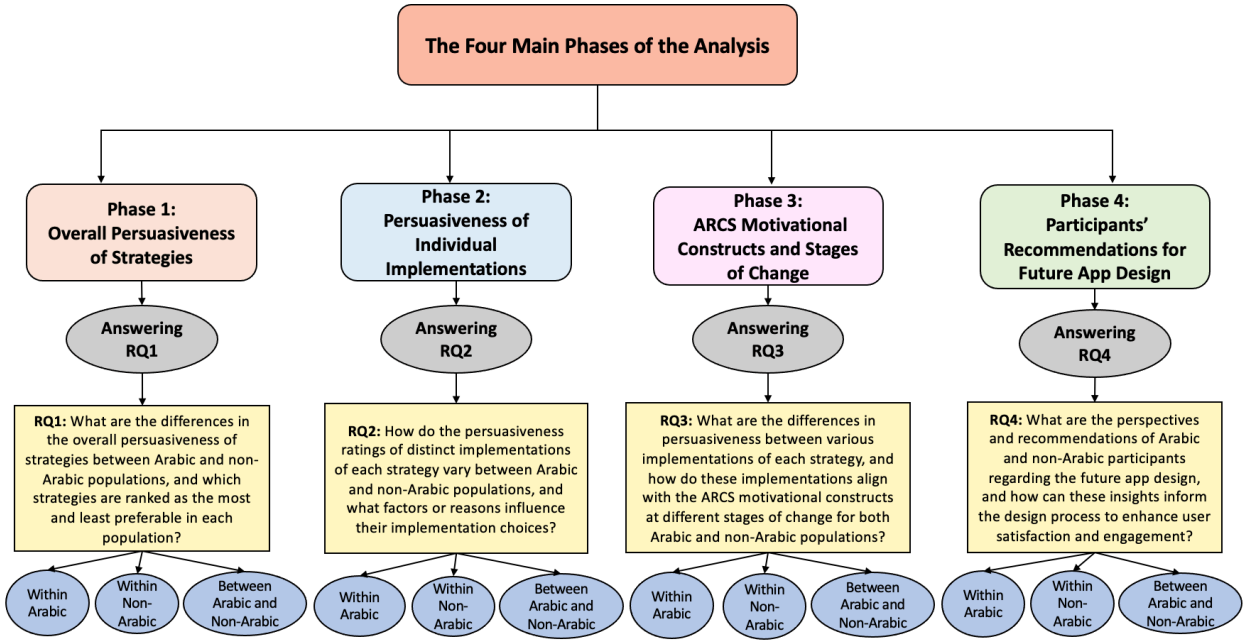


Figure 60: The Four Main Phases of the Analysis for the User-Study Based on the Research Questions.

6.4.1 Phase 1: Comparing the Persuasiveness of all the Strategies (Overall)

This section presents the comparison of our data analysis regarding the persuasiveness of all strategies (overall) for the Arabic and non-Arabic populations. I employed an RM-ANOVA with the strategies and implementations as within-subject factors. This is followed by pairwise comparisons of each strategy between the two implementations to determine whether significant differences are present in the overall effectiveness of the strategies across the two implementations. The findings of the RM-ANOVA for the Arabic and non-Arabic populations reveal significant main effects of strategy type ($F_{9.146,\ 5021.144} = 9.150$, $p < 0.0001$ and $F_{7.084,\ 3889.138} = 25.523$, $p < 0.0001$, respectively). This indicates that there are significant differences in the persuasiveness of the strategies overall within each population, irrespective of implementation. Additionally, the findings indicate significant main effects of implementation type for the Arabic and non-Arabic populations ($F_{1.000} = 549.000$, $p < 0.0001$ and $F_{1.000} = 50.599$, $p < 0.0001$, respectively). This also indicates that there are significant differences between implementations with respect to their persuasiveness. Furthermore, a significant interaction between implementation and strategy was observed for both the Arabic and non-Arabic populations ($F_{7.340,}$

$_{4029.687}$ = 92.677, $p < 0.0001$ and $F_{7.048, 3869.347} = 18.229$, $p < 0.0001$, respectively). This indicates that the perceived effectiveness of a persuasive strategy might differ across different implementations.

6.4.1.1 COMPARING THE PERSUASIVENESS OF THE OVERALL STRATEGIES AMONG THE ARABIC POPULATION

For the Arabic population, the Bonferonni-corrected pairwise comparison reveals that the tunneling strategy (Mean = 5.81, SD = 1.555) emerged as the predominantly preferred strategy, followed by goal-setting (Mean = 5.583, SD = 1.309), self-monitoring (Mean = 5.579, SD = 1.283), reminder (Mean = 5.534, SD = 1.398), simulation (Mean = 5.518, SD = 1.354), and reward (Mean = 5.483, SD = 1.451). SD refers to the standard deviation. These top six strategies show the highest persuasiveness for the Arabic population. Furthermore, the results show that the reduction strategy (Mean = 5.368, SD = 1.513) significantly differs from tunneling, as it is the least preferred overall. The remaining strategies of competition (Mean = 5.475, SD = 1.452), personalization (Mean = 5.452, SD = 1.420), praise (Mean = 5.450, SD = 1.453), suggestion (Mean = 5.408, SD = 1.459), and cooperation (Mean = 5.406, SD = 1.523) are in the second half of the list, with competition leading the list (see Figure 61). The means of all twelve persuasive strategies in our study among the Arabic population are above the midpoint "natural value" of 4, as shown by the horizontal line in the figure. Table 14 presents the results of pairwise comparisons between twelve persuasive strategies among the Arabic population (adapted from [4]). Each comparison shows the differences between one strategy and the remaining eleven strategies. A significance level of $p < 0.05$ or lower indicates a significant difference between the compared strategies.

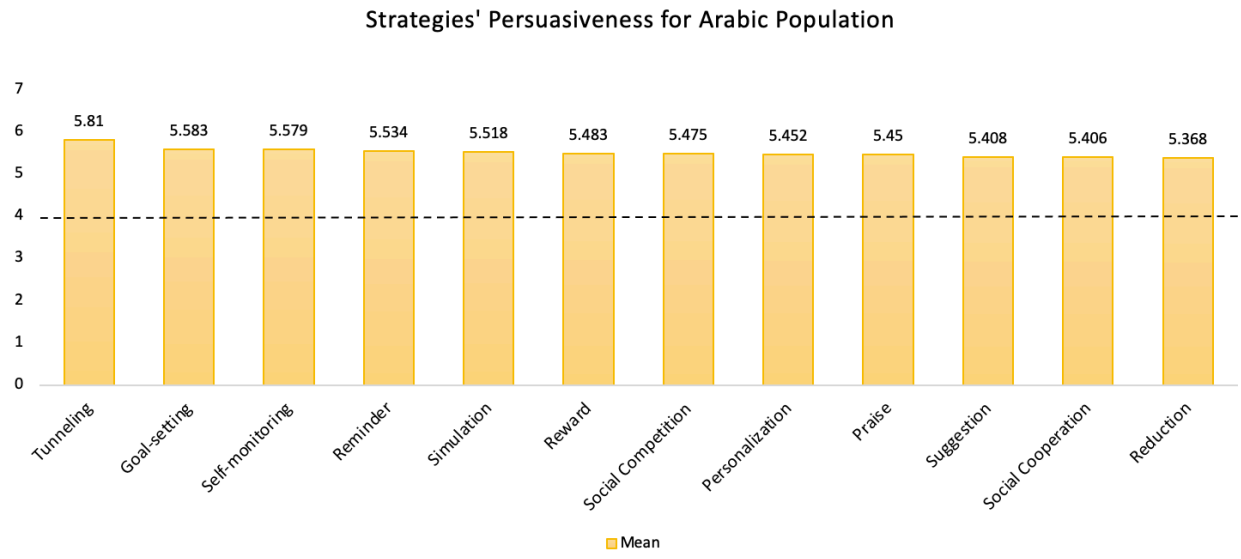


Figure 61: A Bar Chart Showing the Overall Persuasiveness of Strategies for the Arabic Population, Ranked from Most to Least Persuasive. The horizontal line indicates a neutral value of 4.

Table 14: Comparative Analysis of Twelve Persuasive Strategies: Highlighting Significant Differences ($p < 0.05$ or lower) through Pairwise Comparisons for the Arabic Population.

Strategies	Self-monitoring	Personalization	Suggestion	Goal-setting	Reminder	Reward	Praise	Reduction	Competition	Tunneling	Cooperation	Simulation
Self-monitoring	-	1.000	0.006	1.000	1.000	1.000	0.769	0.000	1.000	0.000	0.158	1.000
Personalization	1.000	-	1.000	0.424	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000
Suggestion	0.006	1.000	-	0.006	0.407	1.000	1.000	1.000	1.000	0.000	1.000	1.000
Goal-setting	1.000	0.424	0.006	-	1.000	1.000	0.276	0.001	1.000	0.000	0.016	1.000
Reminder	1.000	1.000	0.407	1.000	-	1.000	1.000	0.026	1.000	0.000	0.330	1.000
Reward	1.000	1.000	1.000	1.000	1.000	-	1.000	1.000	1.000	0.000	1.000	1.000
Praise	0.769	1.000	1.000	0.276	1.000	1.000	-	1.000	1.000	0.000	1.000	1.000
Reduction	0.000	1.000	1.000	0.001	0.026	1.000	1.000	-	0.749	0.000	1.000	0.246
Competition	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.749	-	0.000	1.000	1.000

Tunneling	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	0.000	0.000
Cooperation	0.158	1.000	1.000	0.016	0.330	1.000	1.000	1.000	1.000	0.000	-	0.848
Simulation	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.246	1.000	0.000	0.848	-

6.4.1.2 COMPARING THE PERSUASIVENESS OF THE OVERALL STRATEGIES AMONG THE NON-ARABIC POPULATION

For the non-Arabic population, the Bonferonni-corrected pairwise comparison indicates that the self-monitoring strategy (Mean = 5.382, SD = 1.136) emerged as the most favored strategy, followed by goal-setting (Mean = 5.216, SD = 1.344), rewards (Mean = 5.201, SD = 1.388), reminders (Mean = 5.184, SD = 1.396), suggestion (Mean = 5.135, SD = 1.401), and personalization (Mean = 5.098, SD = 1.421). These top six strategies show the highest persuasiveness for the non-Arabic population. Furthermore, the results show that the simulation strategy (Mean = 4.832, SD = 1.690) significantly differs from self-monitoring, as it is the least preferred overall. The remaining strategies, including reduction (Mean = 5.025, SD = 1.553), praise (Mean = 4.969, SD = 1.552), competition (Mean = 4.959, SD = 1.621), tunneling (Mean = 4.958, SD = 1.551), and cooperation (Mean = 4.932, SD = 1.627), are within the second half of the range, with reduction leading the list (see Figure 62). The means of all twelve persuasive strategies in our study among the non-Arabic population are above the midpoint "natural value" of 4, as shown by the horizontal line in the figure. Table 15 presents the results of pairwise comparisons between twelve persuasive strategies among the non-Arabic population (adapted from [4]). Each comparison illustrates the differences between one strategy and the remaining eleven strategies. A significance level of $p < 0.05$ or lower indicates a significant difference between the compared strategies.

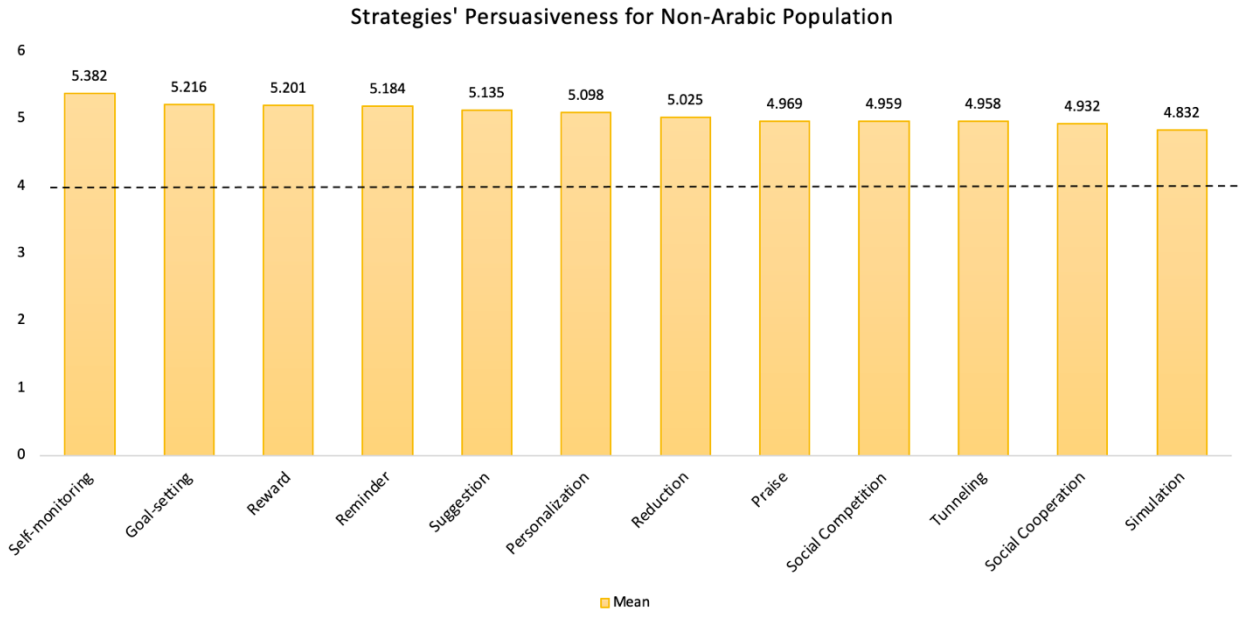


Figure 62: A Bar Chart Showing the Overall Persuasiveness of Strategies for the Non-Arabic Population, Ranked from Most to Least Persuasive. The horizontal line indicates a neutral value of 4.

Table 15: Comparative Analysis of Twelve Persuasive Strategies: Highlighting Significant Differences ($p < 0.05$ or lower) through Pairwise Comparisons for the Non-Arabic Population.

Strategies	Self-monitoring	Personalization	Suggestion	Goal-setting	Reminder	Reward	Praise	Reduction	Competition	Tunneling	Cooperation	Simulation
Self-monitoring	-	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Personalization	0.000	-	1.000	0.528	1.000	1.000	0.217	1.000	0.237	0.149	0.029	0.000
Suggestion	0.000	1.000	-	1.000	1.000	1.000	0.000	0.825	0.007	0.004	0.000	0.000
Goal-setting	0.000	0.528	1.000	-	1.000	1.000	0.000	0.002	0.000	0.000	0.000	0.000
Reminders	0.000	1.000	1.000	1.000	-	1.000	0.000	0.012	0.000	0.000	0.000	0.000
Rewards	0.001	1.000	1.000	1.000	1.000	-	0.000	0.016	0.000	0.000	0.000	0.000
Praise	0.000	0.217	0.000	0.000	0.000	0.000	-	1.000	1.000	1.000	1.000	0.049
Reduction	0.000	1.000	0.825	0.002	0.012	0.016	1.000	-	1.000	1.000	1.000	0.001

Competition	0.000	0.237	0.007	0.000	0.000	0.000	1.000	1.000	-	1.000	1.000	0.122
Tunneling	0.000	0.149	0.004	0.000	0.000	0.000	1.000	1.000	1.000	-	1.000	0.146
Cooperation	0.000	0.029	0.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	-	0.731
Simulation	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.001	0.122	0.146	0.731	-

6.4.1.3 COMPARING THE PERSUASIVENESS OF THE OVERALL STRATEGIES BETWEEN ARABIC AND THE NON-ARABIC POPULATIONS

The findings of the two-way mixed ANOVA comparison between Arabic and non-Arabic populations regarding the strategies reveal significant main effects ($F_{9.052,9939.384}$= 16.989, $p < 0.001$). Furthermore, the findings indicate that Arabic participants demonstrated a stronger preference for all twelve persuasive strategies compared to non-Arabic participants. Specifically, for the self-monitoring strategy, Arabic participants exhibited a greater preference (Mean = 5.579, SD = 1.283) than non-Arabic participants (Mean = 5.382, SD = 1.136).

Similarly, in the personalization strategy, Arabic participants showed a higher preference (Mean = 5.452, SD = 1.420) compared to non-Arabic participants (Mean = 5.098, SD = 1.421).

In terms of the suggestion strategy, non-Arabic participants displayed a lower preference (Mean = 5.135, SD = 1.401) in contrast to Arabic participants (Mean = 5.408, SD = 1.459).

For the goal-setting strategy, Arabic participants exhibited a stronger inclination (Mean = 5.583, SD = 1.309) than non-Arabic participants (Mean = 5.216, SD = 1.344).

The reminder strategy also revealed differences, with non-Arabic participants showing reduced inclination (Mean = 5.184, SD = 1.396) compared to Arabic participants (Mean = 5.534, SD = 1.398). Arabic participants were more favored in the reward strategy (Mean = 5.483, SD = 1.451) than non-Arabic participants (Mean = 5.201, SD = 1.388).

In the praise strategy, Arabic participants exhibited a stronger preference (Mean = 5.450, SD = 1.453) than non-Arabic participants (Mean = 4.969, SD = 1.552).

Arabic participants also favored the reduction strategy (Mean = 5.368, SD = 1.513) over non-Arabic participants (Mean = 5.025, SD = 1.553).

Regarding the competition strategy, non-Arabic participants demonstrated a reduced inclination (Mean = 4.959, SD = 1.621) compared to Arabic participants (Mean = 5.475, SD = 1.452).

For the tunneling strategy, Arabic participants exhibited a greater preference (Mean = 5.81, SD = 1.555) than non-Arabic participants (Mean = 4.958, SD = 1.551).

Lastly, in the cooperation strategy, non-Arabic participants showed a lower preference (Mean = 4.932, SD = 1.627) in comparison to Arabic participants (Mean = 5.406, SD = 1.523).

In summary, Arabic participants consistently favored all twelve persuasive strategies over their non-Arabic counterparts. The pairwise comparison results indicate significant differences in the persuasiveness of the twelve persuasive strategies between Arabic and non-Arabic populations (see Table 16). Figure 63 shows the persuasiveness of strategies overall for Arabic and non-Arabic participants.

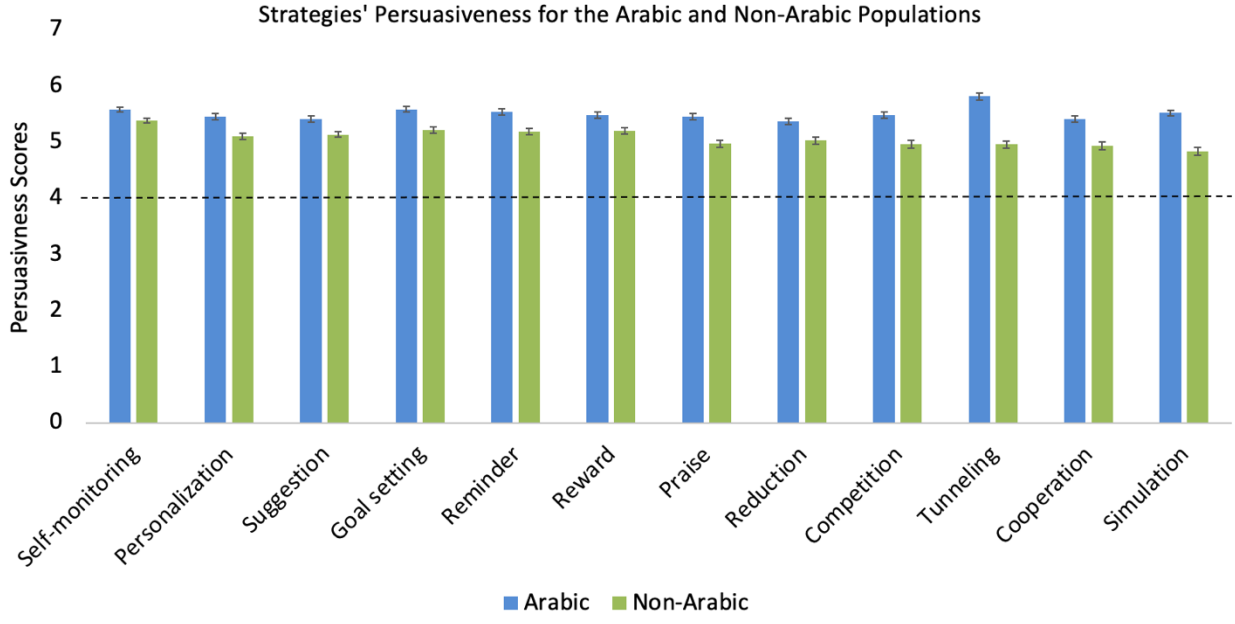


Figure 63: Persuasiveness of Strategies Overall for Arabic and Non-Arabic Participants.

Table 16: Means, Standard Deviations, and P-Values of the Persuasiveness of the 12 Persuasive Strategies Employed in the User-Study for Arabic and Non-Arabic Participants.

		Arabic		Non-Arabic		Pairwise Comparisons
#	Persuasive Strategy	Mean	Std. Deviation	Mean	Std. Deviation	P-Value
1	Self-monitoring	5.579	1.283	5.382	1.136	0.002
2	Personalization	5.452	1.420	5.098	1.421	0.000
3	Suggestion	5.408	1.459	5.135	1.401	0.000
4	Goal-setting	5.583	1.309	5.216	1.344	0.000
5	Reminder	5.534	1.398	5.184	1.396	0.000
6	Reward	5.483	1.451	5.201	1.388	0.000
7	Praise	5.450	1.453	4.969	1.552	0.000
8	Reduction	5.368	1.513	5.025	1.553	0.000
9	Social Competition	5.475	1.452	4.959	1.621	0.000
10	Tunneling	5.810	1.555	4.958	1.551	0.000
11	Social Cooperation	5.406	1.523	4.932	1.627	0.000
12	Simulation	5.518	1.354	4.832	1.690	0.000

6.4.2 Phase 2: Comparing the Persuasiveness of Individual Implementations

This section provides an analysis of the persuasiveness of distinct implementations of each strategy for both Arabic and non-Arabic populations, with the aim of understanding the reasons behind their choices. Figure 64 and Figure 65 show sample codes and themes generated from phase 2.

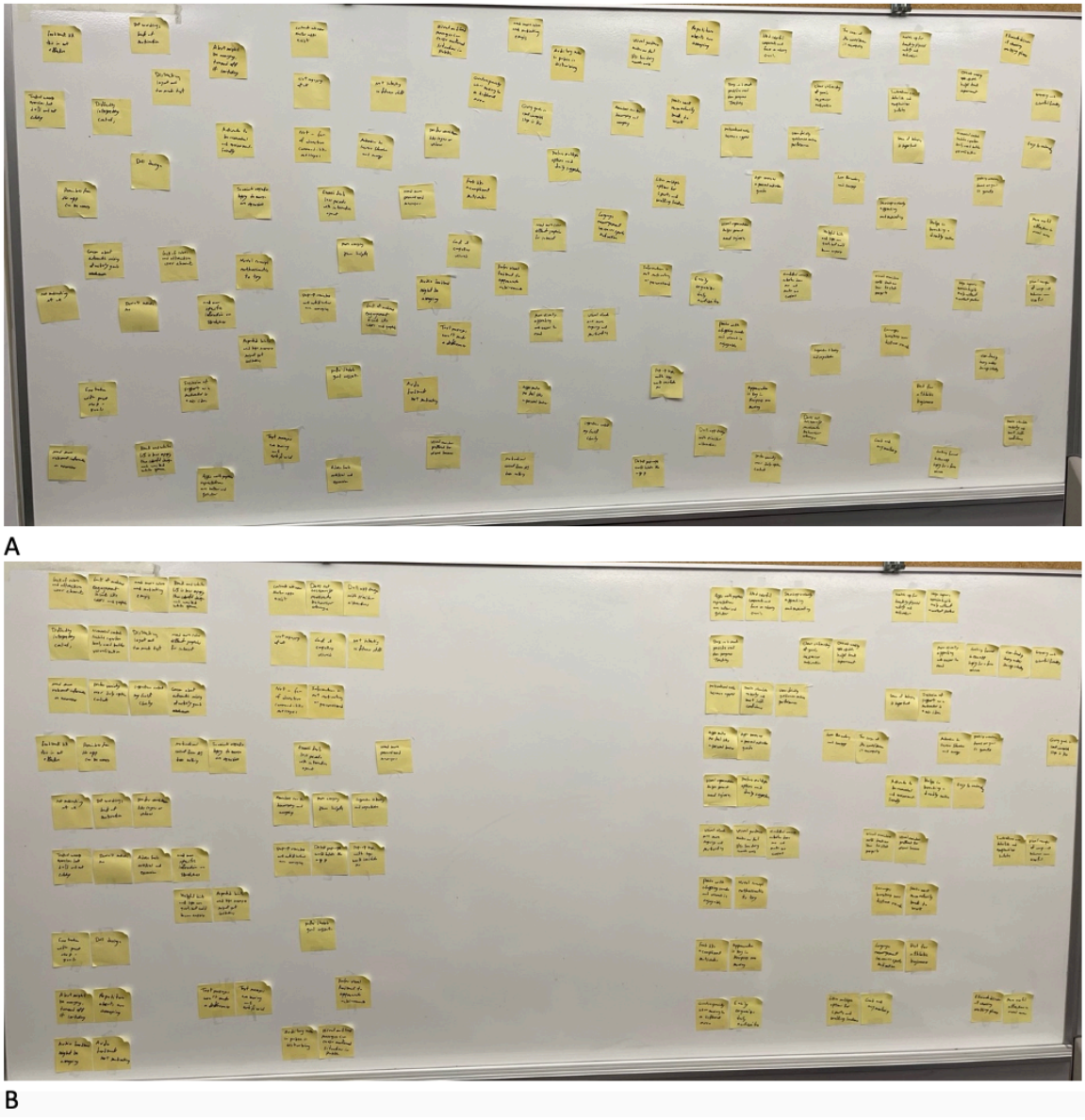


Figure 64: Codes Generated from Phase 2 of the Comparison of the Persuasiveness of Individual Implementations.

Figure 65: Themes Generated from Phase 2 of the Comparison of the Persuasiveness of Individual Implementations.

6.4.2.1 COMPARING THE PERSUASIVENESS OF IMPLEMENTATIONS OF EACH STRATEGY FOR THE ARABIC POPULATION

This section presents the comparison of our data analysis regarding the persuasiveness of distinct implementations of each strategy for the Arabic population.

Table 17 shows the implementation types of each persuasive strategy employed in the survey. For the Arabic participants, using the (pairwise comparisons) of the RM-ANOVA, our findings indicate that the persuasiveness of distinct implementations of the same strategy differs. Using the one-sample t-test, I found that persuasiveness scores for various implementations significantly surpassed the midpoint rating of 4 ($p < .0001$) based on the 7-point Likert scale used to evaluate perceived persuasiveness. Figure 66 and Table 18 present the persuasiveness of two distinct implementations of each strategy for the Arabic population. "IMPL-1" refers to the first implementation of the strategy, while "IMPL-2" refers to the second implementation. The acronym "Ar.P" represents a participant from the Arabic population, while "En.P" refers to a participant from the non-Arabic population. I use numbers to identify the Arabic participants (e.g., Ar.P-1, Ar.P-2, Ar.P-3, ….) and the non-Arabic participants (e.g., En.P-1, En.P-2, En.P-3, …..).

Table 17: Implementation Types (IMPL-1, and IMPL-2) of Each Individual Strategy.

Persuasive Strategy	Implementation 1 (IMPL-1)	Implementation 2 (IMPL-2)
Self-monitoring	Textual and Numerical **Self-monitoring** Feedback	Numerical and Visual **Self-monitoring** Feedback
Personalization	**Personalized** Motivational Content	**Personalized** Goal Recommendations
Suggestion	Textual **Suggestion** Notifications	Visual **Suggestion** Notifications
Goal Setting	Default/System-based **Goals**	Customized/User-Driven **Goals**
Reminders	Automatic/System-based **Reminders** (Push **Reminders**)	Customized/User-Driven **Reminders** (Pop-up **Reminders**)
Rewards	Collecting of Virtual **Reward** Points	Collecting of Virtual **Reward** Badges
Praise	Textual **Praise**	Audio and Visual **Praise**
Reduction	**Reduction** as a List of Different Predefined Options for Nearby Activities	**Reduction** as a Set of Predefined PA Plans/Goals
Competition	**Competition** as a Leaderboard	Displaying a Progress Bar for Each **Competitor**
Tunneling	**Tunneling** as Textual/Written Instructions	**Tunneling** as Map Visualization for Walking Routes
Cooperation	Message Exchange via Social **Cooperation** Networks	**Cooperation** as Teamwork

Simulation	Users' PA Movements' Interactions in the Real World to **Simulate** and Present the Users' Progress (**Battery Charging**)	**Simulation** as Educational Tips/Images to Realize the Cause and Effect of PA and SB on Health (**Current and Target Body-Shape Images**)

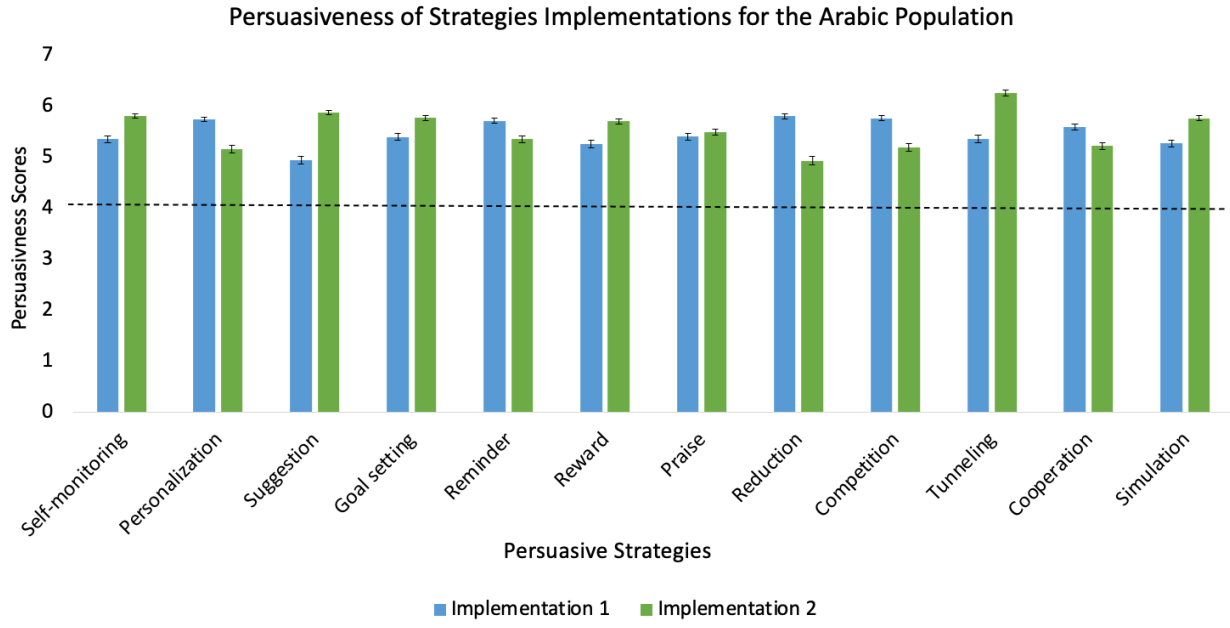


Figure 66: A clustered bar chart presenting the overall persuasiveness of two different implementations of distinct strategies according to the Arabic population. The horizontal line represents the neutral "midpoint" rating of 4 (based on the 7-point Likert scale employed in rating the perceived persuasiveness questionnaire (PPQ) items).

Table 18: Means, Standard Deviations, and One Sample t-Test Results of the Implementations' Persuasiveness of the 24 Persuasive Strategies' Implementations Employed in the User-Study for Arabic Participants.

Persuasive Strategy	Implementations	Mean	Std. Deviation	One Sample t-Test Results
Self-monitoring	IMPL-1	5.352	1.550	t(549)=20.452, p<0.001
	IMPL-2	5.806	1.015	t(549)= 41.712, p<0.001
Personalization	IMPL-1	5.745	1.126	t(549)= 36.352, p<0.001
	IMPL-2	5.159	1.715	t(549)= 15.841, p<0.001
Suggestion	IMPL-1	4.941	1.858	t(549)= 11.879, p<0.001
	IMPL-2	5.875	1.059	t(549)= 41.508, p<0.001
Goal-setting	IMPL-1	5.395	1.529	t(549)= 21.397, p<0.001
	IMPL-2	5.772	1.089	t(549)= 38.154, p<0.001
Reminder	IMPL-1	5.716	1.219	t(549)= 33.013, p<0.001

	IMPL-2	5.352	1.578	t(549)= 20.093, p<0.001
Reward	IMPL-1	5.258	1.721	t(549)= 17.142, p<0.001
	IMPL-2	5.708	1.181	t(549)= 33.908, p<0.001
Praise	IMPL-1	5.405	1.508	t(549)= 21.843, p<0.001
	IMPL-2	5.496	1.398	t(549)= 25.096, p<0.001
Reduction	IMPL-1	5.807	1.111	t(549)= 38.135, p<0.001
	IMPL-2	4.929	1.915	t(549)= 11.377, p<0.001
Social Competition	IMPL-1	5.762	1.204	t(549)= 34.322, p<0.001
	IMPL-2	5.188	1.700	t(549)= 16.392, p<0.001
Tunneling	IMPL-1	5.362	1.879	t(549)=9.476, p<0.001
	IMPL-2	6.258	1.231	t(549)= 31.526, p<0.001
Social Cooperation	IMPL-1	5.595	1.330	t(549)= 28.136, p<0.001
	IMPL-2	5.218	1.717	t(549)= 16.628, p<0.001
Simulation	IMPL-1	5.273	1.585	t(549)= 18.834, p<0.001
	IMPL-2	5.763	1.124	t(549)= 36.780, p<0.001

6.4.2.1.1 Self-monitoring Strategy

For Arabic participants, with regard to the self-monitoring strategy, the findings showed that IMPL-2 (Mean = 5.806, SD = 1.015) of the self-monitoring strategy is perceived as significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 5.352, SD = 1.550). SD refers to the standard deviation. Figure 66 illustrates the persuasiveness of two different implementations of each strategy within the context of the Arabic population. The findings from our thematic analysis of qualitative data revealed that Arabic participants showed a preference for IMPL-2 (**Numerical and Visual Feedback**, such as pie charts, graphs, and progress bars). They favored this implementation due to its ***visual appeal***, finding that graphs, charts, and visual elements allowed them to ***access information quickly***, making it easily ***understandable*** and motivating them to engage in physical activities. Furthermore, they found IMPL-2 helpful and ***easy for tracking*** PA, motivating themselves, ***improving their exercise habits***, and enhancing their health and performance. The sample comments from Arabic participants are shown below under the following themes:

Theme 1: Visual Appeal and Graphical Representation

"*The second app **appealed to me** because it is **easy** on the eyes and **quickly understandable**, while the first one is just numbers, which means it's not motivating*." [Ar.P - 60] (IMPL-2).

"*I like the **colorful** components and the focus on achieving a goal*." [Ar.P - 511] (IMPL-2).

"*From my perspective, I find that apps with **graphical representations** are **better and quicker** for accessing the required information.*" [Ar.P - 23] (IMPL-2).

Theme 2: Utility and Motivation

"*This is what I was looking for, an Arabic app that helps me **track** my physical activity and **motivates me** to engage in sports*." [Ar.P - 76] (IMPL-2).

"*I think this app will help me **improve my exercise habits**, especially when I don't have a friend to accompany me for a workout.*" [Ar.P - 117] (IMPL-2).

Conversely, Arabic participants who did not prefer IMPL-1 (**Textual and Numerical Feedback** such as textual representation) indicated that the implementation is: 1) ***dull, boring, and unengaging***, 2) ***lack of colors, attractive elements, and graphics***, 3) ***Black and white user interface and blank spaces***, *4)* ***not motivating***, *5)* ***the contents are not new***. Below, we present sample comments from Arabic participants, organized according to thematic categories:

Theme 1: Lack of Visual Appeal and Engagement

"*It **lacks colors and attractive** user elements*." [Ar.P - 2] (IMPL-1).

"*It's a nice program, but it **lacks** audience engagement elements like **colors and graphics***." [Ar.P - 31] (IMPL-1).

"***Boring** a bit. I would prefer more colors and motivating emojis*." [Ar.P - 32] (IMPL-1).

"*The **black and white UI** is **less engaging** than a colorful design. There is a **lot of blank white wasted space***." [Ar.P - 511] (IMPL-1).

Theme 2: Lack of Novelty and Motivation

"*I **didn't feel that the content was new**, and this idea **exists** in apps that support daily step tracking.*" [Ar.P - 32] (IMPL-1).

"*The app's design is **dull**, and there are **similar apps***." [Ar.P - 141] (IMPL-1).

"*It's a good way of monitoring my activity, but it **does not necessarily motivate me** to change my behavior*." [Ar.P - 509] (IMPL-1).

6.4.2.1.2 Personalization Strategy

For Arabic participants, concerning the personalization strategy, IMPL-1 (Mean = 5.745, SD = 1.126) is significantly more persuasive ($p < .001$) than IMPL-2 (Mean = 5.159, SD = 1.715). Our qualitative findings indicate that Arabic participants prefer IMPL-1 (**Personalized Motivational Content**) due to the significance of motivational content and positive messaging in PA apps. Arabic participants believe that motivational words and personalized encouragement are ***more appealing*** and essential for ***staying motivated***, ***building self-confidence***, and ***achieving PA goals***. Furthermore, the personalized motivations and encouragements play an essential role in creating ***a sense of belonging*** and support within the app. Arabic participants appreciate feeling connected and supported as they work towards their PA goals. Presented below are some comments provided by Arabic participants, categorized according to thematic considerations:

Theme 1: Motivational Content and Positive Messaging

"*It's **more appealing** because it has motivational words*." [Ar.P - 92] (IMPL-1).

"*Receiving praise acts as a stimulus for my body to **stay active** and strive **to achieve** or surpass **my goals***." [Ar.P - 493] (IMPL-1).

"*It boosts my **self-confidence**, **motivates** my activity, offers user-friendly guidance in physical exercise, and enhances my performance with comprehensive guidance*." [Ar.P - 360] (IMPL-1).

Theme 2: Sense of Belonging and Support

"***A sense of belonging***." [Ar.P - 151] (IMPL-1).

" *It's a **nice** idea when the app includes **support** as a **personal motivator** or a **personal coach***." [Ar.P - 117] (IMPL-1).

On the other hand, Arabic participants who dislike IMPL-2 (**Personalized Goal Recommendations**) expressed concerns about the ***repetitiveness of the content*** and ***lack of motivation*** in the app. They found the daily content to be ***repetitive*** and, in some cases, ***harder to understand***. Additionally, there were concerns about the app automatically raising activity level goals, potentially ***putting users at risk of overexercising,*** and the perception that the app was trying to ***increase the workload without clear relevance***. They also found that the message resembles a ***directive***, conveying an order to them

(referred to as a ***command-like*** message), which was not preferable. Below are some comments from Arabic participants regarding IMPL-2, organized by thematic category:

Theme 1: Repetitiveness and a Lack of Clarity and Relevance

"*I **don't prefer** daily **repetitive content***." [Ar.P - 16] (IMPL-2).

"*I might find the suggested content **harder to understand** than the previous content*." [Ar.P - 30] (IMPL-2).

"*I'm **concerned** about the app's design to automatically raise people's activity level goals. This **puts people at risk of overexercising**, I think.*" [Ar.P - 511] (IMPL-2).

"*There **should be more relevant** information on why to continue the exercises.*" [Ar.P - 207] (IMPL-2).

Theme 2: Lack of Motivation and Personalization

"*The app presents more information which is helpful but again **it's nothing** but a very brief summary. I think this feature is **not motivated or personalized**.*" [Ar.P - 509] (IMPL-2).

"*While this interface is straightforward, I'm **not a fan** of the **directive 'command-like' message***." [Ar.P - 501] (IMPL-2).

7.4.2.1.3 Suggestion Strategy

For Arabic participants, regarding the suggestion strategy, IMPL-2 (Mean = 5.875, SD = 1.059) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 4.941, SD = 1.858). Arabic participants' qualitative comments showed that IMPL-2 (**Visual Suggestion Notifications**) is preferable because of the ***inclusion of images*** and ***visual instructions*** as they find this ***motivating***, ***helpful***, and ***clear***. Visual representations make it ***easier to understand*** exercises and the ***correct way to perform*** them, ***reducing the risk of injuries*** and enhancing the overall exercise experience. Here are comments from Arabic participants concerning IMPL-2, structured based on thematic categories:

Theme 1: Visual Exercise Guidance

"***Love** the inclusion of **instructional images***." [Ar.P - 511] (IMPL-2).

"*Using illustrative images **makes it easier and clear***." [Ar.P - 103] (IMPL-2).

"*Visual representation of the **correct way to do an exercise** would help me.*" [Ar.P - 504] (IMPL-2).

"*This feature will help me **reduce muscle injuries** by explaining and displaying important exercises.*" [Ar.P - 6] (IMPL-2).

Theme 2: Motivation and Encouragement

"*Practical steps with **images** can be a personal **motivator** for me.*" [Ar.P - 21] (IMPL-2).

"*This feature is **very motivating and helpful**.*" [Ar.P - 110] (IMPL-2).

Nevertheless, IMPL-1 (**Textual Suggestion Notifications**) is less preferred for Arabic participants because it is ***boring***, ***annoying***, ***dull***, ***repetitive***, and has a ***lack of visualization and motivation***. Here are some comments from Arabic participants pertaining to IMPL-1, categorized thematically:

Theme 1: Lack of Motivation and Visualization

"***Not motivating** at all.*" [Ar.P - 16] (IMPL-1).

"*These wordings look **dull** and **didn't motivate me**.*" [Ar.P - 277] (IMPL-1).

"*I am **not a fan of textual pop-up** suggestions. I prefer visualization such as images or video tutorials.*" [Ar.P - 508] (IMPL-1).

Theme 2: Ineffectiveness and Annoyance

"*The suggestion is **very boring and repetitive**.*" [Ar.P - 472] (IMPL-1).

"*But it would just be **discouraging** if I had to keep being reminded.*" [Ar.P - 468] (IMPL-1).

"This would be **more annoying** than anything else." [Ar.P - 510] (IMPL-1).

6.4.2.1.4 Goal-setting Strategy

For Arabic participants, with regard to the goal-setting strategy, IMPL-2 (IMPL-2: Mean = 5.772, SD = 1.089) is significantly more persuasive ($p < .001$) than IMPL-1 (IMPL-1: Mean = 5.395, SD = 1.529). Based on the Arabic participants' qualitative comments, IMPL-2 (**Customized/User-Driven Goals**) is favored by Arabic participants because of the inclusion of ***customization and personalization*** features. Arabic participants value ***the ability to set their own goals*** that are tailored to their individual **circumstances**, **preferences, and health conditions**. They also emphasize the importance of ***setting logical and achievable goals***. They appreciate the ***flexibility*** to choose goal numbers that are realistic and align with their daily activity levels. They find it beneficial to set goals

that are within reach ***to avoid frustration***. ***Customization*** features are seen as encouraging and motivating, as they allow users to ***have control*** over their goal setting. Below are some comments that support our findings and are categorized into themes:

Theme 1: Customization and Personalization

"*I prefer this option to the previous one as it allows me to **customize** options that **suit my personal life** more than before.*" [Ar.P - 30] (IMPL-2).

"*I like this much better - **love the ability to set your own goals** (better for accessibility)*." [Ar.P - 511] (IMPL-2).

"*I like that I can set the goal **according to my circumstances**.*" [Ar.P - 60] (IMPL-2).

"***Customized goal** is great as it would help the older aged user based on **their health conditions**.*" [Ar.P - 543] (IMPL-2).

Theme 2: Logical and Achievable Goals

"*The required number of steps varies according to a **person's activity level**.*" [Ar.P - 68] (IMPL-2).

"*People's abilities and circumstances **differ**... so it's **good to have space** to set the daily goal*." [Ar.P - 103] (IMPL-2).

However, IMPL-1 (**Default/System-based Goals**) is less favored by Arabic participants because they found the ***interface not appealing***, ***not eye-catching***, and ***not motivating***. They described the style as ***dull*** and ***boring*** and expressed that it ***did not encourage*** them. They also stressed the significance and ***desire for flexibility in setting goals***. They preferred suggestions over specific goals and believed that users should determine suitable targets for themselves. Arabic participants suggested that ***goals should have minimum and maximum limits*** and that the app should allow users to choose their own number of steps. They also wanted the flexibility to increase or decrease goals based on their health status or other reasons. Some users felt that the system setting an automatic and specific goal might lead to ***frustration and a lack of commitment***. Below are comments that bolster our findings and are organized into thematic categories:

Theme 1: Lack of Appeal in the User Interface

"*It's good to always have a goal to make progress, but so far, I have an issue with the user interface as **it's not appealing** to me and **not eye-catching**.*" [Ar.P - 3] (IMPL-1).

"*This is also **boring** and **didn't encourage** me much more.*" [Ar.P - 277] (IMPL-1).

"*The design is **dull**.*" [Ar.P - 43] (IMPL-1).

"*Setting the number of steps by the program may **lead to frustration** if not achieved.*" [Ar.P - 84] (IMPL-1).

Theme 2: Desire for Flexibility in Goal Setting

"*I prefer a suggestion rather **than a specific goal**. Everyone **should determine the suitable target** for themselves, and the app can help improve the goal as the days go by.*" [Ar.P - 6] (IMPL-1).

"*It's better if the goal is flexible, meaning it has a **minimum and maximum limit**.*" [Ar.P - 16] (IMPL-1).

"*I **prefer to have the flexibility** of setting my own goal.*" [Ar.P - 492] (IMPL-1).

6.4.2.1.5 Reminder Strategy

For Arabic participants, regarding the reminder strategy, IMPL-1 (Mean = 5.716, SD = 1.219) is significantly more persuasive ($p < .001$) than IMPL-2 (Mean = 4.929, SD = 1.915). Based on the qualitative feedback, Arabic participants perceived IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) as ***highly useful***, particularly in situations where prolonged sitting or inactivity is common. Automatic reminders that are based on the user's activity level are seen as ***more valuable*** than manual reminders. Arabic participants value these reminders for their crucial role in ***monitoring their progress***, ***combating inactivity***, and ***providing proactive motivation to overcome laziness***. Below, comments that bolster our findings are organized into thematic categories:

Theme 1: Importance of Automatic Reminders

"*The app should remind me automatically **based on my activity that day**.*" [Ar.P - 75] (IMPL-1).

"*I **liked** the fact that the reminders are **based on the user's activity** rather **than being random**.*" [Ar.P - 492] (IMPL-1).

"*I find the reminders **useful for people who sit a lot in a chair** during work, so they can remember that they should walk while sitting between each period.*" [Ar.P - 23] (IMPL-1).

Theme 2: User Engagement and Motivation

"*If the system **monitors me** and frequently nudges me to **take action and stand-up or walk**, it can be **quite helpful**. It serves as **motivation to break free from my laziness** or other distractions and get things done.*" [Ar.P - 234] (IMPL-1).

On the other hand, some Arabic participants disliked IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) because they expressed ***resistance to and annoyance*** with these reminders, indicating that they may not find them beneficial or may not use the reminder feature. Some ***found the idea of reminders annoying and irritating***, while others felt it was ***unnecessary to schedule PA reminders*** due to their limited and random availability. There was a preference for default messages for reminders rather than a manual setup, and participants generally ***disliked features that rang or sounded like alarms***. Here are some examples from the Arabic participants' qualitative comments:

Theme 1: Resistance to and Annoyance with Reminders

"*I **won't use** the reminder feature.*" [Ar.P - 45] (IMPL-2).

"*A bit **annoying**.*" [Ar.P - 59] (IMPL-2).

"*For me, I have **limited and random times** for physical activities and scheduling them is totally **unnecessary and not useful**.*" [Ar.P - 509] (IMPL-2).

"***Don't like** anything that would **ring**.*" [Ar.P - 286] (IMPL-2).

"*It looks and **sounds the alarm/snooze/stop feature**, which I **don't like** to begin with :)*" [Ar.P - 501] (IMPL-2).

"*Despite scheduling times (which can be **troublesome**), I often find these notifications **annoying** and tend to simply **close them without reading them**.*" [Ar.P - 174] (IMPL-2).

6.4.2.1.6 Reward Strategy

For Arabic participants, regarding the reward strategy, IMPL-2 (Mean = 5.708, SD = 1.181) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 5.258, SD = 1.721). Qualitative feedback from Arabic participants indicated a preference for IMPL-2 (**Collecting of Virtual Reward Badges**) because of the powerful ***motivation*** provided by badges and rewards in PA apps. Arabic participants found badges to be ***excellent motivators*** representing ***achievable goals and challenges***. The concept of badges and titles is considered ***more useful than points***, and it has been **successful in**

motivating users in various contexts. The following are sample comments from qualitative feedback that validate our findings:

Theme 1: Motivation through Badges and Rewards

"*Badges will be an **excellent motivator** for many people as they represent **measurable and achievable goals and challenges***." [Ar.P - 30] (IMPL-2).

"*Using badges or titles is **more useful than points**, and this system is implemented in some gyms and even in video game consoles like PlayStation and Xbox, and it has **proven its effectiveness in motivating** users*." [Ar.P - 154] (IMPL-2).

Conversely, Arabic participants did not prefer IMPL-1 (**Collecting of Virtual Reward Points**) because they expressed a ***lack of motivation*** from the offered incentives, finding them ***unencouraging and primitive***. They ***questioned the value of virtual points*** and were uncertain about their use. Some participants appreciated the concept of rewards but ***preferred more tangible benefits***, such as discounts or real rewards. The following are sample comments from Arabic participants' qualitative feedback that confirm our findings:

Theme 1: Lack of Motivation from Incentives

"*The point rewards are **very primitive** and **don't provide motivation***." [Ar.P - 151] (IMPL-1).

"***Not considered** an incentive.*" [Ar.P - 137] (IMPL-1).

Theme 2: Lack of Significance of Virtual Points

"*I **don't think** that point rewarding is **important***." [Ar.P - 505] (IMPL-1).

"*Virtual points count **wouldn't help me increase** my active time.*" [Ar.P - 508] (IMPL-1).

Theme 3: Unclear Benefits of Virtual Points

"***No one** knows **how to use** the points*." [Ar.P - 32] (IMPL-1).

"*Points are OK, but I'm wondering **where they can actually be utilized?***" [Ar.P - 262] (IMPL-1).

Theme 4: Desire for Tangible Rewards

"*I **don't personally prefer** this method unless those points can be exchanged for **something more tangible**, such as credit for the (App store or Google play), or discount offers, for instance.*" [Ar.P - 501] (IMPL-1).

6.4.2.1.7 Praise Strategy

For Arabic participants, regarding the praise strategy, IMPL-2 (Mean = 5.496, SD = 1.398) is perceived as more persuasive than IMPL-1 (Mean = 5.405, SD = 1.508), though the difference in persuasiveness is not significant (p = .131). According to the Arabic participants' qualitative feedback and comments, IMPL-2 (**Audio and Visual Praise**) is favored by Arabic participants because of the ***novelty and positive feedback*** within a PA app. Arabic participants appreciated novel features, such as ***clapping sounds***, ***fireworks***, and ***visually appealing effects*** that celebrate their achievements. These elements are seen as ***motivational*** and are liked by participants who find them exciting and ***enjoyable***. Below are some sample comments from Arabic participants' qualitative feedback that further validate our findings:

Theme 1: Novelty and Positive Feedback

"*Offering praise is a **positive** choice. Moreover, the inclusion of **clapping sounds**, **fireworks**, and **visually appealing effects** feels like a celebration of my efforts. Without a doubt, I thoroughly **enjoy** this feature.*" [Ar.P - 234] (IMPL-2).

"*The concept is **novel and new** to me, so I'm enthusiastic about trying it out.*" [Ar.P - 501] (IMPL-2).

However, IMPL-1 (**Textual Praise**) was less preferred by the Arabic participants because it is ***annoying, repetitive, canned, boring,*** and ***not motivating***. Arabic participants found that textual motivational messages and alerts are generally considered to have a ***minimal impact on users' motivation***. They ***preferred visual feedback***. Some participants highlighted the importance of authenticity in feedback, suggesting that AI-generated praise ***may lack effectiveness***. Here are some example comments from Arabic participants' qualitative feedback that provide additional support for our findings:

Theme 1: Annoyance with Textual Alerts

"*It might have the **opposite effect**. In reality, I **turn off** this feature if **it's annoying**.*" [Ar.P - 30] (IMPL-1).

"***Repetitive** alerts **annoy** me.*" [Ar.P - 84] (IMPL-1).

Theme 2: Ineffectiveness of Textual Messages

"*I **don't think** it will make **a difference** for me.*" [Ar.P - 45] (IMPL-1).

"*I **don't prefer** text messages.*" [Ar.P - 152] (IMPL-1).

"*This is **boring**. It **didn't give me** much **energy** to do.*" [Ar.P - 277] (IMPL-1).

"*I **don't really care** too much about it. It seems **artificial** and **canned**.*" [Ar.P - 468] (IMPL-1).

Theme 3: Preference for Visual Feedback

"*I **expect something more visual** to appreciate myself for achieving the target.*" [Ar.P - 234] (IMPL-1).

6.4.2.1.8 Reduction Strategy

For Arabic participants, with regard to the reduction strategy, IMPL-1 (Mean = 5.807, SD = 1.111) is significantly more persuasive ($p < .001$) than IMPL-2 (Mean = 4.929, SD = 1.915). Thematic analysis of Arabic qualitative feedback revealed that Arabic participants favored IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) due to the ***convenience***, ***usability***, and ***practicality*** of the implementation's features related to location selection, exploration, and variety. They appreciated the ***ability to discover new walking locations***, ***receive directions***, and ***break from their routines***, which helped ***motivate*** them to stay active. The integration of Google Maps and other location-tracking features was particularly well-received. Below are sample comments from Arabic participants' qualitative feedback that further reinforce our findings:

Theme 1: Convenience and Location Selection

"***Great** because it helps me and **eliminates the dilemma** of choosing **walking places**.*" [Ar.P - 76] (IMPL-1).

"*I **liked** the **Google Map location** feature.*" [Ar.P - 284] (IMPL-1).

"*It seems really useful and **practical**. I especially like that it **offers directions to walk** I can **easily pull up** through the app.*" [Ar.P - 468] (IMPL-1).

Theme 2: Exploration and Variety

"*I **like** having **multiple options** for sports and walking locations.*" [Ar.P - 89] (IMPL-1).

"***Wonderful**, especially when **moving to a different area**.*" [Ar.P - 38] (IMPL-1).

Theme 3: Motivation and Breaking Routine

"*Knowing the distances **encourages me to break new records** for new distances*." [Ar.P - 87] (IMPL-1).

"*That can help in **breaking my deadly routine**.*" [Ar.P - 502] (IMPL-1).

On the other hand, IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) is less preferred by Arabic participants due to its ***complexity*** and ***lack of the suitability, usability, and flexibility*** features. Arabic participants expressed a ***desire for flexibility and variation*** in their exercise routines. They suggested that the implementation should offer several options for exercise locations and routines. They also conveyed ***a lack of interest*** in the proposed implementation and found it ***unsuitable*** for their needs. They used straightforward phrases such as "***I don't like it***" and "***It doesn't suit me***" to express their disinterest. Some Arabic participants cited ***scheduling issues*** and ***irrelevant timing*** as reasons for their lack of enthusiasm. Additionally, they also ***preferred a simpler and more user-friendly*** implementation of the feature, finding certain aspects of the feature ***confusing*** and favoring a more straightforward user interface. Here are some comments from Arabic participants' qualitative feedback that provide additional support for our findings:

Theme 1: Desire for Flexibility and Variation

"*There **should be several options**, and it might be nice if there were a daily suggestion **rather than a set plan** as a form of variation.*" [Ar.P - 30] (IMPL-2).

"*I **prefer** a list of my nearby walking activity locations **(first implementation)**.*" [Ar.P - 396] (IMPL-2).

Theme 2: Lack of Interest and Suitability

"*I **don't like it**.*" [Ar.P - 35] (IMPL-2).

"*It **doesn't suit me**.*" [Ar.P - 81] (IMPL-2).

"***Scheduling** a planned location with a timetable and **irrelevant time**.*" [Ar.P - 137] (IMPL-2).

Theme 3: Preference for Simplicity and Usability

"*This **looks confusing** at first glance.*" [Ar.P - 510] (IMPL-2).

"*I think I **prefer the simpler UI**.*" [Ar.P - 511] (IMPL-2).

6.4.2.1.9 Competition Strategy

For Arabic participants, regarding the competition strategy, IMPL-1 (Mean = 5.762, SD = 1.204) is significantly more persuasive ($p < .001$) than IMPL-2 (Mean = 5.188, SD = 1.700). Qualitative

findings reveal that Arabic participants favored IMPL-1 (**Competition as a Leaderboard**) due to their ***enthusiasm*** for competing with others and the ***motivation*** they draw from leaderboards. The competitive elements embedded within PA apps can ***evoke a sense of achievement***, similar to ranking in a game. The presence of leaderboards, badges, and trophies is ***visually appealing,*** and they serve as ***effective motivators***, particularly for those with a natural competitive drive. Additionally, Arabic participants emphasized the significance of community-building through shared experiences, expressing a ***preference for group competitions*** that foster a sense of community spirit. Below are comments from Arabic participants' qualitative feedback that further corroborate our findings:

Theme 1: Visual Appeal and Presentation

"*I **prefer this presentation format** over the visual presentation bar*." [Ar.P - 29] (IMPL-1).

"*The **visual appearance** is also **good** with **badges and trophies***." [Ar.P - 274] (IMPL-1).

Theme 2: Motivation and Competition

"***Leaderboard** ranking **motivates me** to **reach the top** during the next time*." [Ar.P - 528] (IMPL-1).

"***Very cool**, it's **like a ranking of a game**, it **simulates** even more the practice of exercises*." [Ar.P - 207] (IMPL-1).

"***Comparing with others** with the leaderboard is a **good motivational factor***." [Ar.P - 321] (IMPL-1).

Theme 3: Community and Social Interaction

"*I think this works well to **foster community***." [Ar.P - 510] (IMPL-1).

In contrast, Arabic participants were not inclined toward IMPL-2 (**Displaying a Progress Bar for Each Competitor**) due to several concerns. They highlighted the ***lack of visual appeal and motivation*** in the proposed implementation and considered progress bars ***less effective*** than badges for motivation. Additionally, they expressed concerns regarding competitiveness and comparison, ***fearing potential frustration and bullying*** if they could not outperform others. The concept of progress bars representing different users' activity levels was seen as potentially ***discouraging for less active individuals***. ***Privacy and sharing concerns*** were prevalent among Arabic participants, with ***discomfort about the amount of information shared*** and the idea of competing against strangers. Sharing personal data and competing against unknown individuals were viewed as intrusive, causing

anxiety among some participants who wished to keep their exercise data private. Below are sample comments organized into thematic categories that strengthen our findings:

Theme 1: Visual Presentation

"*This is **looking bad**.*" [Ar.P - 533] (IMPL-2).

Theme 1: Negative Perception of Competition and Comparison

"*This feature **might cause frustration** if I can't outperform others.*" [Ar.P - 6] (IMPL-2).

"*I'd **feel pretty bad** if I saw a lot of people **ahead of me**.*" [Ar.P - 468] (IMPL-2).

"*This might lead to **shaming or bullying**.*" [Ar.P - 504] (IMPL-2).

"*The difference in **using columns** will be significant among competitors, **making the least active person give up**.*" [Ar.P - 16] (IMPL-2).

Theme 2: Lack of Motivation

"*This is **less motivating**; progress bars **don't have the same effect** as badges.*" [Ar.P - 396] (IMPL-2).

Theme 3: Privacy and Information Sharing Concerns

"*This would **be too much information** for me to handle and would make me **uncomfortable with sharing with others**.*" [Ar.P - 510] (IMPL-2).

"***Don't like it** at all. **Don't want** people **to know my business**.*" [Ar.P - 286] (IMPL-2).

6.4.2.1.10 Tunnelling Strategy

For Arabic participants, with regard to the tunneling strategy, IMPL-2 (Mean = 6.258, SD = 1.231) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 5.362, SD = 1.879). Based on the qualitative feedback, Arabic participants preferred IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) due to the ***integration of maps technology***, as it results in ***clearer and easier layouts***. Visual maps are favored for their ability to help users make decisions about their routes, especially in unfamiliar locations. The use of ***satellite imagery*** is considered a nice addition, and participants express a ***preference for map visualization over textual descriptions.*** Overall, map visualization features are seen as a valuable enhancement to PA apps. Below are comments from Arabic participants regarding IMPL-2, categorized thematically:

Theme 1: Integration of Maps Technology

"***Great*** *with the* ***integration of maps technology****.*" [Ar.P - 38] (IMPL-2).

"*Using* ***satellite imagery*** *in directions is* ***nice****.*" [Ar.P - 87] (IMPL-2).

"***Utilizing maps*** *is helpful and may* ***facilitate easier exploration*** *of the surroundings*." [Ar.P - 154] (IMPL-2).

Theme 2: Clearer and Easier Layout

"***Clearer and easier*** *layout.*" [Ar.P - 43] (IMPL-2).

"***Seeing*** *the route through a* ***map*** *is always* ***preferable over a written description****.*" [Ar.P - 528] (IMPL-2).

Theme 3: Suitable Walking Paths

"*It will be* ***truly helpful*** *if walking paths are carefully input, so there are* ***suitable routes for walking****.*" [Ar.P - 45] (IMPL-2).

"*I* ***like*** *this* ***map visualization*** *for* ***walking routes****.*" [Ar.P - 266] (IMPL-2).

In contrast, Arabic participants showed less preference for IMPL-1 (**Tunneling as Textual/Written Instructions**) due to its ***complexity and difficulty***, ***ineffectiveness and lack of motivation***, a ***preference for visual information***, and ***practical and usability issues***. Arabic participants found this implementation ***complex and hard to understand***, which made it challenging to navigate during workouts. Furthermore, IMPL-1 was seen as ***ineffective and uninspiring, not motivating*** participants to exercise. Thus, Arabic participants ***preferred visual instructions*** over written ones, ***finding text unappealing and boring***. Practical concerns also expressed include reading text during exercise, the ***inconvenience*** of holding phones while running, ***weather-related challenges***, and a ***lack of informative signs*** on walking paths. Below are comments from Arabic participants' qualitative feedback regarding IMPL-1, further reinforcing our findings:

Theme 1: Complexity and Difficulty

"*This feature is* ***very difficult and complicated****.*" [Ar.P - 2] (IMPL-1).

"*A bit* ***hard to understand****.*" [Ar.P - 43] (IMPL-1).

"*This does not make sense to me as* ***it's not easy to read or navigate while doing a workout****.*" [Ar.P - 509] (IMPL-1).

Theme 2: Ineffectiveness and a Lack of Motivation

"*It's a **waste of time**.*" [Ar.P - 4] (IMPL-1).

"*It **won't motivate me** to perform*." [Ar.P - 68] (IMPL-1).

"***Boring** approach*." [Ar.P - 75] (IMPL-1).

Theme 3: Preference for Visual Information

"***Written** instructions are **not appealing**.*" [Ar.P - 502] (IMPL-1).

"*I **prefer visual information** over reading all this text.*" [Ar.P - 29] (IMPL-1).

Theme 4: Practical and Usability Issues

"***Reading long text** during exercise **isn't suitable**.*" [Ar.P - 16] (IMPL-1).

"*I **wouldn't want** to hold/read my phone **while running**.*" [Ar.P - 146] (IMPL-1).

"*The **weather** in most of our **Arab countries doesn't help**.*" [Ar.P - 69] (IMPL-1).

"***Hard to determine distance** without a visual map or **informative signs** on the walking path to clarify the intended route.*" [Ar.P - 31] (IMPL-1).

6.4.2.1.11 Cooperation Strategy

For Arabic participants, pertaining to the cooperation strategy, IMPL-1 (Mean = 5.595, SD = 1.330) is significantly more persuasive ($p < .001$) than IMPL-2 (Mean = 5.218, SD = 1.717). Qualitative comments from Arabic participants indicate a preference for IMPL-1 (**Message Exchange via Social Cooperation Networks**) because they found the social chat and group activity feature highly motivating. They appreciated the ***support, encouragement, and friendships*** that come from engaging with others who share similar PA goals. Social interaction is seen as a way to break the monotony and ***make PAs more enjoyable***. ***Building relationships and meeting new people*** through PAs is another positive aspect mentioned, and participants believe that the feature ***fosters cooperation and group motivation***. Overall, social features in PA apps are valued for their ability to enhance motivation and provide a sense of community. Here are example comments from Arabic participants' qualitative feedback that confirm our findings:

Theme 1: Motivation and Social Support

"***Walking with other** people helps with **motivation**.*" [Ar.P - 154] (IMPL-1).

"*This feature is more than **wonderful**. It's really **motivating** to find a whole team that **motivates each other**, and this breaks the boredom.*" [Ar.P - 3] (IMPL-1).

Theme 2: Building Relationships and Meeting People

"*It's possible to **help form new relationships** through **engaging in activities**.*" [Ar.P - 6] (IMPL-1).

"*I **like** it because it will help me **meet people who like exercise**.*" [Ar.P - 166] (IMPL-1).

Theme 3: Encouragement and Bonding

"*It makes a **bond with people**.*" [Ar.P - 234] (IMPL-1).

"*It's **good** because it **fosters cooperation** among athletes*." [Ar.P - 149] (IMPL-1).

"***Social chatting** room **encourages group performance**. It helps in group **motivation***." [Ar.P - 360] (IMPL-1).

On the other hand, Arabic participants exhibited a lower preference for IMPL-2 (**Cooperation as Teamwork**) due to a ***lack of interest in challenges and teams*** within the implementation features. Arabic participants expressed concerns about ***the impact of one person's efforts on the team*** and the potential ***confusion or complexity*** of team-based motivating factors. The idea of team members, receiving points as rewards, and various motivating factors ***seemed overly complex and overwhelming***, potentially diminishing their motivation and clarity of purpose. Below are comments from Arabic participants' qualitative feedback concerning IMPL-2, providing further confirmation of our findings:

Theme 1: Lack of Interest in Challenges and Teams

"***Not suitable** for me.*" [Ar.P - 54] (IMPL-2).

"***Challenges** are **not my thing***." [Ar.P - 75] (IMPL-2).

"*I **don't like socializing**.*" [Ar.P - 155] (IMPL-2).

"*Personally, **I don't have time for people**.*" [Ar.P - 60] (IMPL-2).

"*The **team** may be **affected by one person's laziness**.*" [Ar.P - 68] (IMPL-2).

Theme 2: Complexity and Confusion

"*The team members and points rewarding seem **just too confusing**, too many different motivating factors influencing me at once.*" [Ar.P - 511] (IMPL-2).

6.4.2.1.12 Simulation Strategy

For Arabic participants, regarding the simulation strategy, IMPL-2 (Mean = 5.763, SD = 1.124) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 5.273, SD = 1.585). According to qualitative feedback, Arabic participants favored IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) due to the motivational aspect of the implementation's features related to ***visualizing target body shape***. Arabic participants appreciated the ***ability to set their target body shape***, as it serves as a ***constant visual reminder*** of their goals. They also appreciated the ***personalized and logical motivation*** that links to their personal data. They mentioned how the feature is ***especially useful for women***. This ***increases awareness and encourages accountability*** in their exercise programs. Below are sample **comments** from Arabic participants' qualitative feedback that corroborate our findings:

Theme 1: Visualizing Target Body Shape for Motivation

"*It's **great** to **set the shape of the target body** for **reminders** and **motivation**.*" [Ar.P - 3] (IMPL-2).

"*I **like** it because it helps you to **continue with your goal** by **showing** you what you **want to achieve**.*" [Ar.P - 166] (IMPL-2).

Theme 2: Personalized and Logical Motivation

"*I find this feature **useful for motivation**, especially for **women**.*" [Ar.P - 23] (IMPL-2).

"***Wonderful** and **logical motivation** linked to **personal data**.*" [Ar.P - 38] (IMPL-2).

Theme 3: Increased Awareness and Accountability

"*It enables the **current performance** and target goal. by this way it **increases our awareness** about our exercise program*." [Ar.P - 360] (IMPL-2).

In contrast, Arabic participants demonstrated a reduced preference for IMPL-1 (**Simulation as Battery Charging**) because they expressed concerns and criticisms regarding the battery simulation feature. They found it ***ineffective***, ***boring***, ***lacking relevance***, and often ***confusing***. Several participants ***struggled to discern the purpose of this interface*** and questioned its significance in tracking their progress. Some participants also expressed ***doubts about the feasibility and realism*** of the idea. Below are examples from Arabic participants' qualitative comments regarding IMPL-1 that validate our findings:

Theme 1: Ineffectiveness and Lack of Relevance

"*The show of charging battery* ***does not affect my active time****.*" [Ar.P - 508] (IMPL-1).

"*The simulation symbols are* ***boring****.*" [Ar.P - 96] (IMPL-1).

"*This seems* ***useless or superfluous****?*" [Ar.P - 468] (IMPL-1).

"*It's* ***quite confusing*** *the battery and how it relates to the user.*" [Ar.P - 262] (IMPL-1).

"*I* ***don't see a purpose for this interface****. The initial survey interface is better and easier to read.*" [Ar.P - 30] (IMPL-1).

Theme 2: Concerns About Realism and Feasibility

"*From my perspective, the battery* ***isn't realistically simulated for the user****.*" [Ar.P - 2] (IMPL-1).

"*The idea is new, so* ***I'm not sure of its feasibility****.*" [Ar.P - 501] (IMPL-1).

In summary, for the Arabic population, the findings from the pairwise comparisons in the RM-ANOVA analysis of Implementation 1 and Implementation 2 for each of the twelve persuasive strategies in our study reveal significant main effects in persuasiveness, except for the praise strategy, which showed no significant difference in persuasiveness or effectiveness (IMPL-1: Mean = 5.405, SD = 1.508; IMPL-2 Mean = 5.496, SD = 1.398). Overall, the findings indicate that Arabic participants preferred Implementation 1 over Implementation 2 for the personalization, reminder, reduction, competition, and cooperation strategies. Conversely, they preferred Implementation 2 over Implementation 1 for the remaining strategies, which are self-monitoring, suggestion, goal-setting, reward, praise, tunneling, and simulation.

6.4.2.2 Comparing the Persuasiveness of Implementations of Each Strategy for the Non-Arabic Population

For the non-Arabic participants, by employing the pairwise comparison of the RM-ANOVA, our findings show that the persuasiveness of distinct implementations of the individual strategy varies.

Table 17 displays the types of implementations for each persuasive strategy in the survey. Through utilization of the one-sample t-test, I discovered that the persuasiveness scores across different implementations exceeded the midpoint rating of 4 ($p < .0001$), as assessed on the 7-point Likert scale measuring perceived persuasiveness.

I utilized a one-sample t-test to evaluate the persuasiveness scores of twelve persuasive strategies included in our user study, along with their two implementation methods among Arabic and non-Arabic populations. This test assessed whether the persuasiveness scores surpassed the neutral score of 4 on a 7-point Likert scale. Our findings reveal that the persuasiveness scores for all strategies and implementations exceeded the midpoint of 4, indicating that these features can effectively influence participants' motivation and behavior towards adopting healthier practices, such as increasing PA. The one-sample t-test is a widely recognized tool frequently used in HCI research studies [218], [194], [217], [221], [220]. Figure 67 and Table 19 show the persuasiveness of two distinct implementations of each strategy for the non-Arabic population.

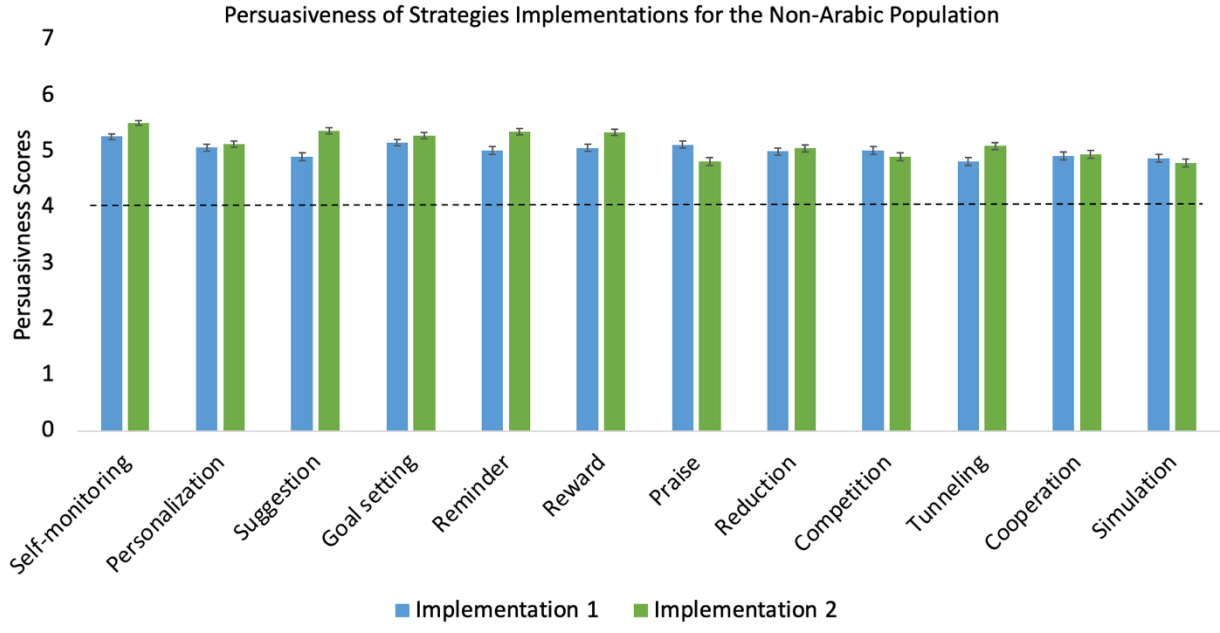


Figure 67: A clustered bar chart presenting the overall persuasiveness of two different implementations of distinct strategies according to the non-Arabic population. The horizontal line indicates the neutral "midpoint" rating of 4 (based on the 7-point Likert scale employed in rating the perceived persuasiveness questionnaire (PPQ) items).

Table 19: Means, Standard Deviations, and One Sample t-Test Results of the Implementations' Persuasiveness of the 24 Persuasive Strategies' Implementations Employed in the User-Study for Non-Arabic Participants.

Persuasive Strategy	Implementations	Mean	Std. Deviation	One Sample t-Test Results
Self-monitoring	IMPL-1	5.262	1.245	t(549)= 23.762, p<0.001
	IMPL-2	5.502	1.026	t(549)= 34.314, p<0.001

Personalization	IMPL-1	5.066	1.438	t(549)= 17.377, p<0.001
	IMPL-2	5.130	1.404	t(549)= 18.872, p<0.001
Suggestion	IMPL-1	4.903	0.000	t(549)= 13.338, p<0.001
	IMPL-2	5.368	1.214	t(549)= 26.421, p<0.001
Goal-setting	IMPL-1	5.156	1.361	t(549)= 19.927, p<0.001
	IMPL-2	5.276	1.327	t(549)= 22.563, p<0.001
Reminders	IMPL-1	5.016	1.541	t(549)= 15.470, p<0.001
	IMPL-2	5.352	1.251	t(549)= 25.341, p<0.001
Rewards	IMPL-1	5.062	1.483	t(549)= 16.801, p<0.001
	IMPL-2	5.339	1.292	t(549)= 24.292, p<0.001
Praise	IMPL-1	5.118	1.462	t(549)= 17.938, p<0.001
	IMPL-2	4.820	1.642	t(549)= 11.717, p<0.001
Reduction	IMPL-1	4.996	1.557	t(549)= 15.002, p<0.001
	IMPL-2	5.053	1.549	t(549)= 15.945, p<0.001
Social Competition	IMPL-1	5.016	1.587	t(549)= 15.003, p<0.001
	IMPL-2	4.902	1.655	t(549)= 12.792, p<0.001
Tunneling	IMPL-1	4.816	1.611	t(549)= 11.888, p<0.001
	IMPL-2	5.099	1.491	t(549)= 17.286, p<0.001
Social Cooperation	IMPL-1	4.917	1.645	t(549)= 13.074, p<0.001
	IMPL-2	4.946	1.610	t(549)= 13.785, p<0.001
Simulation	IMPL-1	4.875	1.634	t(549)= 12.551, p<0.001
	IMPL-2	4.789	1.745	t(549)= 10.606, p<0.001

6.4.2.2.1 Self-monitoring Strategy

For non-Arabic participants, regarding the self-monitoring strategy, the findings indicate that IMPL-2 (Mean = 5.502, SD = 1.026) of the self-monitoring strategy is perceived as significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 5.262, SD = 1.245). The analysis of qualitative feedback demonstrated that non-Arabic participants showed a preference for IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**) due to their strong appreciation for the ***visual representation of their progress*** through bars, charts, and graphs, finding it motivating and goal-oriented. They valued the ***clarity*** provided by progress bars and percentage-based targets, which

made their goals ***more understandable and achievable***. The ***user-friendly design***, ***intuitive graphical interface***, and ***engaging features*** contributed to their interest in using the app regularly. Non-Arabic participants emphasized the ***significance of making performance comparisons*** for improvement and ***the app's ability to establish clear goals***. They expressed anticipation for the app's release and the potential ***benefits of weekly progress updates***, hoping that ***a free version*** will be made available. Below are comments from non-Arabic participants regarding IMPL-2, categorized by thematic category:

Theme 1: Visual Aid for Progress Tracking

"*The **bars and charts** can give me a **real-time visual aid** of **how I'm progressing** or where I need to pick it up.*" [En.P - 11] (IMPL-2).

Theme 2: Motivation and Clear Understanding of Goals

"*Think this app is even **better** in that it makes it **super clear** how close you are to **reaching your goals**, which makes you even **more motivated** to reach them.*" [En.P - 130] (IMPL-2).

"*The overall **weekly update** would help me see **where I need improvement**.*" [En.P - 29] (IMPL-2).

Theme 3: User-Friendly and Engaging Design

"*More **visually appealing** and also **easier to read**.*" [En.P - 206] (IMPL-2).

"*The **user-friendly** effect of the app made me use the app **interestingly**.*" [En.P - 90] (IMPL-2).

"*The formatting is **better** than the previous one and **very engaging**. Also **colorful**.*" [En.P - 133] (IMPL-2).

"*I'm **looking forward to this app**. I hope there is **a free version**.*" [En.P - 85] (IMPL-2).

On the contrary, non-Arabic participants showed a decreased preference for IMPL-1 (**Textual and Numerical Feedback such as textual representation**) due to numerous ***usability and user experience issues*** they encountered with the implementation. These issues included a ***distracting layout***, a ***poor visual hierarchy***, and ***a lack of engaging design elements***. Additionally, non-Arabic participants found it ***challenging to interpret the content*** and recommended replacing numerical figures with more user-friendly data visualizations. They expressed a ***desire for a more stimulating and captivating design***, with the incorporation of color and graphics to enhance the overall user experience. Furthermore, many participants ***lacked interest*** in fitness-related content and deemed the

implementation ***unengaging***, asserting that textual content alone ***failed to motivate or engage them***. Below are comments from non-Arabic participants' qualitative feedback that offer further substantiation of our findings:

Theme 1: Usability and User Experience Issues

"*I had **difficulties** and **spent some time interpreting** the contents.*" [En.P - 306] (IMPL-1).

"*Some color/different graphics **would make** the app **more interesting/captivating**.*" [En.P - 326] (IMPL-1).

"*The **layout is a bit distracting**. It's **difficult** to tell that the icons and text are supposed to go together. Also, there is **far too much text** surrounding today's steps.*" [En.P - 2] (IMPL-1).

"***Numerical contents** to represent the step count induce **cognitive load** in the user's mind. A better visualization method like a line **graph or chart would be better** to help the user see their progress.*" [En.P - 302] (IMPL-1).

Theme 2: Lack of Motivation and Engagement

"*This app is **not engaging at all**.*" [En.P - 41] (IMPL-1).

"*I'm just **not interested** in this kind of fitness stuff.*" [En.P - 4] (IMPL-1).

"*But there **aren't really any graphs or other visuals** that might compel me to work really hard at that goal.*" [En.P - 19] (IMPL-1).

6.4.2.2.2 Personalization Strategy

For non-Arabic participants, with regard to the personalization strategy, IMPL-2 (Mean = 5.130, SD = 1.404) is perceived as more persuasive than IMPL-1 (Mean = 5.066, SD = 1.438), but the persuasiveness of those implementations is not significantly different (p=.073). Qualitative findings indicate that non-Arabic participants expressed a preference for IMPL-2 (**Personalized Goal Recommendations**) because it served as ***a personal motivation guide and trainer***, featuring ***positive wording and imagery*** that fostered optimism. The ***goal-driven approach***, which offers ***clear objectives and manageable steps***, effectively ***engaged users*** and ***encouraged effort***. Many participants noted they had ***increased energy and stamina*** as the implementation ***motivated them to pursue their goals***. Overall, non-Arabic participants expressed a desire for continuous improvement and valued the implementation's role as a fitness coach, providing guidance and setting goals to enhance their exercise routines. Below are sample comments from non-Arabic participants' qualitative feedback that support and validate these findings:

Theme 1: Personal Motivation and Guidance

"*I find the app to be like a **personal motivation guide**.*" [En.P - 17] (IMPL-2).

"*This app makes me feel like a **personal trainer**.*" [En.P - 285] (IMPL-2).

Theme 2: Positive Wording and Imagery

"*I **love** the **wording** and **imagery**.*" [En.P - 33] (IMPL-2).

" *I **love** the reminder, also the **drawing/image** of the lady/coach/trainer is **super nice** and **encouraging**.*" [En.P - 130] (IMPL-2).

Theme 3: Effort and Energy Boost

"*It **motivates** us to increase our **stamina and energy**.*" [En.P - 203] (IMPL-2).

"*I **love** the way **pushing** ourselves **towards our goal**.*" [En.P - 230] (IMPL-2).

Theme 4: Goal-Driven Approach:

"***Giving goals in small, manageable steps is key**, and I think this looks like one that would do this.*" [En.P - 317] (IMPL-2).

On the other hand, non-Arabic participants showed less interest in IMPL-1 (**Personalized Motivational Content**) due to a ***negative perception of motivational messages***. Many participants found these messages ***annoying*** and were ***skeptical about their effectiveness***, favoring raw data and specific goals instead. There were also ***concerns about privacy and intrusiveness***, with participants valuing the privacy of their exercise routines. Additionally, they expressed a ***desire for more personalized and relevant content*** in the implementation rather than generic motivational messages. Overall, non-Arabic participants exhibited diverse preferences and concerns regarding motivational elements in the app. Below are categorized comments from non-Arabic participants regarding IMPL-1:

Theme 1: Negative Perception of Motivational Messages

"*Feedback like this is **not effective for me**, and **I would not use it**. I like **specific goals** identified and not just a statement like the one made on this app.*" [En.P - 9] (IMPL-1).

"*It can be **annoying**, though, having reminders from the app so constantly.*" [En.P - 130] (IMPL-1).

Theme 2: Skepticism about Motivational Impact

"*For me, **motivational content** from an AI **does nothing for me**.*" [En.P - 11] (IMPL-1).

"*This is **frankly obnoxious**. Having an **inanimate object** try to encourage me **doesn't work**--I know this from experience of using a health app in a different category, and I know **I would rapidly, if not instantly ignore it***." [En.P - 70] (IMPL-1).

Theme 3: Concerns About Privacy and Intrusiveness

"*I treat my exercise as **a private matter**. Having an **interactive agent** makes the **exercise feels less private***." [En.P - 304] (IMPL-1).

Theme 4: Desire for More Personalization

"***It doesn't feel very personalized**, seems like a very basic, expected message. So, **I need it more personalized to me***." [En.P - 75] (IMPL-1).

6.4.2.2.3 Suggestion Strategy

For non-Arabic participants, with respect to the suggestion strategy, IMPL-2 (Mean = 5.368, SD = 1.214) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 4.903, SD = 0.000). Qualitative findings indicate that non-Arabic participants preferred IMPL-2 (**Visual Suggestion Notifications**) because they found it ***motivating and engaging to see characters demonstrating stretches***, as it ***provided a clear guideline for their exercises***, making them feel more accurate and involved. The visual elements ***drew them in***, ***fostering curiosity about specific movements*** and ***increasing their likelihood of using the app***. Participants also appreciated that the implementation ***could teach them proper stretching and exercise techniques***. Visual reminders were ***particularly favored, especially by visual learners***. Furthermore, participants valued the reminders about ***warm-ups and detailed instructions***. They found this feature superior to other options ***as it not only explained warm-up behaviors but also visually demonstrated proper execution***, making it useful for those seeking a comprehensive warm-up routine. Overall, non-Arabic participants favored this implementation due to its engaging visual guidance, educational aspects, and safety considerations. Below are comments from non-Arabic participants about IMPL-2, categorized thematically:

Theme 1: Engagement and Visual Guidance

"***Seeing those characters do** the stretches would be **very helpful and motivating***." [En.P - 33] (IMPL-2).

"*I think this is a **much better design than the box above**. Using **visual elements is much more engaging** and makes it feel like **I'm doing accurate** work **because I'm being given a guideline** for what to do*." [En.P - 2] (IMPL-2).

"***Having** the warm-up activities **shown graphically** like this **draws me in** and **makes me curious about the specific movements involved**. It does make me more likely to use the app and also **makes me interested** in using the app more than the text-only option at the top*." [En.P - 19] (IMPL-2).

Theme 2: Education and Learning

"*I **love** this because it could **teach me** how to **stretch and exercise properly***." [En.P - 26] (IMPL-2).

"***Visual reminders** and textual reminders both are good. I would **personally prefer visual ones** because **I am a visual learner.***" [En.P - 302] (IMPL-2).

Theme 3: Safety and Proper Form

"*I especially **like** the feature that reminds me of **the importance of warmups before beginning more strenuous activity**, and the **instructions are detailed***." [En.P - 85] (IMPL-2).

"*This is **better** than the other feature **because it provides examples of warm-up behaviors** that should be done and **visually shows the user how to properly do them**. It would be **more useful** to those who wish to do a warm-up*." [En.P - 334] (IMPL-2).

On the contrary, non-Arabic participants showed a reduced preference for IMPL-1 (**Textual Suggestion Notifications**) for several reasons. Firstly, they found the textual format ***lacking in motivation and appeal***, with some describing it as ***dull and not eye-catching***, leading to a perception of ***artificiality and excessive advice***. Participants expressed a ***desire for clear guidance on stretches***, which was absent in this version. Secondly, ***frequent pop-up notifications and reminders proved to be a source of irritation and annoyance***, with some participants stating a strong aversion to such ***interruptions*** during app usage. Lastly, ***concerns were raised about the potential for the content to become repetitive and nagging***, particularly ***if it consistently offered information already known to the users***, leading to possible irritation and decreased engagement. In summary, participants were dissatisfied with this implementation due to issues related to motivation, annoyance, and concerns about repetitive content. Below are sample comments from non-Arabic participants' qualitative feedback that further reinforce our findings:

Theme 1: Lack of Motivation and Appeal in Textual Format

"*Even though the app suggests warm-up exercises, but* ***the textual form just looks dull and does not look catchy***." [En.P - 306] (IMPL-1).

"***I don't like*** *this because* ***it doesn't motivate me***." [En.P - 26] (IMPL-1).

"*That kind of advice* ***feels artificial and too much***." [En.P - 71] (IMPL-1).

"***If it doesn't tell*** *me* ***what stretches to actually do*** *- probably* ***would ignore it***." [En.P - 337] (IMPL-1).

Theme 2: Irritation and Annoyance with Pop-Up Notifications

"*This would be* ***annoying*** *to get reminders and* ***notifications like this***." [En.P - 30] (IMPL-1).

"***I detest pop-ups****. The moment anything pops up while I'm doing something,* ***I would delete that app***." [En.P - 11] (IMPL-1).

"*I think* ***pop-up texts*** *with tips would* ***irritate me to death****. I already get enough notifications and such*." [En.P - 43] (IMPL-1).

Theme 3: Concerns About Repeated or Repetitive Content

"*Helpful hints and tips are always good.* ***I would wonder at what point it might become 'nagging' though***." [En.P - 317] (IMPL-1).

"*Might be relevant the first time I receive the notification,* ***but if the same messages are always repeated that I already know*** *(e.g., stretching for exercise)* ***it might get a bit irritating***." [En.P - 333] (IMPL-1).

6.4.2.2.4 Goal-setting Strategy

For non-Arabic participants, relating to the goal-setting strategy, IMPL-2 (Mean = 5.276, SD = 1.327) is perceived as significantly more persuasive (p = .034) than IMPL-1 (Mean = 5.156, SD = 1.361). Based on the qualitative feedback and comments from non-Arabic participants, IMPL-2 (**Customized/User-Driven Goals**) was favored among non-Arabic participants because they expressed a ***strong desire for empowerment and personalization***, valuing the ability to ***set and customize their PA goals*** according to their individual preferences and energy levels, which fosters ***a sense of control and engagement***. The ***adaptability and lifestyle-friendly nature of goal customization*** are also highly regarded, as they allow users to adapt to their unique circumstances and

starting points. This ***flexibility*** of customizing goals ***reduces pressure*** and ***promotes a sustainable and tailored*** approach to fitness. Overall, the findings emphasize the importance of user-driven goal setting and personalization in fostering engagement, motivation, and long-term PA success. Below are comments from non-Arabic participants' qualitative feedback regarding IMPL-2, further substantiating our findings:

Theme 1: Empowerment and Personalization

"*I find the ability to* ***control and customize*** *to be* ***empowering***." [En.P - 306] (IMPL-2).

"I **like** the **flexibility** and ability to **customize my steps**. There are days when I just want to do the bare minimum, whereas other days when I **feel like superman**." [En.P - 11] (IMPL-2).

Theme 2: Control and Engagement

"***Feeling in control*** *is a huge part of fitness. Being able to set goals is* ***a good way*** *to* ***keep me engaged and motivated***." [En.P - 49] (IMPL-2).

Theme 3: Adaptability and Lifestyle-Friendly

"***Everyone starts at different stages****...Being able to change this setting would help me* ***stay on track and meet the goals*** *that I want to meet.*" [En.P - 331] (IMPL-2).

Theme 4: Flexibility and Pressure Reduction

"Being able to **customize goals** is **nice** and **won't put too much unnecessary pressure on me**." [En.P - 336] (IMPL-2).

Conversely, non-Arabic participants exhibited a lower preference for IMPL-1 (**Default/System-based Goals**) as they expressed ***a strong desire for customization and control over their goals***, with many emphasizing the importance of setting their own objectives rather than having them imposed by the app. They also ***held a negative perception of automatic and imposed goals***, viewing them as ***inflexible and lacking personalization***. Non-Arabic participants also expressed the need for personalization and context in goal recommendations, suggesting it should consider factors such as ***medical conditions and individual circumstances***. Finally, participants offered suggestions for improvement, such as ***providing personalized goals and brief contextual information*** to help users make informed choices. Below are comments from non-Arabic participants regarding IMPL-1, sorted into thematic categories:

Theme 1: Desire for Customization and Control Over Goals

"*I **prefer to set my own goals** and don't need this.*" [En.P - 21] (IMPL-1).

"*This is a central feature, but if the user is unable to change the goal, **that would be an issue**. Many people have **different activity levels**, and 10,000 steps may be **far too little or far too many** for some individuals' goals.*" [En.P - 2] (IMPL-1).

Theme 2: Negative Perception of Imposed Goals

"*I don't like **inflexible** goals.*" [En.P - 78] (IMPL-1).

"*I **don't like automatic** recommendations, they are **too general**.*" [En.P - 54] (IMPL-1).

"I **would not want a system** to tell me what I should be doing. I would be **very perturbed** by this, to be honest, and **definitely ignore it**." [En.P - 68] (IMPL-1).

Theme 3: Need for Personalization and Context

"***It would be nice to see recommended and personalized goals**, in case the goal suggested is too much.*" [En.P - 314] (IMPL-1).

"*The **auto goal** may be a **negative feature** for individuals who have been **sedentary or have health issues**.*" [En.P - 311] (IMPL-1).

"*I **don't think I will take goal advice** from the app. **Unless the app has all my medical info** and recommended **by a doctor** or something.*" [En.P - 321] (IMPL-1).

6.4.2.2.5 Reminder Strategy

For non-Arabic participants, in reference to the reminder strategy, IMPL-2 (Mean = 5.352, SD = 1.251) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 5.016, SD = 1.541). Our qualitative findings reveal that non-Arabic participants favor IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) due to the significance of ***personalization and control***, ***scheduling flexibility***, ***motivation***, and ***accountability*** as well as the prevention of SB in a PA or activity tracking system. Participants appreciated the ***sense of control***, ***scheduling options***, and ***motivational tools***, which collectively enhance their experience and adherence to PA routines. The ***user-friendly approach***, including scheduled reminders, is highly regarded for ***empowering individuals*** to take charge of their activity schedules and accountability, ultimately promoting a more active and healthier lifestyle. Below are comments from non-Arabic participants categorized based on thematic considerations:

Theme 1: Personalization and Control

"*Once you put the **control in my hands**, that is **much better***." [En.P - 266] (IMPL-2).

"***Even if it still uses notification**, it is my notification, which **I feel is more relevant** and less annoying*." [En.P - 304] (IMPL-2).

Theme 2: Scheduling Flexibility

"*Setting reminders **based on my preferred schedule** helps me **keep organized** on the times I dedicate to work and **physical activity***." [En.P - 306] (IMPL-2).

Theme 3: Motivation and Accountability

"*A **future goal reminder** is a very **useful and powerful** tool*." [En.P - 63] (IMPL-2).

"*I **rely** a lot on my **reminders** to **keep me on track for my daily activities**, and I think this would be useful.*" [En.P - 535] (IMPL-2).

Theme 4: User-Friendly Approach

"***Scheduled reminders** are **better** than random ones, especially for **people who live a monotonous life***." [En.P - 336] (IMPL-2).

Conversely, non-Arabic participants who hold a negative opinion of IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) expressed ***negative attitudes*** towards push notifications and reminders. They highlighted their ***annoyance***, ***preference for autonomy in setting goals***, and ***concerns about potential negative emotional impacts***, including feelings of judgment and guilt, while also expressing ***annoyance with default auto-reminders***. In summary, participants exhibited specific responses and preferences regarding push notifications in the PA app. Below, you can find comments provided by non-Arabic participants, organized based on thematic considerations:

Theme 1: Negative Attitudes Towards Push Notifications and Reminders

"***Push** notification is **very irritating***." [En.P - 35] (IMPL-1).

"***Notifications** are generally **annoying to me**, especially if they're just the **default ones***." [En.P - 19] (IMPL-1).

"*Might get **on my nerves** if it was **too pushy***." [En.P - 337] (IMPL-1).

Theme 2: Preference to Autonomy and Control Over Goals

"***I don't need** a push notification, **I'd prefer to set my own personal goals and plans***." [En.P - 111] (IMPL-1).

Theme 3: Concerns About Negative Emotional Impact

"*For anyone who worries too much regarding their health, I feel that this application* ***would have negative implications and effects on the user***." [En.P - 325] (IMPL-1).

6.4.2.2.6 Reward Strategy

For non-Arabic participants, as for the reward strategy, IMPL-2 (Mean = 5.339, SD = 1.292) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 5.062, SD = 1.483). The qualitative findings indicate that non-Arabic participants showed a preference for IMPL-2 (**Collecting Virtual Reward Badges**) because they expressed a strong preference for ***a gamified and positively reinforced approach*** to PA tracking, emphasizing the ***motivational power of virtual badges***. The appeal lies in the ***visually engaging nature of badges***, which is reminiscent of achievements in ***video games***, creating an ***enjoyable experience***. Non-Arabic participants appreciated the ***sense of accomplishment*** and ***quantifiable goals*** associated with badges, perceiving them as ***fun and motivational elements*** in their PA journey. The desire for badges to be visually displayed and the competitive goal they represent further contribute to participants' preference, making the overall implementation a compelling and effective means of enhancing PA engagement. Below are sample comments from non-Arabic participants' qualitative feedback that provide additional support for our findings:

Theme 1: Gamification and Motivation

"*I* ***enjoy*** *that the* ***badges*** *represent* ***quantifiable goals***." [En.P - 326] (IMPL-2).

"*Virtual* ***badges rewards*** *really* ***bring me a sense of accomplishment*** *and an endeavor to accomplish more goals and possibly set and* ***accomplish even tougher goals***." [En.P - 306] (IMPL-2).

"*I* ***like*** *the idea of having* ***badges/awards*** *for different goals being hit. This makes me think about* ***achievements in video games****, which are sometimes* ***a good way to motivate me to achieve*** *certain things in those games*." [En.P - 19] (IMPL-2).

In contrast, non-Arabic participants exhibited a decreased inclination for IMPL-1 (**Collecting of Virtual Reward Points**) because they expressed ***a lack of motivation*** concerning points as a reward-based system. This indicated that random rewards or points ***do not effectively encourage*** them to engage in PA. Some participants expressed ***a desire for tangible rewards*** or the ***ability to redeem***

points for real-world benefits like gift cards. ***Clarity and utility*** were key concerns for participants, as they emphasized the ***need to understand what the virtual points are used for*** and whether they hold any practical value. Overall, non-Arabic participants expressed enthusiasm for virtual points with a clear purpose and value. Below are comments from non-Arabic participants' qualitative feedback that further support our findings:

Theme 1: Lack of Motivation of Points Rewards

"*A **reward point** based system is **not really motivating** to me.*" [En.P - 24] (IMPL-1).

"*A reward system **would not work for me**. My goals are important and **getting a random reward does not motivate me**.*" [En.P - 9] (IMPL-1).

Theme 2: Desire for Tangible Rewards

"***Unless** points can **be converted to gift cards**, they are **useless**.*" [En.P - 39] (IMPL-1).

"***Unless** points can **be redeemed for something**, this **wouldn't really do anything** for me.*" [En.P - 169] (IMPL-1).

Theme 3: Lack of Clarity and Utility

"*I would **want to know** what the **virtual points are used for**.*" [En.P - 32] (IMPL-1).

"***It's not clear what I'd do with the points**, if they're of no use **what's the point of having them**.*" [En.P - 335] (IMPL-1).

6.4.2.2.7 Praise Strategy

For non-Arabic participants, in relation to the praise strategy, IMPL-1 (Mean = 5.118, SD = 1.462) is significantly more persuasive ($p < .001$) than IMPL-2 (Mean = 4.820, SD = 1.642). Thematic qualitative findings reveal that non-Arabic participants favored IMPL-1 (**Textual Praise**) due to their recognition of the ***significance of appreciation and positive feedback in motivating*** individuals to engage in physical activities. Participants expressed that receiving compliments and praise, presented in ***visually appealing*** fonts and text, ***played a crucial role in making them feel valued and motivated to achieve their PA goals***. They also emphasized how features such as praise and encouragement ***enhance user engagement and satisfaction***, ***especially benefiting athletic beginners*** by reinforcing

their commitment to PA and fostering a sense of contentment. These findings collectively underline the importance of positive reinforcement and user engagement strategies within PA tracking applications. Below are comments from non-Arabic participants' qualitative feedback that support these findings:

Theme 1: Positive Encouragement as Motivation

"***Feels*** *like a* ***real compliment*** *from a friend.*" [En.P - 285] (IMPL-1).

"***Appreciation plays a key role*** *in keeping me* ***moving****, and this is a fact in my case.*" [En.P - 3] (IMPL-1).

"*I* ***love*** *the* ***positive encouragement****. Makes you* ***feel like you are doing well*** *and* ***makes you feel good*** *so makes you want to* ***keep working towards your goals****.* ***Positivity wins****.*" [En.P - 130] (IMPL-1).

Theme 2: Enhancing User Engagement and Satisfaction

"*I think this* ***would be best*** *for* ***athletic beginners****.*" [En.P - 325] (IMPL-1).

"*The* ***language encouragement*** *can* ***call the heart more*** *unyielding voice, so that* ***I be more active in sports****.*" [En.P - 367] (IMPL-1).

In contrast, non-Arabic participants exhibited a reduced preference for IMPL-2 (**Audio and Visual Praise**). They expressed ***annoyance and disinterest in audio feedback***, perceiving it as potentially ***irritating and ineffective for motivation***. Furthermore, concerns arose regarding ***privacy and social awkwardness in public*** settings, where audible notifications ***could be disruptive***. The influence of ***simplicity and age-related factors*** was evident, as some participants favored visual rewards, and older participants were less inclined toward receiving auditory feedback. Additionally, those who habitually ***kept their phones on mute*** or ***favored data-driven feedback*** found audio notifications to be ineffective. Lastly, many non-Arabic participants regarded audio rewards as ***short-term motivators***, providing ***momentary satisfaction but lacking lasting impact***. The following comments from non-Arabic participants provide further validation of our findings:

Theme 1: Annoyance and Disinterest in Audio Feedback

"*The* ***audio*** *would probably be* ***quite annoying****.*" [En.P - 4] (IMPL-2).

"*This feature* ***does not interest*** *or* ***motivate me at all****.*" [En.P - 24] (IMPL-2).

Theme 2: Privacy and Social Concerns

"*This **auditory noise/announcement may be disturbing to me** when I am in situations that my phone needs to be silenced*." [En.P - 31] (IMPL-2).

"*This is another case that **I don't like very much**. This **visual and sound message** can certainly **annoy and cause some awkward situations in public**. I **would not use it** at all.*" [En.P - 114] (IMPL-2).

Theme 3: Preference for Simplicity and Age-Related Factors

"*This would probably be a bit much for me, and **I would prefer a simple visual reward instead of an audible one***." [En.P - 66] (IMPL-2).

"*Visual or auditory praise is fine, but **I don't really prefer this method, given my age***." [En.P - 306] (IMPL-2).

Theme 4: Ineffectiveness and Short-Term Motivation

"*I have my **phone on mute** most of the time, and **I do not feel this would be a motivating factor for me**.*" [En.P - 535] (IMPL-2).

"*Praise works the same way for me, **it feels good for a second and then back to working***." [En.P - 336] (IMPL-2).

6.4.4.2.8 Reduction Strategy

For non-Arabic participants, relating to the reduction strategy, IMPL-2 (Mean = 5.053, SD = 1.549) is more persuasive than IMPL-1 (Mean = 4.996, SD = 1.557), but the persuasiveness of those implementations is not significantly different (p=.257). The analysis of non-Arabic qualitative feedback revealed that participants favored IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) due to the significant monitoring and motivation features it offers for walking plans. Non-Arabic participants highlighted the ***convenience and ease of monitoring***, expressing their ***appreciation for the tool's organization and clarity***. They also stressed ***the importance of motivation and variety***, as they found this feature valuable for introducing ***diversity into their workouts***. Furthermore, participants ***confirmed the tool's user-friendly*** and ***customizable nature***, expressing their ***satisfaction*** with the options and ***flexibility*** it provides. Finally, they commended the tool for its ***time-saving capabilities*** and its promotion of ***eco-friendly exercise choices***. Overall, the feedback suggests that the implementation is well-received for its monitoring, motivation, user-friendliness, and

practicality. Below are comments from non-Arabic participants about IMPL-2, organized into thematic categories:

Theme 1: Convenience and Ease of Monitoring

"***Good*** *and* ***easy monitoring*** *for us.*" [En.P - 14] (IMPL-2).

"*I* ***like*** *this feature. I can* ***easily organize my daily activities****.*" [En.P - 119] (IMPL-2).

Theme 2: Motivation and Variety

"*A* ***helpful tool to allow variety in my workout*** *without the guesswork of distance and efficiency.*" [En.P - 31] (IMPL-2).

"*This keeps me* ***interesting*** *rather* ***than boring to the same accustomed locations daily****.*" [En.P - 160] (IMPL-2).

Theme 3: User-Friendly and Customizable

"*I* ***like*** *that there are* ***options****.*" [En.P - 41] (IMPL-2).

"*This implementation is* ***more flexible****. It enables me to* ***establish a weekly plan to go to a different location*** *each day. Besides,* ***I have the control*** *to either accept the suggested location or change to some other location.*" [En.P - 306] (IMPL-2).

Theme 4: Time and Environment Considerations

"*Providing different targets for walking plans* ***reduces our time and saves our energy****.*" [En.P - 230] (IMPL-2).

"***Easy way for me to do exercise*** *and motivate me to be* ***economical and environment friendly****.*" [En.P - 539] (IMPL-2).

Conversely, non-Arabic participants exhibited a reduced preference for IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) due to ***skepticism regarding its superiority over existing alternatives***, such as ***Google Maps***, for activity discovery. Many participants found the suggestions provided by the implementation to be ***irrelevant to their specific activities and locations***, thereby limiting its utility. ***Privacy concerns and data sharing*** also emerged as significant issues, as ***participants were hesitant to share their personal location data***. Moreover, some participants expressed ***a preference for user-generated options and dynamic exploration***. Overall, opinions were mixed, with some finding potential usefulness in the implementation ***but not considering it a primary***

selling point, especially in ***rural areas*** where other attractions are more desirable. Below are comments from non-Arabic participants concerning IMPL-2, sorted into thematic categories:

Theme 1: Skepticism and Existing Alternatives

"*I think there are **other apps that already do this better**.*" [En.P - 4] (IMPL-1).

"***I'd directly open Google Maps** if I need to find **somewhere to go**.*" [En.P - 111] (IMPL-1).

Theme 2: Privacy Concerns and Data Sharing

"***I would not want** to provide **my personal location data** to the app.*" [En.P - 120] (IMPL-1).

"*I would be **concerned about privacy issues** regarding requesting data from **Google**.*" [En.P - 312] (IMPL-1).

Theme 3: Preference for User-Generated Options

"*Although system-generated locations based on my current location sound interesting for me, **I would like to try or play with other options dynamically**.*" [En.P - 306] (IMPL-1).

Theme 4: Mixed Reactions and Limited Usefulness

"*This might be a **nice additional feature** but **would not be a prime selling point** for me.*" [En.P - 314] (IMPL-1).

Theme 5: Lack of Relevance to Individual Activities

"***I live in a small town**. It is **not relevant** to me*." [En.P - 26] (IMPL-1).

"***I live in a rural area** with already **known walking trails**. Other attractions would be more useful for me*." [En.P - 535] (IMPL-1).

6.4.2.2.9 Competition Strategy

For non-Arabic participants, with respect to the competition strategy, IMPL-1 (Mean = 5.016, SD = 1.587) is significantly more persuasive (p = .013) than IMPL-2 (Mean = 4.902, SD = 1.655). The qualitative findings indicate that non-Arabic participants showed a preference for IMPL-1 (**Competition as a Leaderboard**) due to their enthusiasm for the competitive aspect of the implementation. They found it helpful in ***sustaining motivation***, ***fostering friendly competition***, and ***aiming to top the leaderboards***. Non-Arabic participants also ***emphasized the positive impact of celebrating results*** and milestones. They ***appreciated the visual representation*** of their progress

through ***virtual rewards and rankings***. Overall, these qualitative findings reaffirm the importance of competition and the ***sense of accomplishment in motivating and engaging*** participants in the activity. Here are comments from non-Arabic participants' qualitative feedback that provide additional support for our findings:

Theme 1: Competition and Motivation

"*Really **useful** because **everyone tries** to reach the **top in the leadership board**.*" [En.P - 103] (IMPL-1).

"***Knowing the gap** between yourself and the people in front of you **will make you more motivated**.*" [En.P - 474] (IMPL-1).

"*This would **be really fun** and **attractive** because it is a **friendly competition,** and it also gives you some **motivation to keep pushing yourself** when you **see others doing it**.*" [En.P - 66] (IMPL-1).

Theme 2: Sense of Achievement and Celebration

"***Happy to see results** like this.*" [En.P - 108] (IMPL-1).

"***Celebration** or the result of achievement is **always a pleasant experience**.*" [En.P - 3] (IMPL-1).

"***I gained a sense of achievement**, **better** to **complete the goal**, exercise themselves.*" [En.P - 346] (IMPL-1).

Conversely, non-Arabic participants exhibited a reduced inclination towards IMPL-2 (**Displaying a Progress Bar for Each Competitor**) because they demonstrated ***a lack of interest and visual appeal*** in these competitive implementation features. They expressed ***disinterest in elements that involve rankings***, ***comparisons with others***, or ***sharing their PAs with peers*** due to concerns about ***privacy and potential discouragement***. Instead, some participants ***preferred individual progress tracking and visual enhancements***, such as badges, for self-motivation. These findings emphasize the importance of balancing competition with privacy and individualized progress tracking when implementing such competitive features in PA applications. Here are comments from non-Arabic participants' qualitative feedback concerning IMPL-2 that further reinforce our findings:

Theme 1: Lack of Interest in Competition

"*I do walking, to keep fit, and **no comparison is required**.*" [En.P - 86] (IMPL-2).

"*Putting me on a **board and comparing** me to **others** and **ranking** to me is something **I am not interested in and would not use**.*" [En.P - 9] (IMPL-2).

Theme 2: Lack of Visual Appeal

"*I **don't like** the ranking as **progress bars**. It is **not visually appealing**.*" [En.P - 41] (IMPL-2).

Theme 3: Privacy Concerns

"***Wouldn't want** this, **I like my privacy**.*" [En.P - 26] (IMPL-2).

"*I **wouldn't want** to **engage in competition** or have people I know **monitor my activity**.*" [En.P - 169] (IMPL-2).

Theme 4: Negative Impact on Motivation and Discouragement

"*The **progress bar** would **add too much pressure** for me.*" [En.P - 304] (IMPL-2).

"*I see myself **being discouraged** by this app **if I cannot measure up** to my 'competitors'.*" [En.P - 85] (IMPL-2).

Theme 5: Prefer Individual Progress Tracking

"***Prefer** to see **my own progress bar**.*" [En.P - 311] (IMPL-2).

"*If **badges** are also **shown** then it will **be more visually appealing**.*" [En.P - 302] (IMPL-2).

6.4.2.2.10 Tunnelling Strategy

For non-Arabic participants, concerning the tunneling strategy, IMPL-2 (Mean = 5.099, SD = 1.491) is significantly more persuasive ($p < .001$) than IMPL-1 (Mean = 4.816, SD = 1.611). Qualitative results indicate that among non-Arabic participants, there was a preference for IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) because they ***appreciated the visual guidance and clarity provided by map-based directions***, finding them easier to follow and more engaging than text-based instructions. Furthermore, many participants noted ***that map visualization motivated them to explore new places while exercising***, adding an element of excitement to their routines. Finally, there was a consensus that ***the user-friendly design and accessibility of the visual map were valuable***, particularly for navigating in unfamiliar areas or during construction. Below are comments from non-Arabic participants' qualitative feedback that provide additional support for our findings:

Theme 1: Visual Guidance and Clarity

"*It **looks great** give **visually attract**, and also **direction with map**.*" [En.P - 38] (IMPL-2).

"*Having it laid out on a **map** like this is **a lot nicer**. It's **easier to follow and digest** when you have a **visual element** involved, instead of just text.*" [En.P - 19] (IMPL-2).

Theme 2: Motivation and Exploration

"*This would be **really useful** for me because **I like seeing data on a map better** and it **motivates me** to get out there and **explore new places while I exercise**.*" [En.P - 66] (IMPL-2).

Theme 3: User-Friendly Design and Accessibility

"*The **visual map** is **intuitive** as well.*" [En.P - 37] (IMPL-2).

"*This **map visualization** is my **preferred method** of following directions, so this would be much **more useful to me**.*" [En.P - 333] (IMPL-2).

On the contrary, non-Arabic participants did not favor IMPL-1 (**Tunneling as Textual/Written Instructions**) due to a strong sense of ***boredom and redundancy***, ***safety concerns***, and a ***preference for visual guidance***. Many participants perceived these textual directions as ***boring and redundant*** because existing navigation apps like ***Google Maps already offer similar features*** with audible directions. ***Safety and distraction concerns*** arose as participants worried that ***reading instructions while walking*** could lead to ***confusion and pose safety risks***. The ***preference for visual directions*** was a common thread, with participants emphasizing the impracticality of text while engaging in physical activities. Lastly, ***age-related factors*** may influence the adoption of this feature. Here are comments from non-Arabic participants' qualitative feedback concerning IMPL-1, providing additional validation of our findings:

Theme 1: Boredom and Redundancy with Existing Apps

"*I just think it looks a bit **bland and boring**.*" [En.P - 266] (IMPL-1).

"*I would just use **Google Maps** for this.*" [En.P - 314] (IMPL-1).

Theme 2: Safety and Distraction Concerns

"*There's just **too much reading** to do **while I'm walking down the street**.*" [En.P - 336] (IMPL-1).

"*This info is good, but the **directions can be confusing** and the **presentation is boring**.*" [En.P - 326] (IMPL-1).

Theme 3: Preference for Visual Directions

"*The feature* ***should be more interactive***." [En.P - 473] (IMPL-1).

"***I only ever look at the route visually*** *on the map, so* ***I wouldn't*** *personally* ***find this useful***." [En.P - 333] (IMPL-1).

Theme 4: Age Considerations

"*The written word description* ***may not be used by many older people***." [En.P - 436] (IMPL-1).

6.4.2.2.11 Cooperation strategy

For non-Arabic participants, regarding the cooperation strategy, IMPL-2 (Mean = 4.946, SD = 1.610) is more persuasive than IMPL-1 (Mean = 4.917, SD = 1.645); however, the persuasiveness of the two implementations is not significantly different (p=.505). Qualitative findings indicate that non-Arabic participants favored IMPL-2 (**Cooperation as Teamwork**) due to the ***sense of responsibility and motivation*** that comes with team dynamics, ***fostering a supportive and collective atmosphere***. The ***enjoyment and fun derived from challenges***, particularly when shared with friends, add a ***positive*** and ***flexible*** dimension to PAs. Teamwork not only enhances relationships but also ***introduces a healthy competition*** that participants find engaging and beneficial. The ***gamification*** of walking emerges as ***a motivating factor***. Furthermore, the ***social aspect extends to enhanced interactions*** through the ***invitation of friends***, creating a supportive and engaging environment for shared PA experiences. Overall, the integration of social elements is perceived as a holistic approach to making PA ***more enjoyable, accountable, and motivating.*** Below are non-Arabic participants' comments regarding IMPL-2, grouped by thematic category:

Theme 1: Social Support and Accountability

"*This is a* ***really good*** *way to keep the users* ***accountable and motivated***." [En.P - 302] (IMPL-2).

"*I would* ***feel more responsible*** *to help* ***contribute to the team***. *I* ***would do more*** *to be a useful member.*" [En.P - 37] (IMPL-2).

Theme 2: Fun and Enjoyment

"***Very funny*** *to try with my* ***friends***." [En.P - 108] (IMPL-2).

"*I think a challenge would be **fun and cooperative**, while **allowing flexibility in walk times**.*" [En.P - 314] (IMPL-2).

Theme 3: Teamwork and Healthy Competition

"*As a **team**, this **leads to healthy competition** and it's very interesting.*" [En.P - 45] (IMPL-2).

Theme 4: Gamification and Motivation

"***Gamifying** the walking in this way could be **motivating**.*" [En.P - 75] (IMPL-2).

"*Challenging with others **motivates to make more efforts**.*" [En.P - 230] (IMPL-2).

Theme 5: Enhanced Social Interactions

"*I **like** the idea **better** that I can **invite** people. People I already know and am friends with.*" [En.P - 266] (IMPL-2).

On the contrary, non-Arabic participants showed less preference for IMPL-1 (**Message Exchange via Social Cooperation Networks**) because they expressed a ***strong preference for solo exercise***, showing a ***desire for individualized workouts*** and a ***lack of interest in socializing*** during PAs. ***Safety and privacy concerns*** emerged, with ***fears of connecting with strangers through the app*** and doubts about the implementation's security. ***Skepticism about the practicality of virtual group walking***, particularly due to potential differences in walking speeds, was also common. Some participants emphasized ***the use of existing communication channels***, such as texting, over integrated social features, which they perceived as ***redundant***. Others viewed the chat rooms feature as ***a waste of time***, expressing doubts about its value and ***emphasizing the importance of maintaining a safe and respectful environment*** within them. Overall, the findings highlight a range of reservations regarding the integration of social elements in PA apps, emphasizing the need for careful consideration of participants' concerns and preferences. Here are non-Arabic participants' comments related to IMPL-1, organized into thematic categories:

Theme 1: Preference for Solo Exercise

"*I like to **exercise alone**.*" [En.P - 259] (IMPL-1).

"***I prefer to work out alone** and **would not** be interested in **chat rooms or communicating** with others.*" [En.P - 9] (IMPL-1).

Theme 2: Safety and Privacy Concerns

"***Could be a dangerous feature*** *as* ***strangers inviting each other does not totally seem safe****, especially for* ***women or teenagers*** *using the app.*" [En.P - 334] (IMPL-1).

Theme 3: Skepticism About Practicality

"***I doubt I would use it*** *personally.*" [En.P - 314] (IMPL-1).

"*Maybe people* ***would end up walking at different speeds*** *and it* ***wouldn't work out****.*" [En.P - 312] (IMPL-1).

Theme 4: Use of Existing Communication Channels

"**I can text my friends**. This **would not be a feature** I would enjoy." [En.P - 535] (IMPL-1).

Theme 5: Concerns and Critiques of Online Chat Rooms

"*Chat room is* ***a waste of time****.*" [En.P - 14] (IMPL-1).

"*Chatting rooms usually* ***need observations for misbehaviors****.*" [En.P - 322] (IMPL-1).

6.4.2.2.12 Simulation Strategy

For non-Arabic participants, regarding the simulation strategy, IMPL-1 (Mean = 4.875, SD = 1.634) is perceived as more persuasive than IMPL-2 (Mean = 4.789, SD = 1.745), though the difference in persuasiveness of the two implementations is not significant (p = .162). Qualitative findings indicate that non-Arabic participants preferred IMPL-1 (**Simulation as Battery Charging**) due to their high appreciation of the implementation's use of ***a positive visual metaphor***—a battery indicator—to represent their PA progress. This metaphor not only ***adds an element of fun and engagement*** to the tracking process but also instills a ***sense of accomplishment, recharging, and motivation.*** The ***visual aid***, particularly the progress bar, is acknowledged as ***a useful monitoring tool*** that offers a ***quick*** and accessible way to ***track achievements***. The battery metaphor, with its ***colorful and positive*** imagery, is seen as a ***powerful motivator*** that ***increases awareness*** of physical health and ***boosts self-confidence***. Overall, the simulated battery charging system enhances participants' engagement and enjoyment, creating a dynamic and interactive experience that enriches the implementation's appeal. Below are comments from non-Arabic participants regarding IMPL-1, sorted into thematic categories:

Theme 1: Positive Visual Metaphor

"*This progression makes me **feel like I'm filling my battery as fast as I can**, and this makes it **fun***." [En.P - 45] (IMPL-1).

"*I **like** this **battery metaphor**, since it would make me **feel like I was recharging my battery** by **engaging in these activities**. It's also **colorful** and brings about **positive feelings** just looking at the indicator, especially as it's getting closer to fully charged.*" [En.P - 19] (IMPL-1).

Theme 2: Visual Aid and Monitoring

"*This would be **useful** to use as **a visual aid***." [En.P - 24] (IMPL-1).

"*It is a **useful progress display** of walking **day-to-day steps***." [En.P - 102] (IMPL-1).

Theme 3: Motivation and Awareness

"*It **boosts self-confidence***." [En.P - 40] (IMPL-1).

"*I personally feel the app will **increase my awareness** of my physical health*." [En.P - 305] (IMPL-1).

"*I would be **goaded to do more** to **achieve a satisfactory result**. It is visually **intuitive** and **easy to understand***." [En.P - 37] (IMPL-1).

Non-Arabic participants showed less preference for IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) due to their strong ***reservations about a 3D body image*** feature. They expressed concerns related to ***body shaming***, ***unrealistic expectations***, and ***compatibility with wellness goals***. These concerns were rooted in the fear that this implementation may promote unhealthy ideals, potentially ***leading to disappointment and negatively impacting self-esteem***. There was ***a collective call for a more holistic approach to health*** that does not focus on body appearance but instead encourages diverse body positivity and wellness goals. Participants also highlighted the ***potential impact on vulnerable groups***, particularly ***those with eating disorders***, emphasizing the need for responsible and inclusive design in PA apps. Here are comments from non-Arabic participants concerning IMPL-2, organized into thematic categories:

Theme 1: Body Image and Self-Esteem Concerns

"***I don't like the 3D person***." [En.P - 105] (IMPL-2).

"***Absolutely not**. All **bodies are good**. This reeks of **body shaming***." [En.P - 43] (IMPL-2).

"***I do not like this feature**. Could create **a lot of disappointment***." [En.P - 318] (IMPL-2).

Theme 2: Preference for a Holistic Approach to Wellness

"*This feature might make sense if the app* ***took a more holistic look at health***." [En.P - 312] (IMPL-2).

"*This type of feature makes people* ***focus more on how they look*** *than on* ***reaching their goals*** *or* ***improving their health***." [En.P - 326] (IMPL-2).

Theme 3: Concerns for Vulnerable Groups

"*I feel this* ***could be dangerous*** *for* ***people with eating disorders***." [En.P - 325] (IMPL-2).

In summary, for the non-Arabic population, the findings from the pairwise comparisons in the RM-ANOVA analysis of Implementation 1 and Implementation 2 for each of the twelve persuasive strategies in our study reveal significant main effects in persuasiveness, except for the personalization, reduction, and cooperation strategies, which showed no significant difference in persuasiveness or effectiveness (personalization: IMPL-1: Mean = 5.066, SD = 1.438; IMPL-2: Mean = 5.130, SD = 1.404; reduction: IMPL-1: Mean = 4.996, SD = 1.557; IMPL-2: Mean = 5.053, SD = 1.549; cooperation: IMPL-1: Mean = 4.917, SD = 1.645; IMPL-2: Mean = 4.946, SD = 1.610).

Overall, the findings indicate that non-Arabic participants preferred Implementation 1 over Implementation 2 for the praise, competition, and simulation strategies. Conversely, they preferred Implementation 2 over Implementation 1 for the remaining strategies, which are self-monitoring, personalization, suggestion, goal-setting, reminder, reward, reduction, tunneling, and cooperation.

6.4.2.3 Comparing the Persuasiveness of Implementations of Each Strategy Between Arabic and Non-Arabic Populations

The findings of the two-way mixed ANOVA comparison between Arabic and non-Arabic populations regarding Implementation 1 of each persuasive strategy reveal significant main effects ($F_{8.778,9638.128} = 24.801$, $p < 0.001$). Figure 68 provides a comparative analysis of the persuasiveness of Implementation 1 within each strategy, identifying variations between Arabic and non-Arabic participants.

For IMPL-1 (**Textual and Numerical Feedback** such as textual representation) of the self-monitoring strategy, our findings reveal that Arabic participants (Mean = 5.352, SD = 1.550) compared to non-Arabic participants showed a slightly greater preference (Mean = 5.262, SD = 1.245).

Similarly, for IMPL-1 (**Personalized Motivational Content**) of the personalization strategy, Arabic participants exhibited a stronger preference (Mean = 5.745, SD = 1.126) than non-Arabic participants (Mean = 5.066, SD = 1.438).

For IMPL-1 (**Textual Suggestion Notifications**) of the suggestion strategy, the findings show that Arabic participants demonstrated a marginally higher inclination (Mean = 4.941, SD = 1.858) compared to non-Arabic participants (Mean = 4.903, SD = 0.000).

Moreover, IMPL-1 of the suggestion strategy is similarly persuasive among both Arabic and non-Arabic participants.

Furthermore, for IMPL-1 (**Default/System-based Goals**) of the goal-setting strategy, Arabic participants displayed more preference (Mean = 5.395, SD = 1.529) compared to non-Arabic participants (Mean = 5.156, SD = 1.361).

For IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) of the reminder strategy, non-Arabic participants showed a lower preference (Mean = 5.016, SD = 1.541) in comparison to Arabic participants (Mean = 5.716, SD = 1.219).

For IMPL-1 (**Collecting of Virtual Reward Points**) of the reward strategy, Arabic participants showed a slightly higher preference (Mean = 5.258, SD = 1.721) compared to non-Arabic participants (Mean = 5.062, SD = 1.483).

For IMPL-1 (**Textual Praise**) of the praise strategy, Arabic participants demonstrated more inclination (Mean = 5.405, SD = 1.508) in comparison to non-Arabic participants (Mean = 5.118, SD = 1.462).

For IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) of the reduction strategy, non-Arabic participants showed a lower preference (Mean = 4.996, SD = 1.557) compared to Arabic participants (Mean = 5.807, SD = 1.111).

For IMPL-1 (**Competition as a Leaderboard**) of the competition strategy, Arabic participants exhibited a stronger inclination (Mean = 5.762, SD = 1.204) than non-Arabic participants (Mean = 5.016, SD = 1.587).

Furthermore, for IMPL-1 (**Tunneling as Textual/Written Instructions**) of the tunneling strategy, Arabic participants exhibited a greater preference (Mean = 5.362, SD = 1.879) than non-Arabic participants (Mean = 4.816, SD = 1.611).

Similarly, for IMPL-1 (**Message Exchange via Social Cooperation Networks**) of the cooperation strategy, Arabic participants showed a higher preference (Mean = 5.595, SD = 1.330) in comparison to non-Arabic participants (Mean = 4.917, SD = 1.645).

Likewise, for IMPL-1 (**Simulation as Battery Charging**) of the simulation strategy, Arabic participants exhibited a stronger inclination (Mean = 5.273, SD = 1.585) compared to non-Arabic participants (Mean = 4.875, SD = 1.634).

Overall, the findings indicate that Arabic participants preferred Implementation 1 of all the strategies more than non-Arabic participants, except for the suggestion strategy, which showed similar levels of persuasiveness or effectiveness. The pairwise comparison results indicate significant differences in the persuasiveness of Implementation 1 among the persuasive strategies between Arabic and non-Arabic populations, except for the self-monitoring and suggestion strategies, which do not show significant differences (see Table 20). A p-value of less than 0.05 is considered significant.

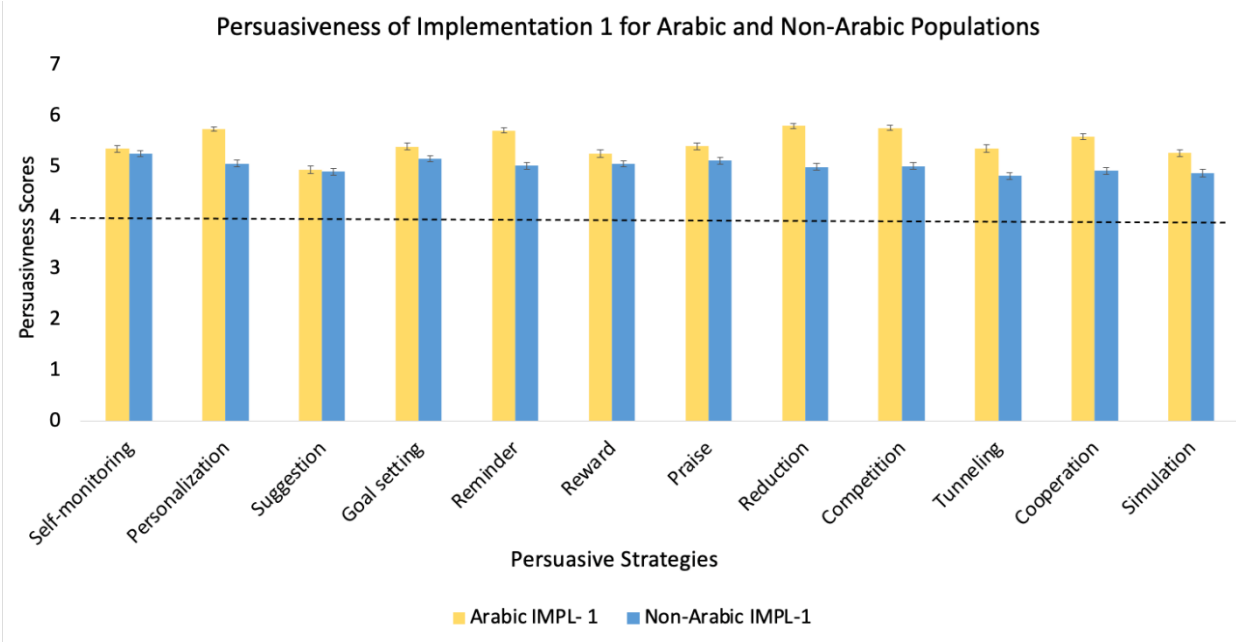


Figure 68: Comparison of Persuasiveness of Implementation 1 for Arabic and non-Arabic Populations.

Table 20: Means, Standard Deviations, and P-Values of the Persuasiveness of Implementation 1 Across Persuasive Strategies in the User-Study for Arabic and Non-Arabic Participants.

		Arabic		Non-Arabic		Pairwise Comparisons
Persuasive Strategy	Implementation Type	Mean	Std. Deviation	Mean	Std. Deviation	P-Value
Self-monitoring	IMPL-1	5.352	1.550	5.262	1.245	0.285
Personalization	IMPL-1	5.745	1.126	5.066	1.438	0.000
Suggestion	IMPL-1	4.941	1.858	4.903	0.000	0.716
Goal-setting	IMPL-1	5.395	1.529	5.156	1.361	0.006
Reminders	IMPL-1	5.716	1.219	5.016	1.541	0.000
Rewards	IMPL-1	5.258	1.721	5.062	1.483	0.044
Praise	IMPL-1	5.405	1.508	5.118	1.462	0.001
Reduction	IMPL-1	5.807	1.111	4.996	1.557	0.000
Social Competition	IMPL-1	5.762	1.204	5.016	1.587	0.000

Tunneling	IMPL-1	5.362	1.879	4.816	1.611	0.000
Social Cooperation	IMPL-1	5.595	1.330	4.917	1.645	0.000
Simulation	IMPL-1	5.273	1.585	4.875	1.634	0.000

The findings of the two-way mixed ANOVA comparison between Arabic and non-Arabic populations regarding Implementation 2 of each persuasive strategy reveal significant main effects ($F_{8.713,9567.227}$= 25,827, $p < 0.001$). Figure 69 provides a comparative analysis of the persuasiveness of Implementation 2 within each strategy, highlighting the differences between Arabic and non-Arabic participants.

For IMPL-2 (**Numerical and Visual Feedback**, such as pie charts, graphs, and progress bars) in the self-monitoring strategy, our findings indicate that Arabic participants (Mean = 5.806, SD = 1.015) exhibited a stronger preference compared to non-Arabic participants (Mean = 5.502, SD = 1.026).

Similarly, in IMPL-2 (**Personalized Goal Recommendations**) of the personalization strategy, Arabic participants showed a slightly higher preference (Mean = 5.159, SD = 1.715) than non-Arabic participants (Mean = 5.130, SD = 1.404).

Consequently, IMPL-2 of the personalization strategy appears to be equally persuasive among both Arabic and non-Arabic participants.

For IMPL-2 (**Visual Suggestion Notifications**) of the suggestion strategy, the results reveal that Arabic participants demonstrated a greater inclination (Mean = 5.875, SD = 1.059) compared to non-Arabic participants (Mean = 5.368, SD = 1.214).

Furthermore, in IMPL-2 (**Customized/User-Driven Goals**) of the goal-setting strategy, Arabic participants displayed a stronger preference (Mean = 5.772, SD = 1.089) compared to non-Arabic participants (Mean = 5.276, SD = 1.327).

On the other hand, in IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) of the reminder strategy, non-Arabic participants showed a greater preference (Mean = 5.352, SD = 1.251) compared to Arabic participants (Mean = 4.929, SD = 1.915).

For IMPL-2 (**Collecting of Virtual Reward Badges**) of the reward strategy, Arabic participants displayed a higher preference (Mean = 5.708, SD = 1.181) compared to non-Arabic participants (Mean = 5.339, SD = 1.292).

In IMPL-2 (**Audio and Visual Praise**) of the praise strategy, Arabic participants showed a greater inclination (Mean = 5.496, SD = 1.398) compared to non-Arabic participants (Mean = 4.820, SD = 1.642).

For IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) of the reduction strategy, non-Arabic participants showed a slightly higher preference (Mean = 5.053, SD = 1.549) compared to Arabic participants (Mean = 4.929, SD = 1.915).

In IMPL-2 (**Displaying a Progress Bar for Each Competitor**) of the competition strategy, Arabic participants exhibited a higher inclination (Mean = 5.188, SD = 1.700) than non-Arabic participants (Mean = 4.902, SD = 1.655).

Furthermore, in IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) of the tunneling strategy, Arabic participants displayed a significantly stronger preference (Mean = 6.258, SD = 1.231) than non-Arabic participants (Mean = 5.099, SD = 1.491).

Similarly, for IMPL-2 (**Cooperation as Teamwork**) of the cooperation strategy, Arabic participants showed a higher preference (Mean = 5.218, SD = 1.717) compared to non-Arabic participants (Mean = 4.946, SD = 1.610).

Additionally, in IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) of the simulation strategy, Arabic participants exhibited a stronger inclination (Mean = 5.763, SD = 1.124) compared to non-Arabic participants (Mean = 4.789, SD = 1.745).

In general, our findings suggest that Arabic participants preferred Implementation 2 in all strategies more than their non-Arabic counterparts, except for the personalization strategy, which exhibited similar levels of persuasiveness or effectiveness for both populations, and for the reminder and reduction strategies, which were more preferred by non-Arabic participants. The pairwise comparison results indicate significant differences in the persuasiveness of Implementation 2 among the persuasive strategies between Arabic and non-Arabic populations, except for the personalization, reminder, and

reduction strategies, which do not show significant differences (see Table 21). A p-value of less than 0.05 is considered significant.

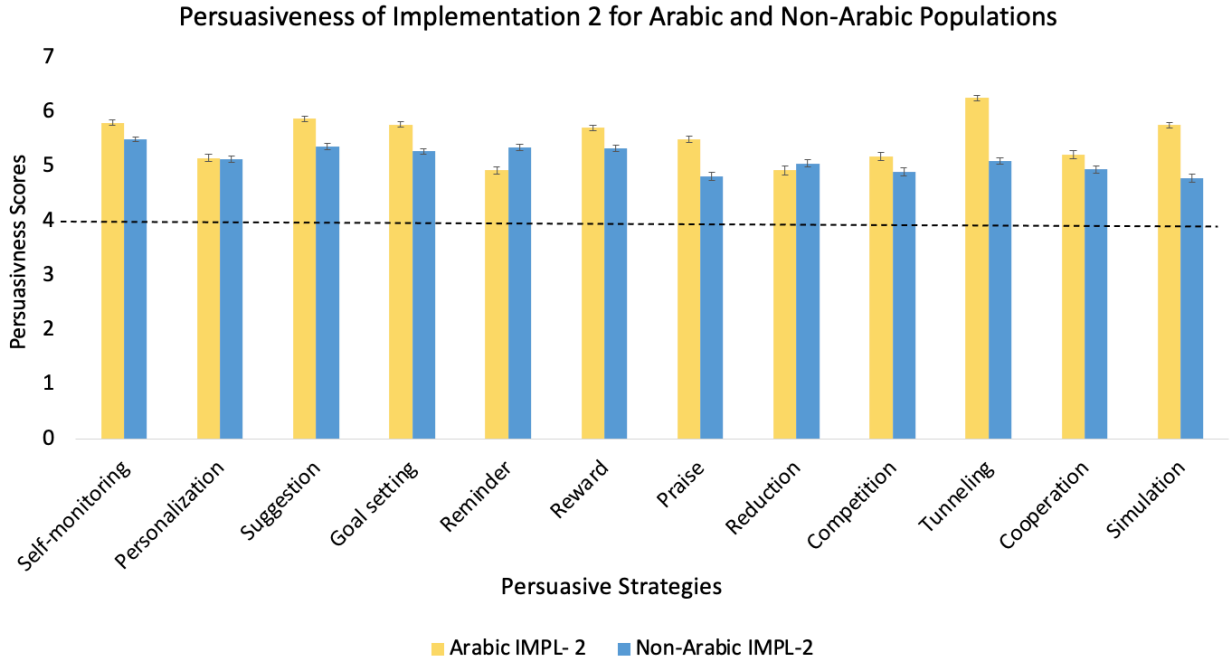


Figure 69: Comparison of Persuasiveness of Implementation 2 for Arabic and Non-Arabic Populations.

Table 21: Means, Standard Deviations, and P-Values of the Persuasiveness of Implementation 2 Across Persuasive Strategies in the User-Study, for Arabic and Non-Arabic Participants.

		Arabic		Non-Arabic		Pairwise Comparisons
Persuasive Strategy	Implementation Type	Mean	Std. Deviation	Mean	Std. Deviation	P-Value
Self-monitoring	IMPL-2	5.806	1.015	5.502	1.026	0.000
Personalization	IMPL-2	5.159	1.715	5.130	1.404	0.763
Suggestion	IMPL-2	5.875	1.059	5.368	1.214	0.000
Goal-setting	IMPL-2	5.772	1.089	5.276	1.327	0.000
Reminders	IMPL-2	4.929	1.915	5.352	1.251	1.000

Rewards	IMPL-2	5.708	1.181	5.339	1.292	0.000
Praise	IMPL-2	5.496	1.398	4.820	1.642	0.000
Reduction	IMPL-2	4.929	1.915	5.053	1.549	0.237
Social Competition	IMPL-2	5.188	1.700	4.902	1.655	0.005
Tunneling	IMPL-2	6.258	1.231	5.099	1.491	0.000
Social Cooperation	IMPL-2	5.218	1.717	4.946	1.610	0.007
Simulation	IMPL-2	5.763	1.124	4.789	1.745	0.000

6.4.3 Phase 3: Comparison of the Relationship between the Implementations of Each Persuasive Strategy and the ARCS Motivational Constructs

This section evaluates the persuasiveness of various implementations of each strategy in relation to the four ARCS motivational constructs (Attention, Relevance, Confidence, and Satisfaction) across different stages of change for both Arabic and non-Arabic populations.

6.4.3.1 The Relationship Between the Implementations of Each Persuasive Strategy and the ARCS Motivational Constructs for the Arabic Population

This section presents the results of our comparative analysis investigating the relationship between the implementations of each persuasive strategy and the ARCS motivational constructs for Arabic participants at different stages of behavior change. Table 22 and Table 23 present the path coefficients (β) and their corresponding significance levels (p) derived from our SmartPLS models. All path coefficients, except those denoted with '–', demonstrate significance at $p < .05$ or lower. The highlighted path coefficients exhibit statistically significant differences between the two implementations for individuals at that particular stage of change. The '–' symbol signifies non-significant path coefficients. "IMPL-1" denotes the first implementation of the strategy, while "IMPL-2" refers to the second implementation. Coefficients in bold represent a significance level of $p < .001$, while non-bolded coefficients represent a significance level of $p < .05$. Participants from the Arabic population are identified with the acronym "Ar.P" (e.g., Ar.P-1, Ar.P-2, Ar.P-3, ...), and participants from the non-Arabic population are identified as "En.P" (e.g., En.P-1, En.P-2, En.P-3, ...).

Table 22: Standard path coefficients and significance of the relationship between each strategy's implementations and ARCS motivational constructs for participants at each stage of change for Arabic participants. Highlighted coefficients are significantly

different across the two implementations for people at that stage of change. '–' indicates non-significant coefficients. Bolded coefficients represent a significance level of p<.001, while un-bolded coefficients represent a significance level of p<.05.

Stage of Change	Strategy	Implementation	ATT	CON	REL	SAT
Precontemplation	Self-monitoring	IMPL-1	0.23	-	-	0.19
		IMPL-2	0.31	0.23	0.21	0.25
	Personalization	IMPL-1	-	0.24	0.33	0.28
		IMPL-2	0.20	-	0.16	0.23
	Suggestion	IMPL-1	0.26	-	0.20	-
		IMPL-2	0.30	0.25	0.26	0.22
	Goal-setting	IMPL-1	0.45	0.19	0.20	0.18
		IMPL-2	0.22	-	**0.35**	0.30
	Reminders	IMPL-1	0.28	**0.32**	0.20	0.22
		IMPL-2	0.16	**0.28**	-	0.36
	Rewards	IMPL-1	-	**0.21**	0.25	0.22
		IMPL-2	0.28	0.23	0.27	0.24
	Praise	IMPL-1	-	0.24	0.22	0.22
		IMPL-2	0.24	0.30	0.23	0.25
	Reduction	IMPL-1	0.21	-	0.50	-
		IMPL-2	-	-	0.33	0.37
	Competition	IMPL-1	0.21	0.23	0.23	0.32
		IMPL-2	-	-	0.21	0.28
	Tunneling	IMPL-1	-	0.29	-	0.20
		IMPL-2	0.21	**0.34**	0.20	0.25
	Cooperation	IMPL-1	0.29	0.30	0.20	0.22
		IMPL-2	0.21	0.23	-	0.19
	Simulation	IMPL-1	-	0.30	-	0.38
		IMPL-2	0.22	0.24	-	0.22
Contemplation	Self-monitoring	IMPL-1	-	0.25	0.23	-
		IMPL-2	**0.20**	0.28	**0.34**	0.21

	Personalization	IMPL-1	0.22	0.27	0.31	-
		IMPL-2	-	0.18	**0.45**	-
	Suggestion	IMPL-1	-	0.33	0.22	-
		IMPL-2	**0.21**	0.41	0.27	0.21
	Goal-setting	IMPL-1	0.28	-	0.36	0.24
		IMPL-2	**0.26**	0.23	0.30	0.22
	Reminders	IMPL-1	**0.31**	0.24	**0.22**	0.23
		IMPL-2	0.37	0.23	-	-
	Rewards	IMPL-1	0. 210	0.19	-	0.25
		IMPL-2	0.24	0.22	-	0.46
	Praise	IMPL-1	-	0.24	0.32	0.29
		IMPL-2	0.23	0.31	0.21	0.26
	Reduction	IMPL-1	0.32	-	0.23	-
		IMPL-2	0.24	-	-	0.31
	Competition	IMPL-1	**0.25**	**0.35**	0.20	0.23
		IMPL-2	0.19	0.24	-	0.21
	Tunneling	IMPL-1	0.24	0.19	0.18	-
		IMPL-2	0.34	0.31	0.25	-
	Cooperation	IMPL-1	-	0.28	0.32	0.32
		IMPL-2	0.30	-	-	-
	Simulation	IMPL-1	-	-	0.58	0.18
		IMPL-2	**0.42**	0.17	0.24	0.27
Preparation	Self-monitoring	IMPL-1	0.19	0.33	0.23	-
		IMPL-2	**0.30**	**0.24**	**0.27**	0.20
	Personalization	IMPL-1	0.20	0.16	**0.51**	0.36
		IMPL-2	-	-	-	0.13
	Suggestion	IMPL-1	-	0.28	0.27	0.21
		IMPL-2	0.22	**0.33**	**0.31**	0.24
	Goal-setting	IMPL-1	0.32	0.18	**0.46**	0.23

		IMPL-2	**0.37**	0.19	**0.29**	0.38
	Reminders	IMPL-1	0.17	-	**0.48**	0.17
		IMPL-2	-	**0.46**	-	**0.31**
	Rewards	IMPL-1	-	-	0.37	0.19
		IMPL-2	0.26	-	**0.32**	0.30
	Praise	IMPL-1	**0.28**	0.35	-	-
		IMPL-2	0.23	**0.30**	**0.29**	0.21
	Reduction	IMPL-1	**0.41**	0.16	**0.26**	0.17
		IMPL-2	-	0.46	0.39	-
	Competition	IMPL-1	0.30	0.27	0.25	**0.21**
		IMPL-2	0.25	0.21	-	-
	Tunneling	IMPL-1	-	0.24	0.19	**0.23**
		IMPL-2	0.21	**0.27**	0.31	0.19
	Cooperation	IMPL-1	**0.25**	0.24	**0.39**	-
		IMPL-2	-	-	0.39	-
	Simulation	IMPL-1	-	0.26	0.32	0.33
		IMPL-2	**0.38**	-	0.24	**0.22**
Action	Self-monitoring	IMPL-1	-	0.26	0.22	0.21
		IMPL-2	0.27	**0.33**	0.23	0.22
	Personalization	IMPL-1	0.30	-	**0.34**	0.25
		IMPL-2	-	0.44	0.23	0.18
	Suggestion	IMPL-1	-	-	0.25	-
		IMPL-2	0.22	0.21	0.40	0.21
	Goal-setting	IMPL-1	-	-	0.30	0.19
		IMPL-2	0.22	**0.30**	0.25	0.22
	Reminders	IMPL-1	0.26	0.25	0.27	0.22
		IMPL-2	-	0.39	-	0.34
	Rewards	IMPL-1	-	-	0.18	0.29
		IMPL-2	0.22	0.21	**0.25**	**0.37**

	Praise	IMPL-1	0.19	0.41	0.28	-
		IMPL-2	0.23	0.33	0.22	0.22
	Reduction	IMPL-1	0.14	**0.36**	**0.34**	0.17
		IMPL-2	-	0.41	-	0.42
	Competition	IMPL-1	**0.21**	**0.32**	**0.41**	0.26
		IMPL-2	-	-	0.33	-
	Tunneling	IMPL-1	-	0.16	-	0.20
		IMPL-2	0.17	**0.27**	0.26	0.31
	Cooperation	IMPL-1	**0.36**	-	**0.35**	0.17
		IMPL-2	-	0.48	-	0.35
	Simulation	IMPL-1	-	0.17	0.22	0.32
		IMPL-2	**0.22**	0.27	**0.31**	0.40
Maintenance	Self-monitoring	IMPL-1	-	0.18	**0.22**	-
		IMPL-2	**0.29**	**0.30**	0.24	0.21
	Personalization	IMPL-1	**0.30**	0.24	**0.40**	-
		IMPL-2	0.20	0.21	0.26	-
	Suggestion	IMPL-1	0.18	0.20	0.33	-
		IMPL-2	0.22	0.26	**0.40**	0.17
	Goal-setting	IMPL-1	**0.22**	-	**0.33**	0.26
		IMPL-2	-	**0.28**	**0.31**	**0.21**
	Reminders	IMPL-1	-	0.26	0.33	0.21
		IMPL-2	**0.36**	0.20	**0.38**	-
	Rewards	IMPL-1	0.27	0.23	0.15	-
		IMPL-2	**0.35**	0.33	**0.31**	0.41
	Praise	IMPL-1	0.16	0.22	0.29	**0.30**
		IMPL-2	0.29	-	0.38	-
	Reduction	IMPL-1	0.21	**0.39**	**0.28**	-
		IMPL-2	-	-	0.41	0.37
	Competition	IMPL-1	**0.28**	0.21	**0.35**	0.23

		IMPL-2	0.24	0.26	**0.33**	0.18
	Tunneling	IMPL-1	-	-	0.42	0.18
		IMPL-2	0.20	0.22	**0.42**	0.24
	Cooperation	IMPL-1	0.21	0.19	**0.48**	0.18
		IMPL-2	0.18	-	**0.52**	0.17
	Simulation	IMPL-1	-	0.23	0.21	0.15
		IMPL-2	0.21	0.36	**0.28**	0.20

ATT = Attention, REL = Relevance, CON = Confidence, SAT = Satisfaction.

6.4.3.1.1 Self-monitoring Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, our findings show that for the self-monitoring strategy, IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**) significantly vary in how they influence behavior change (see Table 22). Specifically, IMPL-2 is significantly associated with Confidence and Relevance ($\beta = .23$, $p < .05$; $\beta = .21$, $p < .05$ respectively) and thus is most appropriate for reinforcing the confidence of people at the Precontemplation stage of change, while IMPL-1 is not related to Confidence or Relevance. Furthermore, IMPL-2 is perceived as more effective for attracting and preserving Attention and Satisfaction constructs than IMPL-1: (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .31$, $p < .05$ and IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta.25$, $p < .05$, respectively). This suggests that to stimulate and preserve the attention and satisfaction of those at the Precontemplation stage, it is better to employ IMPL-2 of the self-monitoring strategy in persuasive systems design. The following sample comments from Arabic participants confirm our findings:

"*This one would **hold my attention** longer than the first format, due to the use of graphs, which I find more physically **appealing** to look at, and a sort of competitive feel that comes from trying to get today's bar a little higher than yesterday's*." [Ar.P - 532] – Attention and Satisfaction (IMPL-2). "*I have the ability to engage in sports, but I need **motivation and encouragement** through such programs. I find these programs **very beneficial**; they will keep laziness away from me and **encourage me** continuously.*" [Ar.P - 104] – Relevance

(IMPL-2). "*It would be a little more motivating to use and more likely to* ***accomplish behavior*** *than the first option.*" [Ar.P - 535] – Confidence (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-1 of the self-monitoring strategy is the only implementation significantly associated with Attention and Satisfaction ($\beta = .20$, $p < .001$, $\beta = .21$, $p < .05$, respectively). Conversely, both IMPL-1 and IMPL-2 of the strategy are significantly related to Relevance (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .34$, $p < .001$) but at a significantly different level, while both implementations are perceived as effective for preserving confidence and are related to the Confidence construct (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .28$, $p < .05$). Accordingly, IMPL-2 is perceived as more effective for increasing attention, relevance, and satisfaction for participants at the Contemplation stage. The following sample comments demonstrate why Arabic participants favor a specific implementation:

"*Yes, the application* ***attracts me*** *to use it and* ***view*** *it on a daily basis*." [Ar.P - 21] – Attention (IMPL-2). "*This is what I was looking for, an Arabic application that helps me track my physical activity and* ***motivates me to do sports such as walking***." [Ar.P - 76] – Confidence (IMPL-2). "*The program will* ***be a useful*** *and distinctive tool to* ***support and enhance*** *physical activity within a large segment of the community*." [Ar.P - 31] – Relevance (IMPL-2). "*In contrast to the prior interface in implementation 1, implementation 2 appeared* ***more appealing and user-friendly****. I particularly appreciated the visuals employed in the second interface*." – [Ar.P – 492] – Satisfaction (IMPL-2).

For Arabic individuals at the **Preparation stage** of behavior change, regarding the self-monitoring strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence and Relevance: (IMPL-1: $\beta = .33$, $p < .05$; IMPL-2: $\beta = .24$, $p < .001$ and IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .27$, $p < .001$, respectively). Consequently, either of the two implementations could be appropriate for reinforcing confidence and relevance due to the lack of significant differences between them. However, IMPL-2 is the only implementation significantly associated with Satisfaction ($\beta = .20$, $p < .05$), and it is significantly more effective in attracting and preserving attention compared to IMPL-1 (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .30$, $p < .001$). Thus, to increase satisfaction and to stimulate and preserve attention among those at the Preparation stage, it is preferable to employ IMPL-2 of the

self-monitoring strategy in persuasive systems design. The following sample comments provide additional support for our findings:

"*The **colored** features of this app and the charts are **good visual representation** and would encourage many people to stay active."* [Ar.P - 508] – Attention and Satisfaction (IMPL-2). "*A convenient and flexible application to **break the barrier of laziness and lethargy**.*" [Ar.P - 157] – Confidence (IMPL-1). "*These screens **motivate me** to improve, and they are really nice to see.*" [Ar.P - 396] – Relevance (IMPL-2).

For Arabic participants at the **Action stage** of behavior change, IMPL-1 and IMPL-2 of the self-monitoring strategy are significantly and similarly related to Confidence, Relevance, and Satisfaction: (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .33$, $p < .001$), (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$), and (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$), respectively. Therefore, since they are not significantly different, both IMPL-1 and IMPL-2 are perceived as similarly effective for increasing and boosting confidence, relevance, and satisfaction. Furthermore, IMPL-2 is the sole implementation significantly associated with Attention ($\beta = .27$, $p < .05$); hence, it is perceived as the most effective for stimulating and preserving Arabic individuals' attention in their ability to change their behavior. Below are sample comments that support our findings:

"*This is even **more attractive**.*" [Ar.P - 533] – Attention (IMPL-2). "*I like the colorful components and the focus on **achieving a goal**.*" [Ar.P - 511] – Confidence (IMPL-2). "*The feature of comparing with exercises **greatly motivates** me.*" [Ar.P - 6] – Relevance (IMPL-2). "*There's a kind of precision and deep focus, and that's **wonderful**.*" [Ar.P - 114] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, concerning the self-monitoring strategy, only IMPL-2 is significantly related to Attention ($\beta = .29$, $p < .001$) and Satisfaction ($\beta = .21$, $p < .05$), thus making it the most effective implementation for stimulating and preserving attention and increasing satisfaction. Both IMPL-1 and IMPL-2 are significantly associated with Confidence (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta = .30$, $p < .001$) but at a significantly different level. Moreover, both IMPL-1 and IMPL-2 are perceived as similarly effective for increasing the relevance of people at the maintenance stage of change (IMPL-1: $\beta = .22$, $p < .001$; IMPL-2: $\beta = .24$, $p < .05$). The following sample qualitative comments provide further validation of our findings:

"*I felt it was a very good App to **monitor** physical activities for everyone and keep good health condition in day-to-day life*." [Ar.P - 534] – Attention (IMPL-2). "*The features in this app immediately drew my attention. They enable me to identify **days of overachievement** and those requiring **extra effort to achieve the goal***." [Ar.P - 268] – Confidence (IMPL-2). "*The presentation of progress activities through bars and graphs is **highly valuable and motivating** to me because it offers a more concise and **user-friendly** representation of data.*" [Ar.P - 269] – Relevance (IMPL-2). "*Graphical presentation is **better** than numerical values.*" [Ar.P - 284] – Satisfaction (IMPL-2).

6.4.3.1.2 Personalization Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, our findings show that for the personalization strategy, only IMPL-1 (**Personalized Motivational Content**) is significantly associated with Confidence ($\beta = .24$, $p < .05$). However, solitary IMPL-2 (**Personalized Goal Recommendations**) is significantly effective for stimulating and preserving Attention ($\beta = .20$, $p < .05$). On the other hand, both IMPL-1 and IMPL-2 of the personalization strategy are significantly related to Relevance (IMPL-1: $\beta = .33$, $p < .05$; IMPL-2: $\beta = .16$, $p < .05$) but at a significantly varying degree. Furthermore, both implementations are perceived as similarly effective for increasing the Satisfaction level of participants at the Precontemplation stage of change (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$) since they are not significantly different. Sample comments below from participants support our findings:

"*This personal recommendation will **make me realize** how am I performing overall. These kinds of reminders will help me to achieve my goals.*" [Ar.P - 542] – Attention (IMPL-2). "*Sometimes, we may feel tired and feel like quitting. This piece of information will **motivate** as well, will **push** people to **reach the goal***." [Ar.P - 515] – Confidence and Relevance (IMPL-1). "*It's **more appealing** because it has motivational words.*" [Ar.P - 92] – Satisfaction (IMPL-1).

For Arabic participants at the **Contemplation stage** of behavior change, with regard to the personalization strategy, IMPL-1 is the only implementation significantly associated with Attention ($\beta = .22$, $p < .001$). Conversely, both IMPL-1 and IMPL-2 of the personalization strategy are significantly associated with Relevance (IMPL-1: $\beta = .31$, $p < .05$; IMPL-2: $\beta = .45$, $p < .001$) but at a

significantly varying degree. Both implementations are perceived as similarly effective in boosting confidence since they are associated with the Confidence construct (IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .18$, $p < .05$), and there is no significant difference between them. However, neither IMPL-1 nor IMPL-2 is related to Satisfaction. The following are example comments that reinforce our findings:

"*Adding a personal aspect makes the subject **more attractive***." [Ar.P - 137] – Attention (IMPL-1). "*This application proves highly beneficial by displaying both **accomplished** and pending goals, aiding **focused** attention on the **remaining objectives***." [Ar.P - 285] – Confidence (IMPL-1). "*Goal recommendations in a warm tone help me to **motivate more** in real life.*" [Ar.P - 545] – Relevance (IMPL-2).

For Arabic participants at the **Preparation stage** of behavior change, concerning the personalization strategy, IMPL-1 is the sole implementation significantly associated with Attention ($\beta = .20$, $p < .05$), Confidence ($\beta = .16$, $p < .05$), and Relevance ($\beta = .51$, $p < .001$); hence, this implementation is most suitable for boosting the attention, confidence, and relevance of people at the Preparation stage of change. On the other hand, IMPL-1 and IMPL-2 are significantly effective in increasing the Satisfaction level of people at that stage of change (IMPL-1: $\beta = .36$, $p < .05$; IMPL-2: $\beta = .13$, $p < .05$) but at a significantly different level. The following are sample comments from Arabic participants regarding the findings:

"*The motivational messages **remind me** to continue my physical activities.*" [Ar.P - 530] – Attention (IMPL-1). "*This app will help and **motivate me** to be **active**, **energetic**, and **lively** every day.*" [Ar.P - 77] – Confidence and Relevance (IMPL-1). "*I **like** the **emotional** motivation system for the **positive energy** it brings to the user*." [Ar.P - 122] – Satisfaction (IMPL-1).

For Arabic participants at the **Action stage** of behavior change, IMPL-1 of the personalization strategy is the only implementation effective in attracting and sustaining Attention ($\beta = .30$, $p < .05$), while IMPL-2 is the only one significantly associated with Confidence ($\beta = .40$, $p < .05$). However, both IMPL-1 and IMPL-2 of the personalization strategy are significantly and similarly related to the Relevance construct (IMPL-1: $\beta = .34$, $p < .001$; IMPL-2: $\beta = .23$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .18$, $p < .05$). The following sample comments present further reinforcement of our results:

"*The motivational phrases **displayed** on this interface during my leisure moments **motivate me** to go for a walk and work towards **my goal**."* [Ar.P - 234] – Attention and Relevance (IMPL-1). "*The personalized goal recommendation feature helps to **increase my activity** and **achieve the goal**.*" [Ar.P - 530] – Confidence (IMPL-2). "*It's a **nice** idea when the app includes support as a personal motivator or a personal trainer.*" [Ar.P - 117] – Satisfaction (IMPL-1).

For Arabic participants at the **Maintenance stage** of behavior change, both IMPL-1 and IMPL-2 of the personalization strategy are significantly associated with Relevance (IMPL-1: $\beta = .40$, $p < .001$; IMPL-2: $\beta = .26$, $p < .05$) but at a significantly different level. Conversely, neither IMPL-1 nor IMPL-2 of the personalization strategy is perceived as effective for increasing satisfaction for people at the Maintenance stage since both implementations are not significantly related to the Satisfaction construct. Moreover, both of the implementations are perceived as effective for stimulating and preserving attention and reinforcing confidence since they are all similarly and significantly associated with the Attention and Confidence constructs (IMPL-1: $\beta = .30$, $p < .001$; IMPL-2: $\beta = .20$, $p < .05$ and IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta.21$, $p < .05$, respectively). The following sample comments from participants offer support for our findings:

"*This feature is like someone **directing my focus** towards the workout.*" [Ar.P - 472] – Attention (IMPL-1). "*Receiving praise acts as a stimulus for my body to **stay active** and strive **to achieve** or surpass **my goals**.*" [Ar.P - 493] – Confidence (IMPL-1). "*Personal recommendation and summary **make me think** as if someone really cares about me. This will **encourage me** to do more for my health.*" [Ar.P - 542] – Relevance (IMPL-1).

6.4.3.1.3 Suggestion Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, concerning the suggestion strategy, IMPL-2 (**Visual Suggestion Notifications**) is the sole implementation significantly associated with Confidence ($\beta = .25$, $p < .05$) and Satisfaction ($\beta = .22$, $p < .05$); hence, it is most suitable for boosting the confidence and satisfaction of people at the Precontemplation stage of change. Conversely, IMPL-1 (**Textual Suggestion Notifications**) and IMPL-2 are significantly effective in increasing the Attention and Relevance level of people at that stage of change (IMPL-1: $\beta = .26$, $p <$

.05; IMPL-2: β = .30, p < .05), (IMPL-1: β = .20, p < .05; IMPL-2: β = .26, p < .05), respectively. The following are sample comments from Arabic participants regarding the findings:

"***Reminding*** *and* ***paying attention*** *to the details of sports activity have an effective role in* ***motivation*** *and continuity.*" [Ar.P - 31] – Attention and Relevance (IMPL-2). "*The images are there so that I can* ***apply*** *the* ***exercises correctly***." [Ar.P - 60] – Confidence (IMPL-2). "*It's* ***enjoyable*** *to have some illustrations and how to do some warm-up exercises.*" [Ar.P - 19] – Satisfaction (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-2 of the suggestion strategy is the only implementation effective in attracting and sustaining Attention (β = .21, p < .001) and increasing Satisfaction (β = .21, p < .05). However, IMPL-1 and IMPL-2 of the suggestion strategy are significantly and similarly effective regarding the Confidence construct (IMPL-1: β = .33, p < .05; IMPL-2: β = .41, p < .05) and Relevance (IMPL-1: β = .22, p < .05; IMPL-2: β = .27, p < .05). The following sample comments present further reinforcement of our findings:

"*Providing* ***visual tips*** *and exercises helps* ***increase motivation*** *to use the app.*" [Ar.P - 137] – Attention and Relevance (IMPL-2). "*Visual Notification tip helps to* ***do better exercise*** *than text messages popup.*" [Ar.P - 534] – Confidence (IMPL-2). "*Displaying exercises with images is* ***wonderful***." [Ar.P - 45] – Satisfaction (IMPL-2).

For Arabic participants at the **Preparation stage** of behavior change, IMPL-2 of the suggestion strategy is the only implementation significantly associated with Attention (β = .22, p < .05). Furthermore, IMPL-2 is significantly more effective than IMPL-1 of the suggestion strategy with regard to the Confidence construct (IMPL-1: β = .28, p < .05; IMPL-2: β = .33, p < .001) and Relevance (IMPL-1: β = .27, p < .05; IMPL-2: β = .31, p < .001). However, both implementations are perceived as effective for increasing satisfaction (IMPL-1: β = .21, p < .05; IMPL-2: β = .24, p < .05). Consequently, IMPL-2 is perceived as more effective for increasing attention, confidence, and relevance for people at the Preparation stage. The following sample comments reveal why Arabic participants favor a specific implementation:

"*Warm-up suggestion will be very useful, especially with the **attractive images** that **show how to perform** the exercise.*" [Ar.P - 515] – Attention (IMPL-2). "*It will help me to **do** my daily **exercises accurately** and increase my physical activity.*" [Ar.P - 146] – Confidence (IMPL-2). "*Images can help with **motivation**.*" [Ar.P - 99] – Relevance (IMPL-2). "*Clear and **beautiful** design.*" [Ar.P - 43] – Satisfaction (IMPL-2).

For Arabic participants at the **Action stage** of behavior change, with regard to the suggestion strategy, IMPL-2 is the only implementation significantly associated with Attention ($\beta = .22$, $p < .05$), Confidence ($\beta = .21$, $p < .05$) and Satisfaction ($\beta = .21$, $p < .05$). However, both IMPL-1 and IMPL-2 of the suggestion strategy are significantly associated with Relevance (IMPL-1: $\beta = .25$, $p < .001$; IMPL-2: $\beta = .40$, $p < .001$) but at a significantly different degree. Subsequently, IMPL-2 is perceived as more effective for increasing people's attention, confidence, relevance, and satisfaction at the Action stage. The following sample qualitative comments provide further validation of our findings:

"*Sports **picture notifications**, I believe, motivate people to do them and **remind** them.*" [Ar.P - 149] – Attention (IMPL-2). "*I strongly agree, as it **prepares the muscles** and **body for exercise**.*" [Ar.P – 42] – Confidence (IMPL-2). "*The visual pop-up can indeed **motivate me** to take more action compared to a simple text message.*" [Ar.P - 492] – Relevance (IMPL-2). "***Better** presentation and contains the information **necessary** to perform the exercise.*" [Ar.P - 509] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, both IMPL-1 and IMPL-2 of the suggestion strategy are significantly and similarly associated with Attention (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$) and Confidence (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .26$, $p < .05$). However, IMPL-2 of the suggestion strategy is the only implementation effective in increasing Satisfaction ($\beta = .17$, $p < .05$). Moreover, IMPL-1 and IMPL-2 significantly vary in how they influence behavior change regarding the Relevance construct (IMPL-1: $\beta = .33$, $p < .05$; IMPL-2: $\beta = .40$, $p < .001$). The following sample comments from participants offer support for our findings:

"*For me, I find that **visual notifications** are very useful, especially for people who don't know useful exercise methods or **how to progress** in sports exercises.*" [Ar.P - 23] – Attention (IMPL-2). "*I much prefer this. It isn't just giving me an empty suggestion on what I could choose to do; it is acting more as a **coach** and **showing** me*

*how to **accomplish it.***" [Ar.P - 532] – Confidence and Relevance (IMPL-2). "*Visual Notification tip helps to do **better** exercise than text messages popup.*" [Ar.P - 534] – Satisfaction (IMPL-2).

6.4.3.1.4 Goal-setting Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, our findings indicate that IMPL-1 (**Default/System-based Goals**) and IMPL-2 (**Customized/User-Driven Goals**) significantly differ in how they motivate behavior change for the goal-setting strategy. Specifically, IMPL-1 is significantly associated with Confidence ($\beta = .19$, $p < .05$), while IMPL-2 is unrelated to Confidence. In addition, IMPL-1 is perceived as more effective in attracting and preserving the Attention construct than IMPL-2: (IMPL-1: $\beta = .45$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$). However, IMPL-2 is perceived as more effective in increasing Relevance (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta.35$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta.30$, $p < .05$). The following example comments from Arabic participants endorse our findings:

"*Goal setting motivates me to do the job seriously. These kinds of **reminders** are very useful.*" [Ar.P - 542] – Attention (IMPL-1). "*It will **help me achieve** the desired fitness level.*" [Ar.P - 146] – Confidence (IMPL-1). "*Giving customization is very **encouraging**. I can increase or decrease my goal as per my abilities and time.*" [Ar.P - 542] – Relevance (IMPL-1). "*It is **good** to have this option to customize the exercise goal.*" [Ar.P - 504] – Satisfaction (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, both IMPL-1 and IMPL-2 of the goal-setting strategy are significantly and similarly associated with Attention (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .26$, $p < .001$), Relevance (IMPL-1: $\beta = .36$, $p < .05$; IMPL-2: $\beta = .30$, $p < .05$), and Satisfaction (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$). Conversely, IMPL-2 of the goal-setting strategy is the sole implementation associated with the Confidence construct ($\beta = .23$, $p < .05$). The following sample comments from participants offer support for our findings:

"*Goal setting and **monitoring** of these goals is a appreciated addition to a fitness **tracker**.*" [Ar.P - 290] – Attention (IMPL-1). "*This one is more friendly and helps the user **increase the goal** to keep **pushing forward**.*" [Ar.P - 509] – Confidence (IMPL-2). "*Goal setting is a very helpful and **motivational tool**. It helps people with*

no clue of how to set a goal to start somewhere." [Ar.P - 505] – Relevance (IMPL-2). "*The step goal is **great** and motivating.*" [Ar.P - 113] – Satisfaction (IMPL-1).

For Arabic participants at the **Preparation stage** of behavior change, IMPL-1 and IMPL-2 of the goal-setting strategy are significantly and similarly related to Attention and Confidence: (IMPL-1: $\beta = .32$, $p < .05$; IMPL-2: $\beta = .37$, $p < .001$), and (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta = .19$, $p < .05$), respectively. Hence, because they are not significantly different, IMPL-1 and IMPL-2 are perceived as similarly effective for attracting and preserving attention and boosting confidence. However, IMPL-1 is more effective in reinforcing Relevance (IMPL-1: $\beta = .46$, $p < .001$; IMPL-2: $\beta = .29$, $p < .001$), while IMPL-2 is significantly associated with increasing Satisfaction (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .38$, $p < .05$). The following are sample comments that support our findings:

"*This feature grabs my **attention**.*" [Ar.P - 148] – Attention (IMPL-2). "*The app will **increase** my **self-confidence**.*" [Ar.P - 77] – Confidence (IMPL-2). "*It **encourages** determination and perseverance.*" [Ar.P - 11] – Relevance (IMPL-1). "*Giving the freedom to plan my own goals is **better**.*" [Ar.P - 137] – Satisfaction (IMPL-2).

For Arabic participants at the **Action stage** of behavior change, IMPL-2 of the goal-setting strategy is the sole implementation significantly related to Attention ($\beta = .22$, $p < .05$) and Confidence ($\beta = .30$, $p < .001$). However, both IMPL-1 and IMPL-2 of the goal-setting strategy are significantly and similarly related to Relevance (IMPL-1: $\beta = .30$, $p < .001$; IMPL-2: $\beta = .25$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$). Consequently, IMPL-2 is perceived as more effective for increasing attention, confidence, and satisfaction for people at the Action stage. The following example comments demonstrate why Arabic participants prefer a particular implementation:

"*Good. **Graphical** representation **attracts me**.*" [Ar.P - 550] – Attention (IMPL-2). "*I much prefer this method of allowing the user, the one who knows their own body, time limitations, and wishes to set their own goals, choosing to either **challenge themselves** or set attainable goals to **keep their momentum going**.*" [Ar.P - 532] – Confidence (IMPL-2). "*A strong **motivator**.*" [Ar.P - 76] – Relevance (IMPL-1). "***Good** feature, so I can set reasonable goals based on my time and ability.*" [Ar.P - 506] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, IMPL-1 of the goal-setting strategy is the sole implementation significantly associated with Attention ($\beta = .22$, $p < .001$). However, IMPL-2 is the only implementation significantly related to Confidence ($\beta = .28$, $p < .001$). Furthermore, IMPL-1 and IMPL-2 of the goal-setting strategy are significantly and similarly related to Relevance and Satisfaction: (IMPL-1: $\beta = .33$, $p < .001$; IMPL-2: $\beta = .31$, $p < .001$), and (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .21$, $p < .001$), respectively. Subsequently, IMPL-1 is perceived as more effective for increasing people's attention, relevance, and satisfaction at the Maintenance stage. The following are sample comments from Arabic participants regarding the findings:

"*Goal **reminders** are considered a feature.*" [Ar.P - 99] – Attention (IMPL-1). "***Customized** step forwarding options are very useful to **do more exercise**.*" [Ar.P - 430] – Confidence (IMPL-2). "*A step count goal provides the **incentive** to be physically more active.*" [Ar.P - 509] – Relevance (IMPL-1). "*The idea of adding instructions from reliable sources like the World Health Organization is a very **nice** idea*." [Ar.P - 117] – Satisfaction (IMPL-1).

6.4.3.1.5 Reminder Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, our findings indicate that for the reminder strategy, IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) significantly vary in how they persuade behavior change. Thus, IMPL-1 is significantly associated with Relevance ($\beta = .20$, $p < .05$), while IMPL-2 is unrelated to the Relevance construct. Furthermore, IMPL-1 is more effective in stimulating and preserving Attention (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .16$, $p < .05$) and increasing Satisfaction (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .36$, $p < .05$). However, both IMPL-1 and IMPL-2 are significantly and similarly effective in boosting Confidence (IMPL-1: $\beta = .32$, $p < .001$; IMPL-2: $\beta = .28$, $p < .001$). Consequently, our findings indicate that to attract and sustain attention, reinforce relevance, and increase satisfaction for people at the Precontemplation stage, it is more promising to apply IMPL-1 of the reminder strategy in persuasive systems design. The following sample comments from Arabic participants validate our findings:

"*I find **notifications** helpful for people who sit a lot on a chair during work so that they can **remember** to walk while sitting between periods.*" [Ar.P - 23] – Attention (IMPL-1). "*Automatic reminders by the system will help the user to **perform** their daily **fitness activities**.*" [Ar.P - 534] – Confidence (IMPL-1). "*I find this application **highly valuable and helpful** as it provides me with automatic reminders regarding my physical activity progress and periods of inactivity*." [Ar.P - 269] – Relevance (IMPL-1). "*It's **better** than the previous method where the user chooses the appropriate time for the reminder*." [Ar.P - 30] – Satisfaction (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-1 and IMPL-2 of the reminder strategy are significantly and similarly related to Attention and Confidence (IMPL-1: $\beta = .31$, $p < .001$; IMPL-2: $\beta = .37$, $p < .05$), and (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$), respectively. Thus, IMPL-1 and IMPL-2 are perceived as similarly effective for stimulating and preserving attention and enhancing confidence due to the lack of a significant difference between them. Nonetheless, IMPL-1 is the sole implementation effective in emphasizing and increasing Relevance and Satisfaction ($\beta = .22$, $p < .001$; $\beta = .23$, $p < .05$, respectively). The following are sample comments that support our findings:

"*Good idea to **catch my attention** and work out in time.*" [Ar.P - 472] – Attention (IMPL-2). "*I liked the idea of the notification; it makes me **engage in physical activity**.*" [Ar.P - 149] – Confidence (IMPL-1). "*As I mentioned earlier, pop-up messages are very important **motivation** for reminders.*" [Ar.P - 117] – Relevance (IMPL-1). "*I **prefer** automatic reminders.*" [Ar.P - 29] – Satisfaction (IMPL-1).

For Arabic participants at the **Preparation stage** of behavior change, concerning the reminder strategy, IMPL-1 is the only implementation significantly associated with Attention ($\beta = .17$, $p < .05$) and Relevance ($\beta = .48$, $p < .001$). However, IMPL-2 is the sole implementation significantly related to Confidence ($\beta = .46$, $p < .001$). Additionally, our findings show that IMPL-1 and IMPL-2 significantly vary in how they increase the Satisfaction of those at the Preparation stage (IMPL-1: $\beta = .17$, $p < .05$; IMPL-2: $\beta = .31$, $p < .001$). Thus, IMPL-1 is more effective in stimulating and sustaining attention and increasing relevance, while IMPL-2 is highly effective in boosting confidence and is more effective in increasing satisfaction. The following sample qualitative comments deliver further justification for our findings:

"*If the application **monitors** the activity and status of the user and sends **notifications** at the right time.*" [Ar.P - 30] – Attention (IMPL-1). "*By human nature, procrastination is common. Such reminders help us **initiate and start exercising**.*" [Ar.P - 3] – Confidence (IMPL-2). "*If the system monitors me and provides regular step reminders, it would be **beneficial**, as it **motivates** me to overcome my laziness or other distractions and take a step forward to walk.*" [Ar.P - 234] – Relevance (IMPL-1). "***Preferable** scheduled times will help the user to perform their daily fitness activities based on their own **preferred** timings*." [Ar.P - 534] – Satisfaction (IMPL-2).

For Arabic participants at the **Action stage** of behavior change, IMPL-1 of the reminder strategy is the only implementation effective in attracting and preserving Attention ($\beta = .26$, $p < .05$) and increasing Relevance ($\beta = .27$, $p < .05$). However, IMPL-2 is more effective in boosting Confidence and increasing Satisfaction than IMPL-1 (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .39$, $p < .05$ and IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .34$, $p < .05$, respectively). The following example comments further illustrate details of our findings:

"*These reminders **address the issue of forgetting the goal**.*" [Ar.P - 116] – Attention (IMPL-1). "*User-modified reminders give the user **control** over the time they are able **to do activities**.*" [Ar.P - 508] – Confidence (IMPL-2). "*It **clearly** gives a kind of **motivation**.*" [Ar.P - 114] – Relevance (IMPL-1). "***Excellent** tool and more personal feature, which is **a plus**.*" [Ar.P - 505] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, regarding the reminder strategy, IMPL-2 is the only implementation significantly associated with Attention ($\beta = .36$, $p < .001$), while IMPL-1 is the sole implementation significantly related to Satisfaction ($\beta = .21$, $p < .05$). Moreover, both IMPL-1 and IMPL-2 of the reminder strategy are significantly and similarly associated with Confidence (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .20$, $p < .05$) and Relevance (IMPL-1: $\beta = .33$, $p < .05$; IMPL-2: $\beta = .38$, $p < .001$). The comments provided by participants below serve as supporting evidence for our findings:

"*It will be helpful to have a **reminder** based on your **actual schedule**.*" [Ar.P - 511] – Attention (IMPL-2). "*This will help me if I am busy in my work and forget about exercise. This reminder will make me take a break and **do the activity.***" [Ar.P - 542] – Confidence (IMPL-1). "*A personalized or customized reminder is extremely*

***useful and encouraging**. I can take a break at a convenient time and continue my job.*" [Ar.P - 542] – Relevance (IMPL-2). "*With life's busyness, this feature is **good**.*" [Ar.P - 2] – Satisfaction (IMPL-1).

6.4.3.1.6 Reward Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, regarding the reward strategy, IMPL-1 (**Collecting of Virtual Reward Points**) and IMPL-2 (**Collecting Virtual Reward Badges**) are significantly and similarly associated with Confidence, Relevance, and Satisfaction: (IMPL-1: $\beta = .21$, $p < .001$; IMPL-2: $\beta = .23$, $p < .05$), (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .27$, $p < .05$), and (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$), respectively. Accordingly, the two implementations could be suitable for boosting and increasing confidence, relevance, and satisfaction because they lack significant differences. However, IMPL-2 is the only implementation that is significantly effective in attracting and preserving Attention ($\beta = .28$, $p < .05$) among those at the Precontemplation stage. The following sample comments offer further support for our findings:

"*I find that **visual** rewards are more **motivating** than points.*" [Ar.P - 23] – Attention and Relevance (IMPL-2). "*Earning badges for my **physical activity achievement** is a **nice** idea.*" [Ar.P - 528] – Confidence and Satisfaction (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-1 and IMPL-2 of the reward strategy are significantly and similarly related to Attention (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$) and Confidence (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .22$ $p < .05$). Both implementations are considered as similarly effective in stimulating and preserving attention and enhancing confidence since there is no significant difference between them. Nevertheless, neither IMPL-1 nor IMPL-2 is associated with Relevance. Furthermore, IMPL-2 is more effective in increasing Satisfaction than IMPL-1 (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .46$, $p < .05$). The following are example comments that support our findings:

"*I find this app extremely helpful, and the badges are **more attractive**.*" [Ar.P - 153] – Attention (IMPL-2). "*Badges **increase** the spirit of **challenge**.*" [Ar.P - 96] – Confidence (IMPL-2). "*I believe that badges are **much better** than points. They will be similar to games.*" [Ar.P - 152] – Satisfaction (IMPL-2).

For Arabic participants at the **Preparation stage** of behavior change, concerning the reward strategy, IMPL-1 is the sole implementation significantly associated with Attention ($\beta = .17$, $p < .05$) and Relevance ($\beta = .48$, $p < .001$). Conversely, IMPL-2 is the only implementation significantly related to Confidence ($\beta = .46$, $p < .001$). Moreover, IMPL-2 is more effective in increasing Satisfaction than IMPL-1 (IMPL-1: $\beta = .17$, $p < .05$; IMPL-2: $\beta = .31$, $p < .001$). Accordingly, to increase relevance and to stimulate and preserve attention among those at the Preparation stage, it is preferable to employ IMPL-1 of the reward strategy in persuasive systems design. However, it is better to employ IMPL-2 to boost confidence and increase satisfaction at this stage of change. The following sample qualitative comments give additional proof for our findings:

"*Badges could foster **a sense of pride** and serve as tangible symbols of achievement that I can **proudly display**.*" [Ar.P - 468] – Attention and Satisfaction (IMPL-2). "*Having points and rewards increases **motivation** and persistence.*" [Ar.P - 19] – Relevance (IMPL-1). "*Badges are **better** than points in different stages.*" [Ar.P - 505] – Relevance (IMPL-2).

For Arabic participants at the **Action stage** of behavior change, our findings reveal that IMPL-2 is the sole implementation for the reward strategy significantly related to the Attention and Confidence constructs ($\beta = .22$, $p < .05$; $\beta = .21$, $p < .05$, respectively). However, IMPL-1 and IMPL-2 are significantly and similarly associated with Relevance (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta = .25$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .29$, $p < .05$; IMPL-2: $\beta = .37$, $p < .001$). Consequently, IMPL-2 is more effective in increasing relevance and satisfaction than IMPL-1, although there is no significant difference between them. This suggests that to attract and preserve the attention, boost the confidence, and increase the relevance and satisfaction of those at the Action stage, it is better to employ IMPL-2 of the reward strategy in persuasive systems design. The following sample comments from Arabic participants support our findings:

"*The **visuals** employed will undoubtedly **motivate** users to **engage in more physical activity** and maintain their usage of the app.*" [Ar.P - 492] – Attention, Confidence, and Relevance (IMPL-2). "*Receiving badges makes me **feel** as if I have **won a real medal**. It will encourage me to **do more exercise**.*" [Ar.P - 542] – Satisfaction and Confidence (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, both IMPL-1 and IMPL-2 of the reward strategy are significantly and similarly associated with Attention (IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .35$, $p < .001$) and Confidence (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .33$, $p < .05$). However, IMPL-1 and IMPL-2 significantly vary in how they increase Relevance (IMPL-1: $\beta = .15$, $p < .05$; IMPL-2: $\beta = .31$, $p < .001$) for those at the Maintenance stage. Moreover, IMPL-2 of the reward strategy is the only implementation effective in increasing Satisfaction ($\beta = .41$, $p < .05$) at that stage of behavior change. The following sample comments from participants offer support for our findings:

"*Rewarding as badges **hold my attention** more than just points.*" [Ar.P - 124] – Attention (IMPL-2). "*I have an affinity for badges and would **make an effort to earn** and proudly display them on my profile.*" [Ar.P - 188] – Confidence (IMPL-2). "*I believe that badges are a **more encouraging** and logical idea for the content of the app (sports) compared to points.*" [Ar.P - 21] – Relevance (IMPL-2). "***Wow**, I **love** that. It makes me **feel** like I'm in some competition or a game.*" [Ar.P - 104] – Satisfaction (IMPL-2).

6.4.3.1.7 Praise Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, regarding the praise strategy, IMPL-2 (**Audio and Visual Praise**) is the only implementation significantly associated with Attention ($\beta = .24$, $p < .001$). However, both IMPL-1 (**Textual Praise**) and IMPL-2 of the praise strategy are significantly and similarly associated with Confidence (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .30$, $p < .05$), Relevance (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$), and Satisfaction (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$). Moreover, due to the lack of a significant difference between them, the two implementations are perceived as effective for boosting confidence and increasing relevance and satisfaction for those at the Precontemplation stage. The comments provided by participants below work as supporting proof for our findings:

"*This sound and **visual notification** is more useful and **attractive** to me.*" [Ar.P - 266] – Attention (IMPL-2). "*Creates a spirit of **competition** and **challenges**.*" [Ar.P - 140] – Confidence (IMPL-2). "*It makes me feel like I'm in a sports club and receiving **encouragement** from my trainers.*" [Ar.P - 104] – Relevance (IMPL-2). "***Well** designed one. **Nice** idea.*" [Ar.P - 528] – Satisfaction (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-2 of the praise strategy is the sole implementation that is significantly effective in attracting and preserving Attention ($\beta = .23$, $p < .05$). Conversely, IMPL-1 and IMPL-2 of the praise strategy are significantly and similarly related to the Confidence, Relevance, and Satisfaction constructs: (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .31$, $p < .05$), (IMPL-1: $\beta = .32$, $p < .05$; IMPL-2: $\beta = .21$, $p < .05$), and (IMPL-1: $\beta = .29$, $p < .05$; IMPL-2: $\beta = .26$, $p < .05$), respectively. Furthermore, both implementations are considered similarly effective in enhancing confidence, relevance, and satisfaction because there is no substantial difference between them. The following sample comments offer further support for our findings:

"*Audible **notifications** will **remind** me constantly*." [Ar.P - 77] – Attention (IMPL-2). "*This paise feature will help me **control** my physical activity for **accomplishing** the goal.*" [Ar.P - 146] – Confidence (IMPL-2). "*Having motivational phrases is **encouraging***." [Ar.P - 19] – Relevance (IMPL-1). "*Psychological support and a **beautiful** and encouraging **feeling***." [Ar.P - 89] – Satisfaction (IMPL-1).

For Arabic participants at the **Preparation stage** of behavior change, IMPL-1 and IMPL-2 of the praise strategy are significantly and similarly associated with Attention and Confidence (IMPL-1: $\beta = .28$, $p < .001$; IMPL-2: $\beta = .23$, $p < .05$ and IMPL-1: $\beta = .35$, $p < .05$; IMPL-2: $\beta = .30$, $p < .001$, respectively). Therefore, IMPL-1 and IMPL-2 are perceived as similarly effective for stimulating and preserving attention and enhancing confidence. Regardless, IMPL-2 is the sole implementation effective in increasing Relevance and Satisfaction ($\beta = .29$, $p < .001$; $\beta = .21$, $p < .05$, respectively). The following are sample comments that support our findings:

"***Displaying** of text **notifications** in this case are helpful and motivating*." [Ar.P - 154] – Attention (IMPL-1). "*This part gives **confidence** and **increases physical activity***." [Ar.P - 115] – Confidence (IMPL-1). "*When praise is in an audio format, it is more and more **motivating**, and therefore, a tremendous step.*" [Ar.P - 42] – Relevance (IMPL-2). "*Praising is a **great** option. Furthermore, the clapping and firework sounds, along with **visually appealing** effects, make it **feel** like a **celebration** of my work. Without a doubt, I absolutely **adore** this feature.*" [Ar.P - 234] – Satisfaction (IMPL-2).

For Arabic participants at the **Action stage** of behavior change, IMPL-1 and IMPL-2 of the praise strategy are significantly and similarly related to Attention (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$), Confidence (IMPL-1: $\beta = .41$, $p < .05$; IMPL-2: $\beta = .33$ $p < .05$), and Relevance (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .22$ $p < .05$). However, IMPL-2 of the praise strategy is the only implementation that is significantly effective in increasing Satisfaction ($\beta = .22$, $p < .05$). The following example comments show further details of our findings:

"*Audible **notifications** are useful and have a **better** impact than text notifications.*" [Ar.P - 23] – Attention and Satisfaction (IMPL-2). "*This step helps in **maintaining regular activity** and looking forward **to doing it more**.*" [Ar.P - 42] – Confidence (IMPL-1). "***Motivational** sentences are also good for **encouragement**.*" [Ar.P - 68] – Relevance (IMPL-1). "*The content of the audio praise is **very good**.*" [Ar.P - 549] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, regarding the praise strategy, IMPL-2 is significantly more effective in attracting and preserving Attention than IMPL-1 (IMPL-1: $\beta = .16$, $p < .05$; IMPL-2: $\beta = .29$, $p < .05$). However, IMPL-1 is the only implementation significantly associated with Confidence ($\beta = .22$, $p < .05$) and Satisfaction ($\beta = .30$, $p < .001$). Furthermore, IMPL-1 and IMPL-2 are significantly and similarly associated with the Relevance construct (IMPL-1: $\beta = .29$, $p < .05$; IMPL-2: $\beta = .38$, $p < .05$). The following are sample comments from Arabic participants regarding the findings:

"*Clapping and firework **sounds and visualizations** make me **pay more attention**.*" [Ar.P - 251] – Attention (IMPL-2). "*Textual praise also motivates to all users, and it's very important **to reach their goals**.*" [Ar.P - 534] – Confidence (IMPL-1). "*Strong and tremendous **encouragement** and support.*" [Ar.P - 89] – Relevance (IMPL-2). "*It is a **good** methodology, and I **like** the message **better**.*" [Ar.P - 505] – Satisfaction (IMPL-1).

6.4.3.1.8 Reduction Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, our findings indicate that for the reduction strategy, only IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) is significantly associated with attracting and preserving Attention ($\beta = .21$, $p < .05$). However, neither IMPL-1 nor IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) is

related to Confidence. On the other hand, both IMPL-1 and IMPL-2 of the reduction strategy are significantly related to Relevance (IMPL-1: $\beta = .50$, $p < .05$; IMPL-2: $\beta = .33$, $p < .05$) but at a significantly varying degree. Additionally, IMPL-2 is the only implementation that is significantly effective in increasing Satisfaction ($\beta = .37$, $p < .05$). The following are sample comments that emphasize our findings:

"*This is a really good feature, and it **draws our attention** to some nearby places that we can reach on foot instead of using a car*." [Ar.P - 3] – Attention (IMPL-1). "*I think this would provide good **encouragement** to explore different places in the community by walking.*" [Ar.P - 510] – Relevance (IMPL-1). "***Better** because it allows me to choose walking locations myself and on days that suit me, not on a daily basis.*" [Ar.P - 3] – Satisfaction (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, concerning the reduction strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with stimulating and preserving Attention (IMPL-1: $\beta = .32$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$). Although there is no significant difference between the two implementations, IMPL-1 is considered more effective in attracting the attention of those at that stage of change. Nevertheless, neither IMPL-1 nor IMPL-2 is associated with the Confidence construct. Moreover, only IMPL-1 is significantly associated with boosting Relevance ($\beta = .23$, $p < .05$). On the other hand, IMPL-2 is the sole implementation significantly associated with increasing Satisfaction ($\beta = .31$, $p < .05$). The following are example comments that support our findings:

"*It's nice to **remind** me of places*." [Ar.P - 60] – Attention (IMPL-1). "*Contains **relevant** information to **motivate** performing more physical activities.*" [Ar.P - 509] – Relevance (IMPL-1). "*Offering diverse suggestions is an **excellent** feature*." [Ar.P - 99] – Satisfaction (IMPL-2).

For Arabic participants in the **Preparation stage** of behavior change, our results indicate significant differences in how IMPL-1 and IMPL-2 of the reduction strategy motivate behavior change. Specifically, IMPL-1 is significantly associated with Attention ($\beta = .41$, $p < .001$) and thus is most appropriate for attracting people's attention at the Preparation stage of change, while IMPL-2 is unrelated to the Attention construct. Furthermore, IMPL-1 and IMPL-2 are significantly associated

with strengthening Confidence (IMPL-1: β = .16, p < .05; IMPL-2: β = .46, p < .05) and enhancing Relevance (IMPL-1: β = .26, p < .001; IMPL-2: β = .39, p < .05) but at a significantly varying level. Thus, IMPL-2 is perceived as more effective for boosting confidence and increasing relevance than IMPL-1. However, IMPL-1 is the sole implementation significantly associated with increasing Satisfaction (β = .17, p < .05). The following comments are indicated to provide further support for our findings:

"*It's an **amazing** app for the user to **see** the location using Google Maps along with time, distance, location, etc.*" [Ar.P - 534] – Attention and Satisfaction (IMPL-1). "*Knowing distances encourages **breaking a new record in walking** a new distance.*" [Ar.P - 87] – Confidence (IMPL-2). "*Predefined routes with calculated distance are **encouraging***" [Ar.P - 508] – Relevance (IMPL-2). "***Good and better** than the weekly plan, with the addition of nearby locations for walking at the same time.*" [Ar.P - 29] – Satisfaction (IMPL-1).

For Arabic participants at the **Action stage** of behavior change, IMPL-1 of the reduction strategy is the sole implementation that is significantly effective in attracting and preserving Attention (β = .14, p < .05) and increasing Relevance (β = .34, p < .001). However, IMPL-1 and IMPL-2 of the reduction strategy are significantly and similarly related to Confidence (IMPL-1: β = .36, p < .001; IMPL-2: β = .41, p < .05). Furthermore, IMPL-1 and IMPL-2 are significantly associated with increasing Satisfaction (IMPL-1: β = .17, p < .05; IMPL-2: β = .42, p < .05) but at a significantly different level. Consequently, IMPL-2 is considered more effective for increasing people's satisfaction at that stage of change. The following sample comments offer further support for our findings:

"*I like the **attention** to detail on how long each walk is so that you can pick accordingly.*" [Ar.P - 337] – Attention (IMPL-1). "*There are supplementary functionalities that **enhance the productivity of my walks**, such as the option to choose alternative destinations from recommended locations. This proves to be exceptionally valuable.*" [Ar.P - 234] – Confidence (IMPL-2). "*Practical and **motivating** suggestions*." [Ar.P - 85] – Relevance (IMPL-1). "*A predetermined exercise and walking route would be **best** for me.*" [Ar.P - 532] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, IMPL-1 of the reduction strategy is the only implementation significantly associated with Attention and Confidence (β = .21, p

< .05; β = .39, p < .001, respectively). Nevertheless, IMPL-1 and IMPL-2 are significantly related to Relevance (IMPL-1: β = .28, p < .001; IMPL-2: β = .41, p < .05) but at a significantly different degree. Accordingly, IMPL-2 is more effective for increasing people's relevance at that stage of change. Furthermore, IMPL-2 of the reduction strategy is the sole implementation that is significantly effective in increasing Satisfaction (β = .37, p < .05), while IMPL-1 is unrelated to the Satisfaction construct. The following sample comments give further support for our findings:

"*It would be useful to **see** a list of walking trails like this.*" [Ar.P - 19] – Attention (IMPL-1). "*Knowing the distances **encourages breaking a new record** for a new distance.*" [Ar.P - 87] – Confidence (IMPL-1). "*If the reduction system is accurate, this is a **great** and **very important and helpful** job, saving a lot of time for the person instead of resorting to a personal weight loss trainer.*" [Ar.P - 42] – Relevance and Satisfaction (IMPL-2).

6.4.3.1.9 Competition Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, IMPL-1 (**Competition as a Leaderboard**) of the competition strategy is the only implementation significantly related to Attention and Confidence (β = .21, p < .05; β = .23 p < .05, respectively). On the other hand, IMPL-1 and IMPL-2 (**Displaying a Progress Bar for Each Competitor**) of the competition strategy are significantly and similarly related to the Relevance and Satisfaction constructs (IMPL-1: β = .23, p < .05; IMPL-2: β = .21, p < .05 and IMPL-1: β = .32, p < .05; IMPL-2: β = .28, p < .05, respectively). Consequently, IMPL-1 and IMPL-2 are perceived as similarly effective for increasing relevance and satisfaction for those at the Precontemplation stage. The following are sample comments from Arabic participants regarding the findings:

"***Seeing** others' activities **encourages** me to put more effort."* [Ar.P - 542] – Attention and Relevance (IMPL-1). "*Leaderboard ranking motivates me to **reach the top** during the next time*." [Ar.P - 528] – Confidence (IMPL-1). "*Competitions are **enjoyable** and truly motivate to achieve goals **without getting bored**.*" [Ar.P - 3] – Satisfaction (IMPL-1).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-1 and IMPL-2 of the competition strategy are significantly and similarly associated with stimulating and preserving

Attention (IMPL-1: $\beta = .25$, $p < .001$; IMPL-2: $\beta = .19$, $p < .05$), strengthening Confidence (IMPL-1: $\beta = .35$, $p < .001$; IMPL-2: $\beta = .24$, $p < .05$), and increasing Satisfaction (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .21$, $p < .05$). Correspondingly, IMPL-1 is more effective for increasing people's attention, confidence, and satisfaction at that stage of change, though there is no significant difference between the two implementations. Furthermore, IMPL-1 is the sole implementation that is significantly effective in increasing Relevance ($\beta = .20$, $p < .05$), while IMPL-2 is not associated with relevance. The following sample qualitative comments deliver further justification for our findings:

"*Leaderboard ranking **shows** your hard work and walking progress.*" [Ar.P - 545] – Attention (IMPL-1). "*Competition helps in **staying committed** to sports.*" [Ar.P - 87] – Confidence (IMPL-1). "*It is **motivating** to have a friendly competition.*" [Ar.P - 509] – Relevance (IMPL-1). "*Badges add **beauty** to the appearance of achievements.*" [Ar.P - 31] – Satisfaction (IMPL-1).

For Arabic participants at the **Preparation stage** of behavior change, IMPL-1 and IMPL-2 of the competition strategy are significantly and similarly related to Attention and Confidence (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$ and IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .21$, $p < .05$, respectively). However, IMPL-1 is the only implementation that is significantly effective in increasing Relevance and Satisfaction ($\beta = .25$, $p < .05$; $\beta = .21$ $p < .001$, respectively). Consequently, IMPL-1 is more effective for stimulating and preserving attention, boosting confidence, enhancing relevance, and increasing satisfaction for those at the Preparation stage of change. The following are example comments that support our findings:

"***Looking** at the leaderboard and comparing myself to others can be a strong source of **motivation**. Additionally, the **visual appeal** of badges and trophies adds to the incentive, **encouraging** me to strive for the top spot on the leaderboard.*" [Ar.P - 234] – Attention, Relevance, and Satisfaction (IMPL-1). "*Competition is great and really motivates me to **achieve my goals** without getting bored.*" [Ar.P - 3] – Confidence (IMPL-1). "*I **prefer** this format of presentation over the visual progress bar.*" [Ar.P - 29] – Satisfaction (IMPL-1).

For Arabic participants at the **Action stage** of behavior change, IMPL-1 of the competition strategy is the only implementation that is significantly effective in attracting and preserving Attention ($\beta = .21$,

$p < .001$), strengthening Confidence ($\beta = .32$, $p < .001$), and increasing Satisfaction ($\beta = .26$, $p < .05$). On the other hand, IMPL-1 and IMPL-2 of the competition strategy are significantly and similarly related to Relevance (IMPL-1: $\beta = .41$, $p < .001$; IMPL-2: $\beta = .33$, $p < .05$). Thus, IMPL-1 is more effective for increasing people's relevance at the Action stage, though there is no significant difference between the two implementations. The comments provided by participants below serve as supporting evidence for our findings:

"*This leaderboard feature will **grab my attention** and **attract** me.*" [Ar.P - 146] – Attention (IMPL-1). "*Having rewards might **motivate** me to **put in extra effort** on the days when I have more free time.*" [Ar.P - 30] – Confidence and Relevance (IMPL-1). "*This feature is **better** with the presence of rewards and will be motivating for activity.*" [Ar.P - 152] – Satisfaction (IMPL-1).

For Arabic participants at the **Maintenance stage** of behavior change, IMPL-1 and IMPL-2 of the competition strategy are significantly and similarly associated with the four ARCS motivational constructs in terms of attracting and preserving Attention (IMPL-1: $\beta = .28$, $p < .001$; IMPL-2: $\beta = .24$, $p < .05$), boosting Confidence (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .26$, $p < .05$), enhancing Relevance (IMPL-1: $\beta = .35$, $p < .001$; IMPL-2: $\beta = .33$, $p < .05$), and increasing Satisfaction (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .18$, $p < .05$). Therefore, the two implementations could be appropriate for boosting and increasing attention, confidence, relevance, and satisfaction because they lack significant differences. The following are sample comments that support our findings:

"*Good **representation** of activities results.*" [Ar.P - 508] – Attention (IMPL-1). "*Ranking progress bar would motivate the user to **achieve their step goal easily** if they get it on a daily basis and compared with competitors.*" [Ar.P - 534] – Confidence (IMPL-2). "*The winning board **motivates** us.*" [Ar.P - 523] – Relevance (IMPL-1). "***Very good** competition feature, and I **like** this one **better**.*" [Ar.P - 505] – Satisfaction (IMPL-1).

6.4.3.1.10 Tunnelling Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) of the tunneling strategy is the sole implementation that is significantly effective in attracting and preserving Attention ($\beta = .21$, $p < .05$) and increasing

Relevance (β = .20, p < .05). However, both IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 of the tunneling strategy are significantly and similarly associated with the Confidence and Satisfaction constructs (IMPL-1: β = .29, p < .05; IMPL-2: β = .34, p < .001 and IMPL-1: β = .20, p < .05; IMPL-2: β = .25, p < .05, respectively). Thus, IMPL-1 and IMPL-2 are perceived as similarly effective for increasing confidence and satisfaction for those at the Precontemplation stage. The following sample comments provide further support for our findings:

"*Interesting and **attention-grabbing***." [Ar.P - 35] – Attention (IMPL-2). "*Clarifying suitable places for walking or suggested sports by location is wonderful and **motivating** for **increased walking***." [Ar.P - 141] – Relevance and Confidence (IMPL-2). "*Using satellite technology in directions is **great***." [Ar.P - 87] – Satisfaction (IMPL-2).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-1 and IMPL-2 of the tunneling strategy are significantly and similarly associated with Attention, Confidence, and Relevance: (IMPL-1: β = .24, p < .05; IMPL-2: β = .34, p < .05), (IMPL-1: β = .19, p < .05; IMPL-2: β = .31, p < .05), and (IMPL-1: β = .18, p < .05; IMPL-2: β = .25, p < .05), respectively. Consequently, IMPL-2 is perceived as more effective for stimulating and preserving attention, strengthening confidence, and boosting relevance for people at the Contemplation stage of change. Nonetheless, neither IMPL-1 nor IMPL-2 is associated with Satisfaction. The following are sample comments that support our findings:

"*It's a beautiful thing because maps make it easier to **track** the route and walking.*" [Ar.P - 149] – Attention (IMPL-2). "*It's really **helpful** for me because I don't know the routes and can't remember them, and it also **motivates me to walk** and enjoy new places*." [Ar.P – 155] – Relevance and Confidence (IMPL-2).

For Arabic participants at the **Preparation stage** of behavior change, IMPL-2 of the tunneling strategy is the sole implementation that is significantly effective in stimulating and preserving Attention (β = .21, p < .05). However, IMPL-1 and IMPL-2 of the tunneling strategy are significantly and similarly associated with Confidence, Relevance, and Satisfaction: (IMPL-1: β = .24, p < .05; IMPL-2: β = .27, p < .001), (IMPL-1: β = .19, p < .05; IMPL-2: β = .31, p < .05), and (IMPL-1: β = .23, p < .001; IMPL-

2: $\beta = .19$, $p < .05$), respectively. Subsequently, the two implementations could be appropriate for increasing confidence, relevance, and satisfaction for those at the Preparation stage. The following are example comments that support our findings:

"*The app contains some content that **catches my attention**, such as routes and directions.*" [Ar.P - 146] – Attention (IMPL-2). "*This feature will help **increase my daily activity**.*" [Ar.P - 77] – Confidence (IMPL-2). "*Visual recommendations will be **useful and motivating**.*" [Ar.P - 152] – Relevance (IMPL-2). "*Route directions are **very good**, helping me to decide which direction to choose for a walking exercise.*" [Ar.P - 542] – Satisfaction (IMPL-1).

For Arabic participants at the **Action stage** of behavior change, IMPL-2 of the tunneling strategy is the only implementation significantly associated with Attention and Relevance ($\beta = .17$, $p < .05$; $\beta = .26$, $p < .05$), respectively. However, IMPL-1 and IMPL-2 of the tunneling strategy are significantly and similarly related to Confidence and Satisfaction (IMPL-1: $\beta = .16$, $p < .05$; IMPL-2: $\beta = .27$, $p < .001$) and (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .31$, $p < .05$), respectively. Consequently, IMPL-2 is perceived as more effective for attracting attention and increasing confidence, relevance, and satisfaction for individuals at the Action stage. The following are sample comments that support our findings:

"***Seeing** the **route** through the map is always **preferable** over written description.*" [Ar.P - 528] – Attention and Satisfaction (IMPL-2). "*It will **boost my walking** activity.*" [Ar.P - 136] – Confidence (IMPL-2). "*This version is **much better** and more **motivating** than the previous one, and I can **understand** it.*" [Ar.P - 30] – Relevance and Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, regarding the tunneling strategy, IMPL-2 is the only implementation significantly associated with Attention ($\beta = .20$, $p < .05$) and Confidence ($\beta = .22$, $p < .05$). However, both IMPL-1 and IMPL-2 of the tunneling strategy are significantly and similarly associated with Relevance (IMPL-1: $\beta = .42$, $p < .05$; IMPL-2: $\beta = .42$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$). Accordingly, either of the two implementations could be suitable for increasing relevance and satisfaction due to the lack of

significant differences between them. The following example comments show further details of our findings:

"***Map visualizations*** *are a good way to know about park or destination whereabouts to* ***practice physical activity*** *such as* ***walking****."* [Ar.P - 542] – Attention and Confidence (IMPL-2). "*Using tunneling feature is* ***helpful*** *and may* ***encourage*** *exploring the surroundings* ***easier****.*" [Ar.P - 154] – Relevance (IMPL-2). "*This map version is* ***much better*** *than the previous textual one, and I can understand it.*" [Ar.P - 30] – Satisfaction (IMPL-2).

6.4.3.1.11 Cooperation Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, concerning the cooperation strategy, both IMPL-1 (**Message Exchange via Social Cooperation Networks**) and IMPL-2 (**Cooperation as Teamwork**) are significantly and similarly associated with Attention (IMPL-1: $\beta = .29$, $p < .05$; IMPL-2: $\beta = .21$, $p < .05$), Confidence (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$), and Satisfaction (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .19$, $p < .05$). Thus, although there is no significant difference between the two implementations, IMPL-1 is perceived as more effective for stimulating and preserving attention, boosting confidence, and increasing satisfaction. Moreover, IMPL-1 is the sole implementation significantly associated with increasing Relevance ($\beta = .20$, $p < .05$). The following sample qualitative comments deliver further justification for our findings:

"*Creating challenges for friends* ***attract*** *commitment to sports.*" [Ar.P - 148] – Attention (IMPL-1). "*Social* ***motivation*** *surpasses programmed motivation, as I feel that it's possible to* ***accomplish physical tasks*** *more when I see others doing them.*" [Ar.P - 30] – Relevance and Confidence (IMPL-1). "*It's a* ***good*** *thing because it fosters a spirit of collaboration among athletes.*" [Ar.P - 149] – Satisfaction (IMPL-1).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-2 of the cooperation strategy is the only implementation significantly associated with Attention ($\beta = .30$ $p < .05$). However, IMPL-1 is the only implementation significantly associated with Confidence ($\beta = .28$ $p < .05$), Relevance ($\beta = .32$ $p < .05$), and Satisfaction ($\beta = .32$ $p < .05$). This suggests that to stimulate and preserve attention, it is better to employ IMPL-2 of the cooperation strategy in persuasive systems design. However, it is more beneficial to utilize IMPL-2 of the cooperation strategy in systems design

to boost and increase the confidence, relevance, and satisfaction of those at the Contemplation stage. The following are sample comments that support our findings:

"***Eye-catching*** *when friends* ***notice*** *the invitation. It's useful for* ***reminding*** *to walk.*" [Ar.P - 149] – Attention (IMPL-2). "*Social chatting room is also important for interacting and* ***walking*** *together, which would* ***motivate*** *and* ***challenge*** *with others.*" [Ar.P - 534] – Confidence and Relevance (IMPL-1). "*This feature is* ***more than wonderful****. It's truly very motivating to find a full team that encourages each other, and this breaks the monotony.*" [Ar.P - 3] – Satisfaction (IMPL-1).

For Arabic individuals at the **Preparation stage** of behavior change, regarding the cooperation strategy, only IMPL-1 is significantly related to Attention ($\beta = .25$, $p < .001$) and Confidence ($\beta = .24$, $p < .05$), thus making it the most effective implementation for stimulating and preserving attention and boosting confidence. However, IMPL-1 and IMPL-2 of the cooperation strategy are identically associated with Relevance (IMPL-1: $\beta = .39$, $p < .001$; IMPL-2: $\beta = .39$, $p < .05$). However, neither IMPL-1 nor IMPL-2 is related to Satisfaction. The following are sample qualitative comments that reinforce our findings:

"*Social chatting room* ***holds my attention*** *and helps in setting a walking plan as a team.*" [Ar.P - 173] – Attention (IMPL-1). "*Socializing may help me* ***be more active****.*" [Ar.P - 508] – Confidence (IMPL-1). "*Highly* ***motivating*** *with the spirit of* ***enthusiasm*** *and challenge.*" [Ar.P - 59] – Relevance (IMPL-1).

For Arabic participants at the **Action stage** of behavior change, concerning the cooperation strategy, IMPL-1 is the only implementation that is significantly effective in stimulating and preserving Attention ($\beta = .36$, $p < .001$) and increasing Relevance ($\beta = .35$, $p < .001$). However, IMPL-2 is the sole implementation significantly associated with boosting Confidence ($\beta = .48$, $p < .05$). Furthermore, IMPL-1 and IMPL-2 are significantly associated with increasing Satisfaction (IMPL-1: $\beta = .17$, $p < .05$; IMPL-2: $\beta = .35$, $p < .05$) but at a significantly different degree. Thus, IMPL-2 of the cooperation strategy is significantly more effective than IMPL-1 in increasing the satisfaction level of people at the Action stage. The following are example comments that support our findings:

"*Good way to **represent** the walking team methodology.*" [Ar.P - 550] – Attention (IMPL-1). "***Challenging** one's abilities helps with development and **staying active**.*" [Ar.P - 40] – Confidence (IMPL-2). "*The idea of participation is **motivating** for everyone.*" [Ar.P - 113] – Relevance (IMPL-1). "*It's **great** that the idea has a specific time frame for completing the challenge without inviting participants to a specific time and place*." [Ar.P - 31] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, regarding the cooperation strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .18$, $p < .05$), Relevance (IMPL-1: $\beta = .48$, $p < .001$; IMPL-2: $\beta = .52$, $p < .001$), and Satisfaction (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta = .17$, $p < .05$). Both implementations are perceived as similarly effective in stimulating and preserving attention, boosting relevance, and increasing satisfaction since there is no significant difference between the two implementations. However, IMPL-1 is the sole implementation significantly associated with boosting Confidence ($\beta = .19$, $p < .05$). The following sample qualitative comments deliver further details of our findings:

"*Having a chat conversation with team members helps in **remembering** and staying **focused** on our walking goal*." [Ar.P - 423] – Attention (IMPL-1). "*Meeting other like-minded people, chatting, and **jogging together** makes me feel excited.*" [Ar.P - 542] – Confidence (IMPL-1). "*A **motivating** feature, especially given the recent situation (COVID-19)*." [Ar.P - 152] – Relevance (IMPL-2). "***Great** feature, it will make my activities **more fun** with a group.*" [Ar.P - 505] – Satisfaction (IMPL-1).

6.4.3.1.12 Simulation Strategy

For Arabic participants at the **Precontemplation stage** of behavior change, concerning the simulation strategy, IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) is the sole implementation that is significantly effective in attracting and preserving Attention ($\beta = .22$, $p < .05$). However, IMPL-1 (**Simulation as Battery Charging**) and IMPL-2 of the simulation strategy are significantly and similarly related to Confidence (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$). Conversely, neither IMPL-1 nor IMPL-2 of the simulation strategy is perceived as effective for increasing relevance for people at the Precontemplation stage since both implementations are not significantly related to the Relevance construct. Furthermore, IMPL-1 and

IMPL-2 are significantly associated with increasing Satisfaction (IMPL-1: $\beta = .38$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$) but at a significantly different level. The following are sample comments that emphasize our findings:

"***Seeing*** *your ultimate body shape* ***displayed*** *can be quite motivating*." [Ar.P - 262] – Attention (IMPL-2). "*knowing my energy levels, represented as a simulated battery, would lead to* ***increase my physical activity***." [Ar.P - 87] – Confidence (IMPL-1). "*It is a* ***good idea*** *to represent my progress in a battery charging format.*" [Ar.P - 528] – Satisfaction (IMPL-1).

For Arabic participants at the **Contemplation stage** of behavior change, IMPL-2 of the simulation strategy is the only implementation significantly associated with Attention and Confidence ($\beta = .42$ $p < .001$; $\beta = .17$ $p < .05$, respectively). However, IMPL-1 and IMPL-2 are significantly associated with increasing Relevance (IMPL-1: $\beta = .58$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$) but at a significantly varying degree. Accordingly, IMPL-1 of the simulation strategy is significantly more effective than IMPL-2 in strengthening the relevance level of those at the Contemplation stage. Moreover, IMPL-1 and IMPL-2 are significantly and similarly associated with Satisfaction (IMPL-1: $\beta = .18$, $p < .05$; IMPL-2: $\beta = .27$, $p < .05$); hence, all the implementations are perceived as similarly effective in increasing satisfaction because there is no significant difference between them. Here are sample remarks from Arabic participants that substantiate our findings:

"*Body shape prediction is* ***attractive****, and it may help me* ***increase my active time***." [Ar.P - 508] – Attention and Confidence (IMPL-2). "*Displaying the user's movements and walking progress is* ***important and encouraging*** *to reach their goals*." [Ar.P - 534] – Relevance (IMPL-1). "*A* ***wonderful*** *and* ***new*** *idea.*" [Ar.P - 16] – Satisfaction (IMPL-2).

For Arabic participants at the **Preparation stage** of behavior change, regarding the simulation strategy, our findings indicate that IMPL-2 is the sole implementation significantly related to Attention ($\beta = .38$, $p < .001$), while IMPL-1 is the only implementation significantly associated with Confidence ($\beta = .26$, $p < .05$). However, IMPL-1 and IMPL-2 are significantly and similarly associated with Relevance (IMPL-1: $\beta = .32$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$); thus, all of these implementations are perceived as equally effective in boosting people's relevance. Moreover, IMPL-1 and IMPL-2 are

significantly related to Satisfaction (IMPL-1: $\beta = .33$, $p < .05$; IMPL-2: $\beta = .22$, $p < .001$) but at a significantly different degree. Accordingly, IMPL-2 is more effective in increasing satisfaction than IMPL-1. Presented below are example comments that corroborate our results:

"*The body shape in the **visual representation** is wonderful*." [Ar.P - 42] – Attention (IMPL-2). "*I adore this feature; it **motivates** me to **walk more** and **enhance** the battery charging simulation.*" [Ar.P - 234] – Relevance and Confidence (IMPL-1). "*An **excellent** and motivating feature to increase activity levels.*" [Ar.P - 152] – Satisfaction (IMPL-1).

For Arabic participants at the **Action stage** of behavior change, regarding the simulation strategy, only IMPL-2 is significantly related to Attention ($\beta = .22$, $p < .001$), thus making it the most effective implementation for stimulating and preserving attention. However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .17$, $p < .05$; IMPL-2: $\beta = .27$, $p < .05$), Relevance (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .31$, $p < .001$), and Satisfaction (IMPL-1: $\beta = .32$, $p < .05$; IMPL-2: $\beta = .40$, $p < .05$). Accordingly, IMPL-2 is more effective than IMPL-1 in stimulating and preserving attention, boosting confidence, and increasing satisfaction, though there is no significant difference between them. The sample qualitative comments below provide additional insights into our results:

"***Seeing** my target goal **image** will **motivate** me to keep doing the walking task."* [Ar.P - 542] – Attention and Relevance (IMPL-2). "*It helps to **achieve** a target body shape goal*." [Ar.P - 530] – Confidence (IMPL-2). "*A **beautiful** idea and **better** than the previous interface.*" [Ar.P - 30] – Satisfaction (IMPL-2).

For Arabic participants at the **Maintenance stage** of behavior change, IMPL-2 of the simulation strategy is the only implementation that is significantly effective in attracting and preserving Attention ($\beta = .21$, $p < .05$). However, IMPL-1 and IMPL-2 of the simulation strategy are significantly related to Confidence (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .36$, $p < .05$) but at a significantly different degree. Furthermore, the two implementations are significantly and similarly associated with Relevance (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .28$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .15$, $p < .05$; IMPL-2: $\beta = .20$, $p < .05$); thus, all of the implementations are perceived as equally effective in

boosting people's relevance and increasing their satisfaction. The subsequent qualitative comments offer more detailed information regarding our findings:

"*I liked that there is a **clear vision** of the current and target body **shape***." [Ar.P - 114] – Attention (IMPL-2). "*It provides excellent **motivation** for slimming down and staying fit. It **keeps me physically active** and **reduces sedentary behavior and laziness.***" [Ar.P - 312] – Relevance and Confidence (IMPL-2). "***Great** and logically linked motivation associated with personal data and body parameters*." [Ar.P - 38] – Satisfaction (IMPL-2).

6.4.3.2 THE RELATIONSHIP BETWEEN THE IMPLEMENTATIONS OF EACH PERSUASIVE STRATEGY AND THE ARCS MOTIVATIONAL CONSTRUCTS FOR THE NON-ARABIC POPULATION

This section presents the comparison of our analysis findings of the relationship between the implementations of each persuasive strategy and the ARCS motivational constructs for non-Arabic participants at different stages of behavior change.

Table 23: Standard path coefficients and significance of the relationship between each strategy's implementations and ARCS motivational constructs for participants at each stage of change for non-Arabic participants. Highlighted coefficients are significantly different across the two implementations for people at that stage of change. '–' indicates non-significant coefficients. Bolded coefficients represent a significance level of p<.001, while un-bolded coefficients represent a significance level of p<.05.

Stage of Change	Strategy	Implementation	ATT	CON	REL	SAT
Precontemplation	Self-monitoring	IMPL-1	0.20	-	-	0.17
		IMPL-2	0.33	0.22	0.24	0.25
	Personalization	IMPL-1	0.30	0.17	-	0.22
		IMPL-2	0.23	-	0.27	-
	Suggestion	IMPL-1	**0.46**	0.19	-	-
		IMPL-2	0.30	0.26	0.23	0.24
	Goal-setting	IMPL-1	0.30	0.19	0.20	0.33
		IMPL-2	-	0.33	-	0.43
	Reminders	IMPL-1	**0.27**	-	0.36	-
		IMPL-2	0.32	0.26	0.25	0.23
	Rewards	IMPL-1	0.27	-	0.22	-
		IMPL-2	0.34	0.21	0.26	0.24
	Praise	IMPL-1	0.28	0.24	0.26	0.25

		IMPL-2	**0.44**	-	0.24	0.17
	Reduction	IMPL-1	**0.27**	0.30	-	0.23
		IMPL-2	0.19	0.28	0.24	0.30
	Competition	IMPL-1	0.27	0.24	0.23	0.27
		IMPL-2	**-**	-	0.19	-
	Tunneling	IMPL-1	0.23	-	0.21	**-**
		IMPL-2	0.29	0.21	0.33	0.22
	Cooperation	IMPL-1	-	0.21	-	0.19
		IMPL-2	0.22	0.24	0.21	0.36
	Simulation	IMPL-1	0.24	0.25	0.31	0.24
		IMPL-2	0.31	-	0.44	-
Contemplation	Self-monitoring	IMPL-1	**0.22**	**-**	**0.21**	-
		IMPL-2	0.34	**0.29**	**0.25**	0.22
	Personalization	IMPL-1	**0.22**	**0.23**	-	**0.35**
		IMPL-2	0.26	0.27	0.18	0.31
	Suggestion	IMPL-1	**0.26**	**0.21**	0.23	**0.23**
		IMPL-2	0.28	0.23	0.25	**0.24**
	Goal-setting	IMPL-1	**0.34**	0.28	0.21	0.20
		IMPL-2	0.29	0.20	-	-
	Reminders	IMPL-1	0.14	0.25	0.22	**0.34**
		IMPL-2	0.17	0.27	0.23	**0.37**
	Rewards	IMPL-1	0.20	-	-	0.30
		IMPL-2	**0.25**	0.23	0.22	**0.34**
	Praise	IMPL-1	0.32	0.16	0.23	0.31
		IMPL-2	**0.26**	-	-	**0.44**
	Reduction	IMPL-1	**0.31**	0.20	0.26	-
		IMPL-2	0.20	0.29	0.38	-
	Competition	IMPL-1	**0.27**	0.16	0.26	0.31
		IMPL-2	-	**0.27**	**0.30**	-

	Tunneling	IMPL-1	**-**	**0.21**	-	**0.28**
		IMPL-2	**0.29**	0.24	0.20	**0.31**
	Cooperation	IMPL-1	-	0.19	0.20	0.24
		IMPL-2	0.20	**0.27**	0.26	0.30
	Simulation	IMPL-1	0.15	0.27	**0.34**	0.26
		IMPL-2	0.25	**0.22**	0.31	0.22
Preparation	Self-monitoring	IMPL-1	0.21	0.20	**0.29**	**0.20**
		IMPL-2	0.28	0.19	**0.35**	0.22
	Personalization	IMPL-1	**0.24**	0.11	**0.37**	0.25
		IMPL-2	0.23	-	-	**0.39**
	Suggestion	IMPL-1	0.16	-	0.34	0.30
		IMPL-2	0.29	0.21	0.29	0.21
	Goal-setting	IMPL-1	0.14	0.20	**0.37**	**0.25**
		IMPL-2	0.21	0.19	**0.28**	0.26
	Reminders	IMPL-1	-	**0.21**	**0.39**	**0.25**
		IMPL-2	0.23	**0.27**	**-**	0.22
	Rewards	IMPL-1	0.19	-	**0.34**	0.38
		IMPL-2	0.24	**0.26**	0.17	**0.39**
	Praise	IMPL-1	**0.32**	-	**0.30**	**0.27**
		IMPL-2	**0.21**	**0.27**	**0.26**	0.15
	Reduction	IMPL-1	**-**	0.20	0.28	-
		IMPL-2	0.21	0.20	**0.38**	**0.24**
	Competition	IMPL-1	0.17	**0.39**	0.27	0.19
		IMPL-2	**-**	-	0.25	0.15
	Tunneling	IMPL-1	0.19	-	-	0.21
		IMPL-2	0.22	-	0.31	0.29
	Cooperation	IMPL-1	-	**0.17**	**0.26**	0.16
		IMPL-2	0.20	**0.31**	**0.33**	0.20
	Simulation	IMPL-1	0.26	0.23	0.32	0.21

		IMPL-2	0.23	0.21	-	-
Action	Self-monitoring	IMPL-1	-	0.20	-	0.29
		IMPL-2	0.31	0.23	0.16	0.32
	Personalization	IMPL-1	-	0.24	-	0.52
		IMPL-2	0.32	-	0.36	-
	Suggestion	IMPL-1	0.24	0.16	-	0.29
		IMPL-2	-	0.32	0.39	-
	Goal-setting	IMPL-1	-	0.31	-	0.45
		IMPL-2	0.23	-	**0.68**	-
	Reminders	IMPL-1	**0.19**	0.17	0.28	0.30
		IMPL-2	0.27	0.26	-	0.38
	Rewards	IMPL-1	-	0.21	**0.19**	-
		IMPL-2	0.25	0.24	**0.36**	0.20
	Praise	IMPL-1	0.22	-	0.43	0.26
		IMPL-2	-	0.23	0.27	0.37
	Reduction	IMPL-1	-	0.23	**0.50**	-
		IMPL-2	-	0.34	0.40	-
	Competition	IMPL-1	0.16	0.26	-	0.35
		IMPL-2	-	0.21	**0.50**	-
	Tunneling	IMPL-1	-	**0.30**	**0.21**	-
		IMPL-2	0.18	0.35	0.34	0.15
	Cooperation	IMPL-1	0.23	-	-	0.31
		IMPL-2	0.24	-	0.31	**0.44**
	Simulation	IMPL-1	**0.36**	0.19	-	0.28
		IMPL-2	0.30	-	0.21	0.38
Maintenance	Self-monitoring	IMPL-1	-	**0.26**	-	**0.22**
		IMPL-2	0.24	0.31	0.24	0.30
	Personalization	IMPL-1	0.30	-	-	0.33
		IMPL-2	-	0.28	0.16	-

	Suggestion	IMPL-1	-	**0.26**	0.22	-
		IMPL-2	0.21	0.32	0.26	0.25
	Goal-setting	IMPL-1	0.25	-	0.22	0.24
		IMPL-2	**0.37**	0.16	-	0.40
	Reminders	IMPL-1	0.26	0.24	-	0.23
		IMPL-2	0.17	0.31	0.20	**0.35**
	Rewards	IMPL-1	-	**0.19**	-	0.22
		IMPL-2	0.27	0.26	0.20	0.31
	Praise	IMPL-1	0.18	0.38	0.21	0.27
		IMPL-2	-	**0.27**	-	0.22
	Reduction	IMPL-1	-	**0.24**	0.26	**0.27**
		IMPL-2	0.16	**0.38**	-	0.32
	Competition	IMPL-1	0.16	0.31	0.29	0.26
		IMPL-2	0.15	-	-	0.23
	Tunneling	IMPL-1	-	0.27	0.25	-
		IMPL-2	-	0.32	0.30	0.20
	Cooperation	IMPL-1	-	0.25	-	0.29
		IMPL-2	0.17	0.36	-	0.34
	Simulation	IMPL-1	0.17	0.21	-	0.23
		IMPL-2	0.24	0.25	**0.27**	0.26

ATT = Attention, REL = Relevance, CON = Confidence, SAT = Satisfaction.

6.4.3.2.1 Self-monitoring Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, our findings show that for the self-monitoring strategy, IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**) significantly differ in how they affect behavior change (see Table 23). Specifically, IMPL-2 is perceived as more effective for attracting and preserving Attention than IMPL-1 (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .33$, $p < .05$). Furthermore, IMPL-2 of the self-monitoring strategy is the only implementation significantly associated with Confidence and Relevance ($\beta = .22$ $p < .05$; $\beta = .24$

$p < .05$, respectively). However, IMPL-1 and IMPL-2 are significantly and similarly associated with Satisfaction (IMPL-1: $\beta = .17$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$). Hence, IMPL-2 is more effective than IMPL-1 in increasing satisfaction, though there is no significant difference between them. This suggests that to stimulate and preserve the attention, confidence, relevance, and satisfaction of those at the Precontemplation stage, it is better to employ IMPL-2 of the self-monitoring strategy in persuasive systems design. The following sample comments from non-Arabic participants support our findings:

"*I found this app set up in a format I really **like**. I found the **colors and graphs** very effective and **attractive**, and they made it easier for me to **see** where I am and what I needed to do to complete my goals. I **like** the **graphs** and the **colors** more than the first one*." [En.P - 9] – Attention and Satisfaction (IMPL-2). "*Very useful to track the steps. It sure improves my **confidence** to **be more active**, and it is easy to use.*" [En.P - 102] – Confidence (IMPL-2). "*The graphical interface is so **intuitive** and very **easy to understand**.*" [En.P - 40] – Relevance (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, IMPL-1 and IMPL-2 of the self-monitoring strategy are significantly associated with attracting and preserving Attention (IMPL-1: $\beta = .22$, $p < .001$; IMPL-2: $\beta = .34$, $p < .05$) but at a significantly different level. Thus, IMPL-2 is perceived as more effective for stimulating attention for those at the Contemplation stage. Furthermore, IMPL-2 is the sole implementation significantly associated with boosting Confidence and increasing Satisfaction ($\beta = .29$, $p < .001$; $\beta = .22$, $p < .05$, respectively). However, IMPL-1 and IMPL-2 are significantly and similarly associated with Relevance (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$); thus, all the implementations are perceived as equally effective in strengthening people's relevance. These qualitative comments presented below shed more light on our study's findings:

"*I think the **bar graph** is useful, particularly for a **visual** learner like me. It helps to **see and monitor** the progression in simple terms, rather than just numbers.*" [En.P - 317] – Attention (IMPL-2). "*I like the way the app counting the steps in walking the calories burned etc. It **motivates** me to **do more walking** and try to **attain the goal** I set*." [En.P - 259] – Confidence and Relevance (IMPL-2). "*I like the way the colors stand out on this screen **better***." [En.P - 169] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, regarding the self-monitoring strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .28$, $p < .05$), Confidence (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .19$, $p < .05$), Relevance (IMPL-1: $\beta = .29$, $p < .001$; IMPL-2: $\beta = .35$, $p < .001$), and Satisfaction (IMPL-1: $\beta = .20$, $p < .001$; IMPL-2: $\beta = .22$, $p < .05$). Both implementations are perceived as similarly effective in stimulating and preserving attention, strengthening confidence, boosting relevance, and increasing satisfaction since there is no significant difference between the two implementations. The sample qualitative comments below provide additional insights into our findings:

"*The **graphs** are much easier to **visualize** the data, along with progress I have made so far and the future progress I need to make to sustain my goals*." [En.P - 31] – Attention (IMPL-2). "*I would like to see all of this data so I can improve my stats. Seeing the stats would **push me to go harder** the next day or week*." [En.P - 22] – Confidence (IMPL-2). "*The bars are **motivating***." [En.P - 41] – Relevance (IMPL-2). "*I find the app **visually appealing** and **optimistic** about my daily goals.*" [En.P - 285] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Action stage** of behavior change, IMPL-2 is the only implementation of the self-monitoring strategy significantly effective in increasing Attention and Relevance ($\beta = .31$, $p < .05$; $\beta = .16$ $p < .05$, respectively). Therefore, employing IMPL-2 of the self-monitoring strategy in persuasive systems design is more beneficial to stimulate and preserve attention and increase the relevance of those at the Action stage. However, IMPL-1 and IMPL-2 are significantly and similarly related to Confidence and Satisfaction (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$ and IMPL-1: $\beta = .29$, $p < .05$; IMPL-2: $\beta = .32$, $p < .05$, respectively). Accordingly, either of the two implementations could be suitable for boosting and increasing confidence and satisfaction because they lack significant differences. Presented below are example comments that corroborate our findings:

"*The **graphs** would be more useful to me, I think. **Easier to see** at a **glance** and more goal-oriented than text alone.*" [En.P - 43] – Attention (IMPL-2). "*I like the features of the app as it gives me knowledge of my progress and it would **motivate** me to **reach my goals**.*" [En.P - 17] – Confidence and Relevance (IMPL-2). "*I think this*

*would be a **very positive and great** added layer to keep me from losing momentum.*" [En.P - 62] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, concerning the self-monitoring strategy, IMPL-2 is the only implementation significantly associated with Attention ($\beta = .24$, $p < .05$) and Relevance ($\beta = .24$ $p < .05$). Hence, utilizing IMPL-2 of the self-monitoring strategy in the design of persuasive systems proves more advantageous for stimulating and sustaining attention and enhancing the relevance for individuals in the Maintenance stage. Conversely, IMPL-1 and IMPL-2 are significantly and similarly effective in boosting Confidence (IMPL-1: $\beta = .26$, $p < .001$; IMPL-2: $\beta = .31$, $p < .05$) and increasing Satisfaction (IMPL-1: $\beta = .22$, $p < .001$; IMPL-2: $\beta = .30$, $p < .05$). Below are sample comments that validate our findings:

"*I **like** the **visual** designing of this app. Like the above fitness app, it will also **help me to monitor** and maintain my physical activities and customized goals.*" [En.P - 281] – Attention and Satisfaction (IMPL-2). "*This shows all my activities and also **motivates me** to **do certain things for physical activity**. If I was not in a low rating on one day, I would feel ashamed, and so I want to **complete the activities** for my health to improve.*" [En.P - 45] – Confidence and Relevance (IMPL-2).

6.4.3.2.2 Personalization Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, concerning the personalization strategy, both IMPL-1 (**Personalized Motivational Content**) and IMPL-2 (**Personalized Goal Recommendations**) are significantly and similarly associated with Attention (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$); hence, they are the most appropriate for stimulating and preserving the attention of people at the Precontemplation stage of change. However, IMPL-1 of the personalization strategy is the sole implementation significantly associated with boosting Confidence ($\beta = .17$, $p < .05$) and increasing Satisfaction ($\beta = .22$, $p < .05$). Furthermore, IMPL-2 is the only implementation that is significantly effective in enhancing Relevance ($\beta = .27$, $p < .05$). Below are sample qualitative comments that elaborate on our findings:

"*The app is **responsive** to my goal and a **reminder**.*" [En.P – 17] – Attention (IMPL-1). "*Result of physical progress gives me **strength to work daily** and also gives **more confident** words to **increase my progress**.*" [En.P – 38] – Confidence (IMPL-1). "*It was like a **personal fitness coach** who was helping me to summarize the last week's exercise and **give me guidance** and **motivation** on how to improve the amount of exercise I was doing.*" [En.P – 359] – Relevance (IMPL-2). "*This feature seems **fantastic**. A **great** source of motivation means a lot.*" [En.P – 63] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Contemplation stage** of behavior change, regarding the personalization strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .22$, $p < .001$; IMPL-2: $\beta = .26$, $p < .05$), Confidence (IMPL-1: $\beta = .23$, $p < .001$; IMPL-2: $\beta = .27$, $p < .05$), and Satisfaction (IMPL-1: $\beta = .35$, $p < .001$; IMPL-2: $\beta = .31$, $p < .05$). Consequently, either of the two implementations could be appropriate for stimulating and preserving attention, improving confidence, and enhancing satisfaction because they lack significant differences. However, only IMPL-2 of the personalization strategy is significantly related to Relevance ($\beta = .18$, $p < .05$), thus making it the most effective implementation for increasing relevance. The following qualitative comments shown below provide additional insights into the findings of our study:

"*The **information provided** is useful and a brief report of my physical activity behavior can **make me attentive** over my actions.*" [En.P – 160] – Attention (IMPL-2). "*It is specific and easy to read. It would help me **accomplish my goals fully**.*" [En.P – 37] – Confidence (IMPL-2). "*It **motivates** us to increase our stamina and energy.*" [En.P – 203] – Relevance (IMPL-2). "*Personalized goal motivation quotes **impressed me a lot**.*" [En.P – 101] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Preparation stage** of behavior change, IMPL-1 and IMPL-2 of the personalization strategy are significantly and similarly associated with Attention (IMPL-1: $\beta = .24$, $p < .001$; IMPL-2: $\beta = .23$, $p < .05$). Accordingly, the two implementations are perceived as equally effective in stimulating and preserving attention due to a lack of significant differences. Nevertheless, only IMPL-1 is significantly related to Confidence ($\beta = .11$, $p < .05$) and Relevance ($\beta = .37$, $p < .001$), thus making it the most effective implementation for strengthening confidence and improving relevance. However, IMPL-1 and IMPL-2 are significantly associated with Satisfaction (IMPL-1: $\beta =$

.25, $p < .05$; IMPL-2: $\beta = .39$, $p < .001$) but at a significantly varying degree. The subsequent qualitative comments provide more detailed information about our findings:

"***Seeing*** *the lady avatar and* ***getting*** *such good* ***feedback*** *would be motivational.*" [En.P – 33] – Attention (IMPL-1). "*Positive reinforcement and motivation are always helpful. Additionally, the reassurance of being able to* ***complete your weekly goals*** *just increases your* ***confidence****.*" [En.P – 336] – Confidence (IMPL-1). "*I would enjoy seeing personalized advice to* ***keep me motivated****.*" [En.P – 22] – Relevance (IMPL-1). "*I* ***love*** *the reminder, also the drawing/image of the lady/coach/trainer is* ***super nice*** *and encouraging.*" [En.P – 130] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Action stage** of behavior change, regarding the personalization strategy, only IMPL-2 is significantly related to Attention ($\beta = .32$, $p < .05$) and Relevance ($\beta = .36$, $p < .05$), thus making it the most effective implementation for stimulating and preserving attention and enhancing relevance. However, IMPL-1 is the only implementation significantly associated with Confidence ($\beta = .24$, $p < .05$) and Satisfaction ($\beta = .52$, $p < .05$). Consequently, IMPL-1 is the sole implementation that is significantly effective in enhancing and increasing the confidence and satisfaction of those at the Action stage. Shown below are example comments that substantiate our findings:

"*This is a good feature -* ***tracking*** *movement etc. works well for me (****very goal-oriented****).*" [En.P – 315] – Attention and Relevance (IMPL-2). "*This function is very useful for me, I can see the* ***completion of my goals*** *after a week, and I can also have a more detailed understanding of my physical condition.*" [En.P – 376] – Confidence (IMPL-1). "*It is almost like a* ***friend cheering up for me****. I believe this app gives me an* ***emotional connection*** *with these features*." [En.P – 281] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Maintenance stage** of behavior change, IMPL-1 of the personalization strategy is the only implementation significantly associated with Attention ($\beta = .30$, $p < .05$) and Satisfaction ($\beta = .33$, $p < .05$), hence making it the most effective implementation for attracting and sustaining attention and enhancing the satisfaction of those at the Maintenance stage. On the other hand, IMPL-2 is the sole implementation significantly related to Confidence ($\beta = .28$, $p < .05$) and Relevance ($\beta = .16$, $p < .05$). Therefore, IMPL-2 is significantly more effective in enhancing

and increasing confidence and relevance. The following are example comments that confirm our findings:

"*The app **feels warm**, like a personal fitness steward, constantly **reminding** and encouraging the user*." [En.P – 359] – Attention and Satisfaction (IMPL-1). "*I appreciate the encouragement to **take the next step in fitness**. I feel that it **makes me strive for excellence***." [En.P – 83] – Confidence (IMPL-2). "*The app design feels like a real person is **motivating** me to achieve my goals. I find it optimistic.*" [En.P – 281] – Relevance (IMPL-2).

6.4.3.2.3 Suggestion Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, our findings indicate that for the suggestion strategy, IMPL-1 (**Textual Suggestion Notifications**) and IMPL-2 (**Visual Suggestion Notifications**) are significantly related to Attention (IMPL-1: $\beta = .46$, $p < .001$; IMPL-2: $\beta = .30$, $p < .05$) but at a significantly varying degree. Consequently, IMPL-1 is perceived as more effective in stimulating and preserving the attention of those at the Precontemplation stage. However, both IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .26$, $p < .05$); thus, the two implementations are perceived as equally effective in boosting people's confidence. Furthermore, only IMPL-2 of the suggestion strategy is significantly associated with increasing Relevance ($\beta = .23$, $p < .05$) and enhancing Satisfaction ($\beta = .24$, $p < .05$). The following sample qualitative comments below provide more insights into our findings:

"***Notification** popup **alerts me** to do the warmup before starting walking; it feels like it guides me.*" [En.P – 38] – Attention (IMPL-1). "*More detail and visual examples are always **better** than just a simple line of encouragement. They don't just tell me what to do, they **tell me how to do it** and show me the **best ways** of **getting it done***." [En.P – 49] – Confidence and Satisfaction (IMPL-2). "*I think this is a much nicer and better tool to help me warm and **inspire me** to start my workout.*" [En.P – 130] – Relevance (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, regarding the suggestion strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .26$, $p < .001$; IMPL-2: $\beta = .28$, $p < .05$), Confidence (IMPL-1: $\beta = .21$, $p < .001$; IMPL-2: $\beta = .23$, $p < .05$), Relevance (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$), and Satisfaction (IMPL-1: β

= .23, p < .001; IMPL-2: β = .24, p < .001). Subsequently, any of the two implementations could be suitable for attracting and preserving attention, reinforcing confidence, increasing relevance, and enhancing satisfaction due to the lack of significant variances. The following are sample comments that emphasize our findings:

"*Having the warm-up activities **shown graphically** like this **draws me in** and makes me **curious** about the specific movements involved.*" [En.P – 19] – Attention (IMPL-2). "*I **like** the pictures, as it **makes it easy** for me to **mimic the exercise.***" [En.P – 79] – Confidence and Satisfaction (IMPL-2). "*The exercise illustrations would help **motivate me** to do the physical activities.*" [En.P – 32] – Relevance (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, IMPL-1 and IMPL-2 of the suggestion strategy are significantly associated with attracting and preserving Attention (IMPL-1: β = .16, p < .05; IMPL-2: β = .29, p < .05) but at a significantly different degree. Therefore, IMPL-2 is perceived as more effective for stimulating attention for those at the Preparation stage. Furthermore, IMPL-2 is the only implementation significantly associated with enhancing Confidence (β = .21, p < .05). Nonetheless, IMPL-1 and IMPL-2 are significantly and similarly associated with Relevance (IMPL-1: β = .34, p < .05; IMPL-2: β = .29, p < .05) and Satisfaction (IMPL-1: β = .30, p < .05; IMPL-2: β = .21, p < .05); hence, the two implementations are perceived as equivalently effective in boosting and increasing people's relevance and satisfaction. Below are sample comments that demonstrate our findings:

"***Seeing** those characters do the stretches would be very helpful and motivating.*" [En.P – 33] – Attention (IMPL-2). "*Having a visual diagram makes it **incredibly easy and effortless** to take time and **just do the task**.*" [En.P – 155] – Confidence (IMPL-2). "*Suggestions would be **useful** as they could help to **motivate me** and remind me of what I could/should be doing before or after physical activity.*" [En.P – 331] – Relevance (IMPL-1). "*As textual pop-up notifications, the user receives basic walking recommendations and **factual ideas**, which is **excellent** for comfort. - 48*" [En.P – 48] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Action stage** of behavior change, IMPL-1 of the suggestion strategy is the only implementation significantly associated with Attention (β = .24 p < .05) and Satisfaction

(β = .29 p < .05). This indicates that to stimulate and preserve people's attention and increase their satisfaction, it is more useful to utilize IMPL-1 of the suggestion strategy in persuasive systems design. However, IMPL-1 and IMPL-2 are significantly associated with Confidence (IMPL-1: β = .16, p < .05; IMPL-2: β = .32, p < .05) but at a significantly varying level. Correspondingly, IMPL-2 is more effective than IMPL-1 in boosting people's confidence at that stage of behavior change. Furthermore, IMPL-2 is the only implementation that is significantly effective in increasing Relevance (β = .39, p < .05). These comments, displayed below, validate our findings:

"*The pop **notification** is a **very good reminder** for people like me that sometimes lose track of time. It would be very useful*." [En.P – 94] – Attention and Satisfaction (IMPL-1). "*It helps me to **do the exercise in the right way** and also **gives me a good result** for my workout*." [En.P – 45] – Confidence (IMPL-2). "*To increase my physical activity level and **motivates me** at each and every level*." [En.P – 102] – Relevance (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, IMPL-2 of the suggestion strategy is the only implementation significantly associated with Attention and Satisfaction (β = .21, p < .05; β = .25, p < .05); therefore, IMPL-2 is considered as the most effective implementation for attracting and preserving attention and increasing the satisfaction of those at the Maintenance stage. However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence and Relevance (IMPL-1: β = .26, p < .001; IMPL-2: β = .32, p < .05 and IMPL-1: β = .22, p < .05; IMPL-2: β = .26, p < .05, respectively). Thus, the two implementations are appropriate for boosting and increasing confidence and satisfaction since they lack significant variances. The following are example comments that corroborate our findings:

"*I **like** the **visual images** of giving and **displaying** different types of stretches that I may not have been using in the past and can now incorporate variety into my workout.*" [En.P – 31] – Attention and Satisfaction (IMPL-2). "*I think this is a much better design than the box above. Using visual elements is much **more engaging and encouraging**, and it makes it **feel** like I'm doing **accurate work** because I'm being given a guideline for what to do.*" [En.P – 2] – Confidence and Relevance (IMPL-2).

6.4.3.2.4 Goal-setting Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, regarding the goal-setting strategy, IMPL-1 (**Default/System-based Goals**) is the sole implementation significantly associated with stimulating and preserving Attention and enhancing Relevance ($\beta = .30$, $p < .05$; $\beta = .20$, $p < .05$, respectively). However, IMPL-1 and IMPL-2 (**Customized/User-Driven Goals**) are significantly associated with increasing Confidence (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .33$, $p < .05$) but at a significantly varying level. Hence, IMPL-2 is more effective than IMPL-1 for boosting confidence for those at the Precontemplation stage. Furthermore, IMPL-1 and IMPL-2 of the goal-setting strategy are significantly and similarly associated with Satisfaction (IMPL-1: $\beta = .33$, $p < .05$; IMPL-2: $\beta = .43$, $p < .05$). Consequently, IMPL-2 is more effective than IMPL-1 in increasing satisfaction, though there are no significant differences. The subsequent comments offer more information concerning our findings:

"*It **alerts** us toward the **attention** to the target goal.*" [En.P – 40] – Attention (IMPL-1). "*Customizing my own goal will make my **confidence level very good**.*" [En.P – 45] – Confidence (IMPL-2). "*It's good to see the daily goal listed, and it is **motivating**.*" [En.P – 24] – Relevance (IMPL-1). "*I **like** the **flexibility** and ability to customize my steps. There are days when I just want to do the bare minimum, whereas other days when I **feel like superman**.*" [En.P – 11] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, concerning the goal-setting strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .34$, $p < .001$; IMPL-2: $\beta = .29$, $p < .05$) and Confidence (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .20$, $p < .05$); therefore, the two implementations are perceived as equally effective in attracting and preserving people's attention and strengthening their confidence. On the other hand, IMPL-1 of the goal-setting strategy is the only implementation that is significantly effective in boosting Relevance and increasing Satisfaction ($\beta = .21$, $p < .05$; $\beta = .20$, $p < .05$, respectively). The following are example comments that confirm our findings:

"*It's really an **awesome** feature that will set my goal automatically and allow me to **pay attention** to my goal.*" [En.P – 3] – Attention and Satisfaction (IMPL-1). "*I like the automatic goal setting. And if I **achieve the goals**, the next step would be to **increase the goal**.*" [En.P – 16] – Confidence (IMPL-1). "*It is **simple** and **straightforward**. Since the goal is set externally, it would **motivate** me.*" [En.P – 37] – Relevance (IMPL-1).

For non-Arabic participants at the **Preparation stage** of behavior change, regarding the goal-setting strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .14$, $p < .05$; IMPL-2: $\beta = .21$, $p < .05$), Confidence (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .19$, $p < .05$), Relevance (IMPL-1: $\beta = .37$, $p < .001$; IMPL-2: $\beta = .28$, $p < .001$), and Satisfaction (IMPL-1: $\beta = .25$, $p < .001$; IMPL-2: $\beta = .26$, $p < .05$). Consequently, any of the two implementations could be suitable for attracting and preserving attention, reinforcing confidence, increasing relevance, and enhancing satisfaction due to the lack of significant variances. The following are sample comments that emphasize our findings:

"***Showing*** *my customize goal in* ***pictorial format*** *will definitely help to achieve great.*" [En.P – 3] – Attention (IMPL-2). "*A system-set goal is like a trainer setting a goal to do, and I like this kind of recommendation that* ***forces me to do an activity.***" [En.P – 259] – Confidence (IMPL-1). "*Automatic goal setting* ***helps*** *me or* ***stimulates*** *me.*" [En.P – 86] – Relevance (IMPL-1). "*This function is* ***very reasonable*** *and* ***very human****; you can set your own sports goals. I* ***like*** *it.*" [En.P – 359] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Action stage** of behavior change, regarding the goal-setting strategy, only IMPL-2 is significantly related to Attention ($\beta = .23$, $p < .05$) and Relevance ($\beta = .68$, $p < .05$), thus making it the most effective implementation for stimulating and preserving attention and enhancing relevance. However, IMPL-1 is the only implementation significantly associated with Confidence ($\beta = .31$, $p < .05$) and Satisfaction ($\beta = .45$, $p < .05$). Accordingly, IMPL-1 is the sole implementation that is significantly effective in boosting and increasing the confidence and satisfaction of individuals at the Action stage. Displayed below are example comments that support our findings:

"*I would be* ***curious*** *to realize the amount of steps I need to set and accomplish.*" [En.P – 29] – Attention (IMPL-2). "*Setting daily goals helps me* ***exercise better*** *and* ***achieve*** *my behavioral* ***goals****.*" [En.P – 346] – Confidence (IMPL-1). "*I personally like setting goals. I find it* ***motivating****.*" [En.P – 71] – Relevance (IMPL-2). "*Automatically setting goals is* ***good*** *as it prevents forgetting to set them and interrupting movement records.*" [En.P – 376] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Maintenance stage** of behavior change, IMPL-1 and IMPL-2 of the goal-setting strategy are significantly associated with attracting and preserving Attention (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .37$, $p < .05$) but at a significantly different level. Consequently, IMPL-2 is more effective for stimulating and preserving attention for those at the Maintenance stage. Furthermore, IMPL-2 is the only implementation significantly associated with enhancing Confidence ($\beta = .16$, $p < .05$). On the other hand, IMPL-1 of the goal-setting strategy is the sole implementation that is significantly effective in boosting Relevance ($\beta = .22$, $p < .05$). Moreover, IMPL-1 and IMPL-2 are significantly associated with Satisfaction (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .40$, $p < .05$) but at a significantly varying degree. Subsequently, IMPL-2 is perceived as more effective for increasing satisfaction. Below are sample comments that explain our findings:

"*I like this so I can **keep track** of how many steps and maybe also use a goal*." [En.P – 26] – Attention (IMPL-2). "*Having the step count be user-changeable is a **good idea**. I can set my own goal and I would **feel more in control** of the **fitness process***." [En.P – 19] – Confidence and Satisfaction (IMPL-2). "*It would help **motivate me** to walk even if I am in my apartment.*" [En.P – 39] – Relevance (IMPL-1).

6.4.3.2.5 Reminder Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, our findings show that for the reminder strategy, IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) are significantly and similarly associated with Attention (IMPL-1: $\beta = .27$, $p < .001$; IMPL-2: $\beta = .32$, $p < .05$); thus, the two implementations are perceived as similarly effective in stimulating and preserving people's attention. However, only IMPL-2 is significantly associated with strengthening Confidence ($\beta = .26$, $p < .05$) and increasing Satisfaction ($\beta = .23$, $p < .05$). Furthermore, IMPL-1 and IMPL-2 of the reminder strategy are significantly related to Relevance (IMPL-1: $\beta = .36$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$) but at a significantly varying degree. The following example comments provide further insights about our findings:

"*This app would help me **remember** when to exercise based on my schedule. It is more convenient.*" [En.P – 72] – Attention (IMPL-2). "*The ability to set alarms and notifications would be useful for me to **reach my activity goals**.*" [En.P – 24] – Confidence (IMPL-2). "*This function can **supervise me** and **let me understand** the consequences of not exercising.*" [En.P – 376] – Relevance (IMPL-1). "*Scheduled reminders are **better** than random ones, especially for people who live a monotonous life.*" [En.P – 336] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, regarding the reminder strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .14$, $p < .05$; IMPL-2: $\beta = .17$, $p < .05$), Confidence (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .27$, $p < .05$), Relevance (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$), and Satisfaction (IMPL-1: $\beta = .34$, $p < .001$; IMPL-2: $\beta = .37$, $p < .001$). Consequently, the two implementations are appropriate for stimulating and preserving attention, boosting confidence, enhancing relevance, and increasing satisfaction because of a lack of significant variances. The following are sample comments that confirm our findings:

"*People who have a forgetting problem can use this application to **get a reminder** about **special events**.*" [En.P – 90] – Attention (IMPL-2). "*Giving me more **control** is always a **good** way to **keep me engaged** and **happy**. I use alarms all the time, and this would be a **good** one.*" [En.P – 49] – Confidence and satisfaction (IMPL-2). "*It shows that we can set a reminder for our schedule, and it **makes it easier for us** to do exercise.*" [En.P – 214] – Relevance (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, only IMPL-2 of the reminder strategy is significantly related to Attention ($\beta = .23$, $p < .05$); hence, it is considered the most effective implementation for attracting attention. On the other hand, IMPL-1 is the only implementation significantly associated with boosting Relevance ($\beta = .39$, $p < .001$). Furthermore, IMPL-1 and IMPL-2 of the reminder strategy are significantly and similarly associated with Confidence (IMPL-1: $\beta = .21$, $p < .001$; IMPL-2: $\beta = .27$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .25$, $p < .001$; IMPL-2: $\beta = .22$, $p < .05$). Thus, both implementations are perceived as similarly effective for boosting confidence and increasing satisfaction because they are all similarly and significantly

associated with the Confidence and Satisfaction constructs. The following are sample comments that support our findings:

"*Having **notifications pop-up** based on my own schedule would be helpful to me, assuming I can enable and disable them at my discretion*." [En.P – 19] – Attention (IMPL-2). "*It wouldn't be intrusive as I customized the alert, and it would **help me achieve my goals** faster.*" [En.P – 37] – Confidence (IMPL-2). "*I **like** this idea because it would **motivate** me to get up more.*" [En.P – 22] – Relevance and Satisfaction (IMPL-1).

For non-Arabic participants at the **Action stage** of behavior change, regarding the reminder strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .19$, $p < .001$; IMPL-2: $\beta = .27$, $p < .05$), Confidence (IMPL-1: $\beta = .17$, $p < .05$; IMPL-2: $\beta = .26$, $p < .05$), and Satisfaction (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .38$, $p < .05$). Accordingly, either of the implementations could be suitable for stimulating and preserving attention, boosting confidence, and increasing satisfaction since they lack significant variances. On the other hand, only IMPL-2 of the reminder strategy is significantly related to Relevance ($\beta = .28$, $p < .05$), thus making it the most effective implementation for increasing relevance. The following comments presented below deliver more insights into our findings:

"*I rely a lot on my **reminders** to **keep me on track** for my daily activities, and I think this would be useful.*" [En.P – 535] – Attention (IMPL-2). "*It allows me to **complete physical activities** within a time set by myself.*" [En.P – 436] – Confidence (IMPL-2). "*I think the push notifications from health apps can **prompt me to change my behavior** sometimes.*" [En.P – 333] – Relevance (IMPL-1). "***Perfect**. Just what you need. An alarm at the time I want.*" [En.P – 78] –Satisfaction (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, our findings indicate that for the reminder strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .17$, $p < .05$) and Confidence (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .31$, $p < .05$); consequently, the two implementations are similarly effective in stimulating and preserving people's attention and boosting their confidence. Conversely, only IMPL-2 of the reminder strategy is significantly associated with strengthening Relevance ($\beta = .20$, $p < .05$).

Moreover, IMPL-1 and IMPL-2 of the reminder strategy are significantly related to Satisfaction (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .35$, $p < .001$) but at a significantly different level. Presented below are sample comments that corroborate our findings:

"*A **push notification** is an effective way to make one **stay alert**. I'd really love the feature.*" [En.P – 63] – Attention (IMPL-1). "*Indicating specific time also **motivates** ourselves to **go and walk towards our goals**.*" [En.P – 230] – Confidence and Relevance (IMPL-2). "*Based on my workload, I can set my **preferable** scheduled times. I **like** it.*" [En.P – 103] – Satisfaction (IMPL-2).

6.4.3.2.6 Reward Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, regarding the reward strategy, IMPL-1 (**Collecting of Virtual Reward Points**) and IMPL-2 (**Collecting Virtual Reward Badges**) are significantly and similarly associated with Attention and Relevance (IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .34$, $p < .05$ and IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .26$, $p < .05$, respectively). Consequently, the two implementations are perceived as equally effective in attracting and preserving attention and increasing relevance because they lack significant differences. However, IMPL-2 is the only implementation that is significantly effective in boosting Confidence and increasing Satisfaction ($\beta = .21$, $p < .05$; $\beta = .24$, $p < .05$, respectively). The following are sample comments that support our findings:

"*It is so **attractive** for badges to reward different models.*" [En.P – 102] – Attention (IMPL-2). "*I **like** the idea of having badges/awards for different **goals being hit**. This makes me think about **achievements** in video games, which are sometimes a **good** way to **motivate me to achieve** certain things in those games.*" [En.P – 19] – Confidence and Satisfaction (IMPL-2). "*Badges are always fun and **motivational**.*" [En.P – 33] – Relevance (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, concerning the reward strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .25$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .34$, $p < .001$). Accordingly, both implementations are perceived as similarly effective for attracting

attention and increasing satisfaction because they lack significant variances. Nevertheless, IMPL-2 of the reward strategy is the sole implementation that is significantly effective in boosting Confidence and increasing Relevance ($\beta = .23$, $p < .05$; $\beta = .22$, $p < .05$, respectively). Below, qualitative comments are presented that elaborate on our findings:

"*Let me have **pride**, let everyone can **pay attention** to me and envy me.*" [En.P – 411] – Attention and Satisfaction (IMPL-2). "*The badges rewarding system helps to **attain the goal**.*" [En.P – 40] – Confidence (IMPL-2). "*The badges rewarding app just might be the deciding factor to **motivate** a lot of people to get more physically active. I see this as being an extremely **useful motivating tool**.*" [En.P – 85] – Relevance (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, our findings show that for the reward strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .17$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .38$, $p < .05$; IMPL-2: $\beta = .39$, $p < .001$); subsequently, the two implementations are similarly effective in stimulating and preserving people's attention and increasing their confidence. On the other hand, only IMPL-2 of the reward strategy is significantly associated with strengthening Confidence ($\beta = .26$, $p < .05$). Additionally, IMPL-1 and IMPL-2 are significantly related to Relevance (IMPL-1: $\beta = .34$, $p < .001$; IMPL-2: $\beta = .17$, $p < .05$) but at a significantly different degree. Consequently, IMPL-1 is more effective for boosting relevance. Displayed below are example comments that confirm our findings:

"*Good **tracking** incentive!*" [En.P – 317] – Attention (IMPL-2). "*This would be such a **fun** way to **reach my goals** because I am a huge fan of gaming and collecting things like badges.*" [En.P – 66] – Confidence and Satisfaction (IMPL-2). "*Getting points and rewards **makes me motivated** and try to earn more points*." [En.P – 230] – Relevance (IMPL-1).

For non-Arabic participants at the **Action stage** of behavior change, regarding the reward strategy, only IMPL-2 is significantly associated with Attention ($\beta = .25$, $p < .05$) and Satisfaction ($\beta = .20$, $p < .05$). Thus, IMPL-2 is more effective for stimulating and preserving attention and increasing satisfaction. However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$); consequently, the two implementations are equally effective in increasing people's confidence at that stage of change. Moreover, IMPL-1 and

IMPL-2 are significantly related to Relevance (IMPL-1: $\beta = .19$, $p < .001$; IMPL-2: $\beta = .36$, $p < .001$) but at a significantly different level. Therefore, IMPL-2 is perceived as more effective for enhancing relevance for those at the Action stage. The following are sample comments from non-Arabic participants that authenticate our findings:

"***Seeing*** *where I am at with the rewards, it will* ***motivate me****.*" [En.P – 539] – Attention and Relevance (IMPL-2). "*I think I would* ***push myself harder*** *to get more badges.*" [En.P – 22] – Confidence (IMPL-2). "*Badges give an accomplished mindset. This feature is* ***awesome****.*" [En.P – 119] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, regarding the reward strategy, IMPL-2 is the sole implementation significantly associated with stimulating and preserving Attention and enhancing Relevance ($\beta = .27$, $p < .05$; $\beta = .20$, $p < .05$, respectively). However, IMPL-1 and IMPL-2 are significantly and similarly associated with boosting Confidence (IMPL-1: $\beta = .19$, $p < .001$; IMPL-2: $\beta = .26$, $p < .05$) and increasing satisfaction (IMPL-1: $\beta = .22$, $p < .05$; IMPL-2: $\beta = .31$, $p < .05$). The two implementations are perceived as equally effective in increasing people's confidence and satisfaction at the Maintenance stage of change. The comments below deliver more information regarding our findings:

"*Badges in a* ***pictorial form*** *is more* ***attractive*** *and plays an* ***appealing*** *role and will keep me motivating.*" [En.P – 5] – Attention and Satisfaction (IMPL-2). "*This can improve the* ***enthusiasm*** *and persistence of the user to adhere to the* ***completion of the goal****, can* ***push*** *the user to* ***pursue higher goals****.*" [En.P – 359] – Confidence and Relevance (IMPL-2).

6.4.3.2.7 Praise Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, concerning the praise strategy, IMPL-1 (**Textual Praise**) and IMPL-2 (**Audio and Visual Praise**) are significantly associated with Attention (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .44$, $p < .001$) but at a significantly different level. Thus, IMPL-2 is perceived as more effective than IMPL-1 for stimulating and preserving attention. However, IMPL-2 is the sole implementation significantly associated with boosting Confidence ($\beta = .24$, $p < .05$). Furthermore, IMPL-1 and IMPL-2 of the praise strategy are

significantly associated with enhancing Relevance (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$) and increasing Satisfaction (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .17$, $p < .05$). Thus, the two implementations are perceived as similarly effective in increasing people's relevance and satisfaction since they lack significant differences. The qualitative comments shown below shed more light on our study's findings:

"*Visual praise **stimulates my curiosity**.*" [En.P – 377] – Attention (IMPL-2). "*The appreciation helps to **maintain the progress towards the goal**.*" [En.P – 40] – Confidence (IMPL-1). "*This textual praise feature will definitely **motivate me**.*" [En.P – 63] – Relevance (IMPL-1). "*I **feel** like I am doing **a good job,** and I am **valued as a person** because of my health and fitness goals.*" [En.P – 83] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Contemplation stage** of behavior change, regarding the praise strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .32$, $p < .05$; IMPL-2: $\beta = .26$, $p < .001$); thus, either of the two implementations could be suitable for stimulating and preserving attention. However, only IMPL-1 of the praise strategy is significantly related to Confidence ($\beta = .16$, $p < .05$) and Relevance ($\beta = .23$, $p < .05$), thus making it the most effective implementation for boosting confidence and increasing relevance. Furthermore, IMPL-1 and IMPL-2 are significantly associated with Satisfaction (IMPL-1: $\beta = .31$, $p < .05$; IMPL-2: $\beta = .44$, $p < .001$); hence, IMPL-2 is more effective than IMPL-1 in increasing satisfaction for those at the Contemplation stage. The following comments provide support for our research findings:

"*Textual praise strategy is **very attractive** to me.*" [En.P – 51] – Attention (IMPL-1). "*This text praise also **stimulates** people to **achieve** something new in **walking goal**.*" [En.P – 90] – Confidence and Relevance (IMPL-1). "*Making visual-audio praise is a **good idea** and really **love** the variety of features in it.*" [En.P – 230] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, regarding the praise strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .32$, $p < .001$; IMPL-2: $\beta = .21$, $p < .001$) and Relevance (IMPL-1: $\beta = .30$, $p < .001$; IMPL-2: $\beta = .26$, $p < .001$). Accordingly, both implementations are perceived as equally effective for stimulating and

preserving attention and reinforcing relevance since they are similarly associated with the Attention and Confidence constructs. However, IMPL-2 is the only implementation significantly associated with boosting Confidence ($\beta = .27$, $p < .001$). Additionally, IMPL-1 and IMPL-2 are significantly associated with Satisfaction (IMPL-1: $\beta = .27$, $p < .001$; IMPL-2: $\beta = .15$, $p < .05$) but at a significantly varying degree. The following are sample comments that support our findings:

"*Some **positive** reinforcement would probably **make me feel good** about using the app to **track my progress**.*" [En.P – 333] – Attention and Satisfaction (IMPL-1). "*Audio-visual praise makes me more excited, **more powerful movement.***" [En.P – 367] – Confidence (IMPL-2). "*A general appreciation will **keep me motivating**.*" [En.P – 160] – Relevance (IMPL-1).

For non-Arabic participants at the **Action stage** of behavior change, our findings reveal that for the praise strategy, only IMPL-1 is significantly associated with attracting and preserving Attention ($\beta = .22$, $p < .05$), while IMPL-2 is the sole implementation significantly associated with strengthening Confidence ($\beta = .23$, $p < .05$). However, IMPL-1 and IMPL-2 are significantly related to Relevance (IMPL-1: $\beta = .43$, $p < .05$; IMPL-2: $\beta = .27$, $p < .05$) but at a significantly different level; hence, IMPL-1 is more effective than IMPL-2 for boosting relevance. Moreover, both IMPL-1 and IMPL-2 are significantly and similarly associated with Satisfaction (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .37$, $p < .05$); consequently, the two implementations are similarly effective in increasing satisfaction for those at the Action stage. Exhibited below are example comments that support our findings:

"*Textual praising feels **pleasant to see**.*" [En.P – 230] – Attention (IMPL-1). "*I gained a **sense of achievement**, better to **complete the goal**, exercise themselves.*" [En.P – 346] – Confidence (IMPL-2). "*Literal encouragement can **motivate** most people.*" [En.P – 462] – Relevance (IMPL-1). "*The visual and voice praise would make the experience **more real and fun**.*" [En.P – 33] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, IMPL-1 of the praise strategy is the sole implementation that is significantly effective in attracting and preserving Attention and boosting Relevance ($\beta = .18$, $p < .05$; $\beta = .21$, $p < .05$, respectively). Therefore, IMPL-1 is perceived as the most effective implementation for stimulating and preserving attention and enhancing

relevance. However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .38$, $p < .05$; IMPL-2: $\beta = .27$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$). Subsequently, the two implementations are similarly effective in improving confidence and increasing satisfaction for those at the Maintenance stage. The following are sample comments that demonstrate our findings:

"*Textual praise is **good**, **holds my attention** and reaffirms that we're on the right **track**.*" [En.P – 336] – Attention and Satisfaction (IMPL-1). "*Textual encouraging and congratulatory praise **help me accomplish my goal**.*" [En.P – 103] – Confidence (IMPL-1). "*The language **encouragement** can call the heart **more unyielding voice**, so that I be more active in sports.*" [En.P – 367] – Relevance (IMPL-1).

6.4.3.2.8 Reduction Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, concerning the reduction strategy, IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) and IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) are significantly and similarly associated with Attention, Confidence, and Satisfaction (IMPL-1: $\beta = .27$, $p < .001$; IMPL-2: $\beta = .19$, $p < .05$), (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .28$, $p < .05$), and (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .38$, $p < .05$), respectively. Accordingly, IMPL-1 and IMPL-2 are perceived as equally effective in attracting and preserving attention and increasing confidence and satisfaction since they lack significant variances. However, only IMPL-2 of the reduction strategy is significantly effective in boosting relevance ($\beta = .24$, $p < .05$). The following are sample comments that corroborate our findings:

"***Showing** nearby places for walking activity helps to reduce our time.*" [En.P – 230] – Attention (IMPL-1). "*This would be beneficial to give me different options of locations and the distances I need to travel **to achieve my goals**.*" [En.P – 31] – Confidence (IMPL-1). "*A selection of pre-defined walking plans based on locales is **helpful and easily available** to the user.*" [En.P – 48] – Relevance (IMPL-2). "*I **like** the additional detail and control this gives me.*" [En.P – 49] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, regarding the reduction strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .31$, $p < .001$; IMPL-2: $\beta = .20$, $p < .05$) and Confidence (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .29$, $p < .05$). Accordingly, both implementations are perceived as similarly effective for attracting attention and boosting confidence because there is no significant difference between them. However, IMPL-1 and IMPL-2 are significantly associated with Relevance (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .38$, $p < .05$) but at a significantly different degree. Furthermore, neither IMPL-1 nor IMPL-2 of the reduction strategy is perceived as effective for increasing satisfaction for people at the Contemplation stage because both implementations are not significantly related to the Satisfaction construct. Below are qualitative comments that support our findings:

"***Showing*** *the geographical* ***location clearly*** *to do walking exercise and won't get lost.*" [En.P – 474] – Attention (IMPL-1). "*Predefined walking plans based on locations help to* ***accomplish my goal easier****.*" [En.P – 103] – Confidence (IMPL-2). "*A* ***more clear plan*** *of their own exercise route will be* ***clear*** *to reach the destination of the* ***enthusiasm will be higher****.*" [En.P – 367] – Relevance (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, only IMPL-2 of the reduction strategy is significantly associated with attracting and preserving Attention ($\beta = .21$, $p < .05$) and enhancing Satisfaction ($\beta = .24$, $p < .001$). On the other hand, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .20$, $p < .05$) and Relevance (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .38$, $p < .001$). Accordingly, the two implementations are perceived as equivalently effective in boosting and increasing confidence and relevance for those at the Preparation stage of the reduction strategy. The following are sample comments that support our findings:

"*This* ***chart*** *is a* ***very clear way to see*** *your daily walking plan.*" [En.P – 357] – Attention (IMPL-2). "***Achieve*** *your step count* ***goal*** *without wasting time.*" [En.P – 376] – Confidence (IMPL-1). "***Easy way*** *for me to do exercise and* ***motivate me*** *to be economical and environment friendly.*" [En.P – 539] – Relevance (IMPL-2). "***Wow****, I really* ***love*** *this feature and* ***love*** *it recommends trails for every day, but you can also* ***easily*** *change the trails to the trail you* ***prefer*** *and then* ***easily*** *get directions to the trail straight from the app via Google Maps.* ***Great feature****!!*" [En.P – 130] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Action stage** of behavior change, regarding the reduction strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .34$, $p < .05$) and Relevance (IMPL-1: $\beta = .50$, $p < .001$; IMPL-2: $\beta = .40$, $p < .05$). Thus, the two implementations are considered similarly effective for boosting confidence and increasing relevance due to a lack of significant differences. However, neither IMPL-1 nor IMPL-2 is effective for stimulating attention and increasing satisfaction for people at the Action stage since both implementations are not significantly related to the Attention or Satisfaction constructs. The following are sample comments from non-Arabic participants that support our findings:

"*I would probably like having some predefined walking plans, since that might make me **more likely to go out and do walking** around the area than if I had to make my own plans.*" [En.P – 19] – Confidence (IMPL-2). "*This would **help encourage me** to branch out of my comfort zone and get to moving in different places so I would like it*." [En.P – 66] – Relevance (IMPL-1).

For non-Arabic participants at the **Maintenance stage** of behavior change, IMPL-2 of the reduction strategy is the sole implementation that is significantly effective in attracting and preserving Attention ($\beta = .16$, $p < .05$), thus making it the most effective implementation for stimulating and preserving attention. However, IMPL-1 and IMPL-2 are significantly associated with Confidence (IMPL-1: $\beta = .24$, $p < .001$; IMPL-2: $\beta = .38$, $p < .001$) but at a significantly varying degree. Accordingly, IMPL-2 is more effective for boosting confidence for those at the Maintenance stage. On the other hand, IMPL-1 of the reduction strategy is the only implementation significantly associated with increasing Relevance ($\beta = .26$, $p < .05$). Furthermore, the two implementations are significantly and similarly effective in increasing Satisfaction (IMPL-1: $\beta = .27$, $p < .001$; IMPL-2: $\beta = .32$, $p < .05$). The following sample qualitative comments provide additional insights into our findings:

"*The ability to **map out** a previously unexplored route would motivate me to get out there and **explore**! Walking is **not so boring** when one has a destination and venturing into 'unexplored territory' gives me an adventure **to look forward** to and makes it **fun**.*" [En.P – 85] – Attention and Satisfaction (IMPL-2). "*This feature helps me to select the right place and **do the workout** in a pleasant manner.*" [En.P – 45] – Confidence (IMPL-2). "*This*

*is something that is **useful and helpful** - I would use this and use the list of places as **motivation** to finish them all.*" [En.P – 68] – Relevance (IMPL-1).

6.4.3.2.9 Competition Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, our findings reveal that for the competition strategy, IMPL-1 (**Competition as a Leaderboard**) is the only implementation significantly associated with Attention, Confidence, and Satisfaction ($\beta = .27$, $p < .05$; $\beta = .24$, $p < .05$; $\beta = .27$, $p < .05$, respectively). Accordingly, IMPL-1 is perceived as the most effective implementation for stimulating and preserving attention, boosting Confidence, and increasing Satisfaction. On the other hand, IMPL-1 and IMPL-2 (**Displaying a Progress Bar for Each Competitor**) are significantly and similarly related to Relevance (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .19$, $p < .05$); thus, the two implementations are perceived as equally effective in enhancing relevance for those at the Precontemplation stage. The sample qualitative comments below provide more insights into our findings:

"***Showing** winners leading board helps us to **see** our progress.*" [En.P – 230] – Attention (IMPL-1). "*It does **encourage** group **challenge**, making it competitive.*" [En.P – 79] – Confidence (IMPL-1). "*Ranking system would **motivate** us a lot.*" [En.P – 101] – Relevance (IMPL-1). "***Celebration** or result of achievement always **pleasant** experience.*" [En.P – 7] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Contemplation stage** of behavior change, concerning the competition strategy, IMPL-1 is the only implementation that is significantly effective in attracting and preserving Attention ($\beta = .27$, $p < .001$) and increasing Satisfaction ($\beta = .31$, $p < .05$). However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .16$, $p < .05$; IMPL-2: $\beta = .27$, $p < .001$) and Relevance (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .30$, $p < .001$); therefore, the two implementations are perceived as similarly effective in boosting people's confidence and strengthening their relevance. The following are example comments that confirm our findings:

"*It would be **great** to compete and **see** your name on the leaderboard.*" [En.P – 37] – Attention and Satisfaction (IMPL-1). "*Having a leaderboard allows me to **work harder on my goals**.*" [En.P – 367] – Confidence (IMPL-2). "*I like the details and comparison with other users. It would **push me more** and **keep me motivated.***" [En.P – 38] – Relevance (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, only IMPL-1 of the competition strategy is significantly related to Attention ($\beta = .17$, $p < .05$) and Confidence ($\beta = .39$, $p < .001$), hence making it the most effective implementation for stimulating and preserving attention and strengthening confidence. On the other hand, IMPL-1 and IMPL-2 are significantly and similarly associated with Relevance (IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .15$, $p < .05$). Consequently, the two implementations are perceived as equally effective in improving relevance and increasing satisfaction since they lack significant variances. The following qualitative comments provide more in-depth information about our findings:

"*Virtual rewards are used to **incentivize** users to walk more, and **pictures** allow users to **see** their rank **clearly**.*" [En.P – 357] – Attention and Relevance (IMPL-1). "*For sure, it can be **motivating** to want to beat your friends and **move up in the ranks.***" [En.P – 75] – Confidence (IMPL-1). "***Happy** to see results like this.*" [En.P – 108] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Action stage** of behavior change, regarding the competition strategy, only IMPL-1 is significantly associated with Attention ($\beta = .16$, $p < .05$) and Satisfaction ($\beta = .35$, $p < .05$). Thus, IMPL-1 is more effective for stimulating and preserving attention and increasing satisfaction. However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .21$, $p < .05$); consequently, the two implementations are equally effective in increasing people's confidence at that stage of change. Moreover, IMPL-2 is the sole implementation significantly related to Relevance ($\beta = .50$, $p < .001$); thus, IMPL-2 is perceived as more effective for enhancing relevance for those at the Action stage. The following are sample comments from non-Arabic participants that support our findings:

"***Seeing*** *and* ***Knowing*** *the gap between yourself and the people in front of you will make you more motivated.*" [En.P – 474] – Attention (IMPL-1). "*Really useful because everyone tries to* ***reach the top*** *on the leadership board.*" [En.P – 103] – Confidence (IMPL-1). "*Through the ranking list of the winners and the visual progress bar of each contestant, I can see my own shortcomings and better* ***motivate myself****.*" [En.P – 103] – Relevance (IMPL-2). "*Leaderboards are* ***good*** *because they put your standing into perspective.*" [En.P – 33] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Maintenance stage** of behavior change, IMPL-1 and IMPL-2 of the competition strategy are significantly and similarly related to Attention (IMPL-1: $\beta = .16$, $p < .05$; IMPL-2: $\beta = .15$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$). Accordingly, both implementations are perceived as similarly effective for attracting attention and increasing satisfaction since there is no significant difference between them. However, IMPL-1 is the only implementation significantly associated with Confidence and Relevance ($\beta = .31$, $p < .05$; $\beta = .29$, $p < .05$, respectively). Consequently, IMPL-1 is perceived as the most effective implementation for boosting confidence and increasing relevance for those at the Maintenance stage. The following sample qualitative comments below provide additional insights into our findings:

"*This would be really fun and* ***attractive*** *because it is a friendly competition, and it also gives you some* ***motivation to keep pushing*** *yourself when you* ***see*** *others doing it*." [En.P – 66] – Attention and Relevance (IMPL-1). "*A rating system is* ***great****. Encourages participants to want to* ***exceed their goals*** *to* ***stay ahead*** *of others.*" [En.P – 78] – Confidence and Satisfaction (IMPL-1).

6.4.3.2.10 Tunnelling Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, regarding the tunneling strategy, IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) are significantly and similarly associated with Attention and Relevance (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .29$, $p < .05$) and (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .33$, $p < .05$, respectively). Consequently, the two implementations are perceived as equally effective in attracting and preserving attention and increasing relevance because they lack significant differences. However, IMPL-2 is the only implementation that is significantly effective in boosting

Confidence and increasing Satisfaction ($\beta = .21$, $p < .05$; $\beta = .22$, $p < .05$, respectively). The following are sample comments that support our findings:

"*The **map** is useful to **see** and use for walking routes.*" [En.P – 24] – Attention (IMPL-2). "*This would be really **useful** for me because I like seeing data on a map better and it **motivates** me to **get out there** and explore new places **while I exercise**.*" [En.P – 66] – Confidence and Relevance (IMPL-2). "*The app feature is **very innovative** and **fun**.*" [En.P – 79] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, regarding the tunneling strategy, only IMPL-2 is significantly associated with Attention ($\beta = .29$, $p < .001$) and Relevance ($\beta = .20$, $p < .05$). Thus, IMPL-2 is more effective for stimulating and preserving attention and increasing relevance. However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .21$, $p < .001$; IMPL-2: $\beta = .24$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .28$, $p < .001$; IMPL-2: $\beta = .31$, $p < .001$); therefore, both implementations are equally suitable and effective in increasing people's confidence and satisfaction at the Contemplation stage. The following are sample comments that confirm our findings:

"***Looking at a map** is more something that I can do while on a run.*" [En.P – 30] – Attention (IMPL-2). "*The map visualization will create an **immersive experience**. I don't need to think about whether I am following my destination. I can just **concentrate on my physical activity (walking)**, and occasionally looking up the map will not be the main overhead.*" [En.P – 306] – Confidence and Satisfaction (IMPL-2). "*It would feel like I'm going on a fresh new adventure and thus **keep me motivated**.*" [En.P – 85] – Relevance (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, concerning the tunneling strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .29$, $p < .05$). Therefore, any of the two implementations could be appropriate for attracting and preserving attention and increasing satisfaction due to a lack of significant variances. Nonetheless, neither IMPL-1 nor IMPL-2 is related to Confidence. Furthermore, IMPL-2 is the only implementation significantly associated with boosting Relevance ($\beta = .31$, $p < .05$). The following are sample comments that emphasize our findings:

"*It **looks great** give **visually attract**, and also direction with map.*" [En.P – 38] – Attention and Satisfaction (IMPL-2). "*Presentation of route map is nice. People who can use this to locate a place and avoid traffic and try walking, and it is **motivation for maintaining health**.*" [En.P – 259] – Relevance (IMPL-2).

For non-Arabic participants at the **Action stage** of behavior change, our findings show that for the tunneling strategy, only IMPL-1 is significantly associated with attracting and preserving Attention and increasing Satisfaction ($\beta = .18$, $p < .05$; $\beta = .15$, $p < .05$, respectively). However, both IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .30$, $p < .001$; IMPL-2: $\beta = .35$, $p < .05$); therefore, the two implementations are similarly effective in attracting attention and increasing satisfaction for those at the Action stage. Furthermore, IMPL-1 and IMPL-2 are significantly related to Relevance (IMPL-1: $\beta = .21$, $p < .001$; IMPL-2: $\beta = .34$, $p < .05$) but at a significantly different level; hence, IMPL-2 is more effective than IMPL-1 for boosting relevance. Exhibited below are sample comments from non-Arabic participants that support our findings:

"*This application gives the **direction** for walking with the **clear image**.*" [En.P – 90] – Attention (IMPL-2). "*I **love** the suggested route idea because I might end up **going for walking activity** on a route I would not have gone.*" [En.P – 130] – Confidence and Satisfaction (IMPL-2). "*Having it laid out in a map for walking like this is a lot nicer. It's **easier to follow and digest** when you have a visual element involved, instead of just text.*" [En.P – 19] – Relevance (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, neither IMPL-1 nor IMPL-2 of the tunneling strategy is related to Attention. Nonetheless, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .32$, $p < .05$) and Relevance (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .30$, $p < .05$). Consequently, the two implementations are equally effective in improving confidence and increasing relevance for those at the Maintenance stage. Furthermore, IMPL-2 of the tunneling strategy is the sole implementation significantly associated with Satisfaction ($\beta = .20$, $p < .05$), making it the most effective implementation for increasing satisfaction. The following are sample comments that demonstrate our findings:

"*The map is useful to use for **walking** routes for **goal achievement**.*" [En.P – 24] – Confidence (IMPL-2). "*The visual directions make it **easy to follow** with designated points on the map to identify the route.*" [En.P – 31] – Relevance (IMPL-2). "*This map visualization is my **preferred method** of following directions for walking, so this would be much **more useful** to me.*" [En.P – 333] – Satisfaction (IMPL-2).

6.4.3.2.11 Cooperation Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, IMPL-2 (**Cooperation as Teamwork**) of the cooperation strategy is the only implementation significantly associated with Attention and Relevance ($\beta = .22$, $p < .05$; $\beta = .21$, $p < .05$); hence, IMPL-2 is considered as the most effective implementation for attracting and preserving attention and boosting the relevance of those at the Precontemplation stage. Nevertheless, IMPL-1 (**Message Exchange via Social Cooperation Networks**) and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .21$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$). Thus, the two implementations are suitable for boosting and increasing confidence because they lack significant variances. Moreover, IMPL-1 and IMPL-2 are significantly related to Satisfaction (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .36$, $p < .05$) but at a significantly different level; therefore, IMPL-2 is more effective than IMPL-1 for increasing satisfaction. The following are example comments that corroborate our findings:

"*The kind of competition helps to **track** and progress towards.*" [En.P – 40] – Attention (IMPL-2). "*I would feel more responsible to **help contribute** to the team. I **would do more** to be a useful member.*" [En.P – 37] – Confidence (IMPL-2). "*Social cooperation gives me a **sense of motivation**.*" [En.P – 285] – Relevance (IMPL-2). "***Very funny** to try with my friends.*" [En.P – 108] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Contemplation stage** of behavior change, concerning the cooperation strategy, IMPL-2 is the sole implementation significantly associated with Attention ($\beta = .20$, $p < .05$). Accordingly, IMPL-2 is perceived as more effective for stimulating and preserving the attention of those at that stage of change. However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence, Relevance, and Satisfaction (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .27$, $p < .001$), (IMPL-1: $\beta = .20$, $p < .05$; IMPL-2: $\beta = .26$, $p < .05$), and (IMPL-1: $\beta = .24$, $p < .05$; IMPL-

2: $\beta = .30$, $p < .05$), respectively. Consequently, IMPL-1 and IMPL-2 are perceived as equally effective in boosting confidence, improving relevance, and increasing satisfaction since they lack significant variances. Presented below are example comments that corroborate our results:

"*Invite friends easily in this application, create challenges between friends* ***looks*** *new and* ***attention grabbing***." [En.P – 38] – Attention (IMPL-2). "*Would be* ***helpful in challenges*** *with friends and* ***keeping*** *each other* ***accountable*** *for* ***reaching the goal***." [En.P – 308] – Confidence (IMPL-2). "*This is a really good way to keep the users* ***accountable and motivated***." [En.P – 302] – Relevance (IMPL-2). "*I see where this could be* ***good and useful*** *to someone with a group of like-minded friends.*" [En.P – 144] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Preparation stage** of behavior change, our findings indicate that for the cooperation strategy, only IMPL-2 is significantly associated with attracting and preserving Attention ($\beta = .20$, $p < .05$). However, IMPL-1 and IMPL-2 are significantly related to Confidence (IMPL-1: $\beta = .17$, $p < .001$; IMPL-2: $\beta = .31$, $p < .001$) but at a significantly different degree. Consequently, IMPL-2 is more effective than IMPL-2 for strengthening confidence. Moreover, IMPL-1 and IMPL-2 are significantly and similarly associated with Relevance (IMPL-1: $\beta = .26$, $p < .001$; IMPL-2: $\beta = .33$, $p < .001$) and Satisfaction (IMPL-1: $\beta = .16$, $p < .05$; IMPL-2: $\beta = .20$, $p < .05$); subsequently, the two implementations are similarly effective in increasing people's relevance and satisfaction. Displayed below are example comments that confirm our findings:

"*Inviting friends to exercise together is very good,* ***very*** *supportive and* ***recognized***." [En.P – 474] – Attention (IMPL-2). "*I would not want to let my team down, so I'd be more likely to* ***accomplish or increase my goals***." [En.P – 315] – Confidence (IMPL-2). "*Gamifying the walking in this way could be* ***motivating***." [En.P – 75] – Relevance (IMPL-2). "*Walking challenge is* ***good*** *and* ***more effective***." [En.P – 165] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Action stage** of behavior change, regarding cooperation strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .23$, $p < .05$; IMPL-2: $\beta = .24$, $p < .05$); thus, the two implementations are similarly effective in stimulating and preserving people's attention. However, neither IMPL-1 nor IMPL-2 of the cooperation strategy is associated with Confidence. Furthermore, IMPL-2 is the sole implementation significantly associated with boosting Relevance ($\beta = .31$, $p < .05$). Moreover, IMPL-1 and IMPL-2 are significantly related

to Satisfaction (IMPL-1: $\beta = .31$, $p < .05$; IMPL-2: $\beta = .44$, $p < .001$) but at a significantly varying level. Accordingly, IMPL-2 is more effective than IMPL-2 for increasing satisfaction. The following sample qualitative comments below provide additional insights into our findings:

"*This team walking challenge **increase my curiosity** to start and win.*" [En.P – 321] – Attention (IMPL-2). "*This direct callout format might be a bit **more motivational** and a better use of social functions. I can see myself feeling obligated to join a friend on their challenge if they asked.*" [En.P – 333] – Relevance (IMPL-2). "*Inviting friends and playing with them makes it **more fun**.*" [En.P – 336] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, only IMPL-2 of the cooperation strategy is significantly effective in stimulating and preserving Attention ($\beta = .17$, $p < .05$). However, IMPL-1 and IMPL-2 are significantly and similarly associated with Confidence (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .36$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .29$, $p < .05$; IMPL-2: $\beta = .34$, $p < .05$). Accordingly, any of the implementations could be suitable is similarly effective for boosting people's confidence and increasing their satisfaction. Furthermore, neither IMPL-1 nor IMPL-2 is effective for increasing the relevance of individuals at the Maintenance stage since both implementations are not significantly related to the Relevance construct. Below are sample comments that support our findings:

"*This feature would let us **focus** on the target walking plan as a group.*" [En.P – 236] – Attention (IMPL-2). "***Make** friends to **exercise** together and **make achievements** together.*" [En.P – 346] – Confidence (IMPL-2). "*I **like** the idea **better** that I can invite people. People I already know and I am friends with.*" [En.P – 266] – Satisfaction (IMPL-2).

6.4.3.2.12 Simulation Strategy

For non-Arabic participants at the **Precontemplation stage** of behavior change, our findings show that for the simulation strategy, IMPL-1 (**Simulation as Battery Charging**) and IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) are significantly and similarly associated with Attention (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .31$, $p < .05$). Therefore, the two implementations are equally effective in stimulating and preserving people's attention since

there is no significant difference between them. Furthermore, only IMPL-2 of the simulation strategy is significantly effective in boosting Confidence ($\beta = .25$, $p < .05$) and increasing Satisfaction ($\beta = .24$, $p < .05$). Moreover, IMPL-1 and IMPL-2 are significantly associated with Relevance (IMPL-1: $\beta = .31$, $p < .05$; IMPL-2: $\beta = .44$, $p < .05$) but at a significantly varying degree. Consequently, IMPL-2 is more effective than IMPL-1 in increasing the relevance of those at the Precontemplation stage. The following are example comments that support our findings:

"***Seeing*** *my body out of shape and back to shape would be* ***very motivating***." [En.P – 37] – Attention and Relevance (IMPL-2). "*This simulation strategy shows the walking goals strong or weak in visual monitoring the progress; it's* ***easy to achieve the goal***." [En.P – 122] – Confidence (IMPL-1). "***Unique and good*** *design*." [En.P – 33] – Satisfaction (IMPL-1).

For non-Arabic participants at the **Contemplation stage** of behavior change, concerning the simulation strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta = .15$, $p < .05$; IMPL-2: $\beta = .25$, $p < .05$), Confidence (IMPL-1: $\beta = .27$, $p < .05$; IMPL-2: $\beta = .22$, $p < .001$), Relevance (IMPL-1: $\beta = .34$, $p < .001$; IMPL-2: $\beta = .31$, $p < .05$), and Satisfaction (IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$). Accordingly, the two implementations are appropriate for stimulating and preserving attention, boosting confidence, enhancing relevance, and increasing satisfaction because of the lack of significant variances. The following are sample comments that confirm our findings:

"*I like this; think it's really useful to* ***see*** *what the results of your goals* ***might look like***." [En.P – 130] – Attention (IMPL-2). "*I* ***like*** *the method to correlate my physical activity levels with respect to battery health. So, if I am running low on battery, then I need to* ***do physical activity sessions****. This creates an* ***urge in me to retain the highest battery power***." [En.P – 306] – Confidence and Satisfaction (IMPL-1). "*Visuals as charging battery can be* ***motivating for me*** *in some cases, and this seems to be a feature that would* ***intrigue me***." [En.P – 331] – Relevance (IMPL-1).

For non-Arabic participants at the **Preparation stage** of behavior change, regarding the simulation strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: $\beta =$

.26, p < .05; IMPL-2: β = .23, p < .05) and Confidence (IMPL-1: β = .23, p < .05; IMPL-2: β = .21, p < .05). Accordingly, both implementations are perceived as similarly effective for attracting attention and boosting confidence because there is no significant difference between them. However, IMPL-2 of the simulation strategy is the sole implementation significantly associated with Relevance (β = .32, p < .05) and Satisfaction (β = .21, p < .05), making it the most effective implementation for increasing relevance and satisfaction. Below are qualitative comments that support our findings:

"*I **like** this battery metaphor, since it would make me **feel** like I was recharging my battery by engaging in these activities. It's also **colorful** and brings about **positive feelings** just **looking at** the indicator, especially as it's getting closer to fully charged.*" [En.P – 19] – Attention and Satisfaction (IMPL-1). "*Knowing the goal, **more firm confidence in the movement**.*" [En.P – 411] – Confidence (IMPL-1). "*I like this color types of **stimulation**.*" [En.P – 131] – Relevance (IMPL-1).

For non-Arabic participants at the **Action stage** of behavior change, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: β = .36, p < .001; IMPL-2: β = .30, p < .05) and Satisfaction (IMPL-1: β = .28, p < .05; IMPL-2: β = .38, p < .05). Consequently, the two implementations are similarly effective in attracting and preserving attention and increasing satisfaction of those at that stage of behavior change. However, IMPL-1 is the sole implementation that is significantly effective in boosting Confidence (β = .19, p < .05), while IMPL-2 is the only implementation that is significantly effective in increasing Relevance (β = .21, p < .05). The following are sample comments that demonstrate our findings:

"*I think this is a fun way to **view** your data, and this would **inspire me to get to the full battery** because it resembles a game*." [En.P – 66] – Attention and Confidence (IMPL-1). "*Setting a target goal body shape could be really useful to **motivate** myself.*" [En.P – 111] – Relevance (IMPL-2). "*The avatar is **quite unique** and **interesting**.*" [En.P – 314] – Satisfaction (IMPL-2).

For non-Arabic participants at the **Maintenance stage** of behavior change, regarding the simulation strategy, IMPL-1 and IMPL-2 are significantly and similarly associated with Attention (IMPL-1: β = .17, p < .05; IMPL-2: β = .24, p < .05), Confidence (IMPL-1: β = .21, p < .05; IMPL-2: β = .25, p < .05), and Satisfaction (IMPL-1: β = .23, p < .05; IMPL-2: β = .26, p < .05). Correspondingly, the two

implementations are suitable for stimulating and preserving attention, boosting confidence, and increasing satisfaction because of the lack of significant variances. However, only IMPL-2 of the simulation strategy is significantly effective in increasing Relevance ($\beta = .27$, $p < .001$). The following are sample comments that endorse our findings:

"*I like the idea of giving me a **visual picture** of what I will **look like** if I succeed in my goals.*" [En.P – 31] – Attention (IMPL-2). "*This feature would show me details and information that would be **helpful in attaining a goal** I set for myself.*" [En.P – 120] – Confidence (IMPL-2). "*This feature will **motivate** and remind me towards my goal.*" [En.P – 63] – Relevance (IMPL-2). "*I am a visual learner and would **love** this feature.*" [En.P – 535] – Satisfaction (IMPL-2).

6.4.3.3 Overall Comparison of the Persuasiveness of the Strategies' Implementations and the ARCS Motivational Constructs For People at Different Stages of Change Between Arabic and Non-Arabic Populations

In this section, I provide an overall comparison of the persuasiveness of the strategies' implementations across the four ARCS motivational constructs (Attention, Relevance, Confidence, Satisfaction) among Arabic and non-Arabic participants at different stages of change (Stage 1: Precontemplation, Stage 2: Contemplation, Stage 3: Preparation, Stage 4: Action, Stage 5: Maintenance). I offer some examples for this comparison, including strategies such as personalization and goal-setting. Overall, our findings reveal that the persuasiveness of the implementations (IMPL-1, IMPL-2) for each persuasive strategy varies at each stage of change and aligns with their corresponding motivational constructs within each population and between the Arabic and non-Arabic populations.

Figure 70 provides a comparison illustrating the differences and similarities in the relationships between the personalization strategy's implementations and the ARCS motivational constructs among Arabic and non-Arabic participants at various stages of change. Regarding the personalization strategy at the **Precontemplation stage** of behavior change, our research reveals distinct associations with the four motivational constructs for Arabic and non-Arabic participants.

For Arabic participants, our findings show that only IMPL-1 (**Personalized Motivational Content**) is significantly linked with Confidence ($\beta = .24$, $p < .05$). In contrast, IMPL-2 (**Personalized Goal Recommendations**) exclusively contributes to stimulating and sustaining Attention ($\beta = .20$, $p < .05$).

Furthermore, both IMPL-1 and IMPL-2 significantly relate to Relevance (IMPL-1: $\beta = .33$, $p < .05$; IMPL-2: $\beta = .16$, $p < .05$), though their impact varies significantly. Similarly, both implementations are equally effective in enhancing Satisfaction levels for Arabic participants during the Precontemplation stage (IMPL-1: $\beta = .28$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$). For non-Arabic participants, both IMPL-1 and IMPL-2 significantly and equally correlate with Attention (IMPL-1: $\beta = .30$, $p < .05$; IMPL-2: $\beta = .23$, $p < .05$). However, IMPL-1 of the personalization strategy is the sole implementation significantly associated with boosting Confidence ($\beta = .17$, $p < .05$) and increasing Satisfaction ($\beta = .22$, $p < .05$). In addition, IMPL-2 is the only implementation that is significantly effective in enhancing Relevance ($\beta = .27$, $p < .05$). In summary, at the Precontemplation stage of behavior change, within the personalization strategy, distinct associations are observed for Arabic and non-Arabic participants. For Arabic participants, IMPL-1 is linked with Confidence, while IMPL-2 focuses on stimulating Attention. Both implementations impact Relevance and Satisfaction, with varying degrees of influence. Conversely, for non-Arabic participants, both IMPL-1 and IMPL-2 significantly influence Attention, with IMPL-1 being the only implementation associated with Confidence and Satisfaction. IMPL-2 stands out in enhancing Relevance. This highlights that the strategy's impact varies between these two participant groups at the Precontemplation stage of behavior change.

In the context of the personalization strategy during the **Contemplation stage**, with respect to Arabic participants, IMPL-1 stands out as the only implementation significantly linked to Attention ($\beta = 0.22$, $p < 0.001$). Conversely, both IMPL-1 and IMPL-2 of the personalization strategy exhibit noteworthy associations with Relevance (IMPL-1: $\beta = 0.31$, $p < 0.05$; IMPL-2: $\beta = 0.45$, $p < 0.001$), but at varying levels of significance. Both implementations equally excel in boosting confidence, as evidenced by their associations with the Confidence construct (IMPL-1: $\beta = 0.27$, $p < 0.05$; IMPL-2: $\beta = 0.18$, $p < 0.05$), with no significant distinction between them. However, neither IMPL-1 nor IMPL-2 demonstrates a connection with Satisfaction. For non-Arabic participants, both IMPL-1 and IMPL-2 are significantly and equally correlated with Attention (IMPL-1: $\beta = 0.22$, $p < 0.001$; IMPL-2: $\beta = 0.26$, $p < 0.05$), Confidence (IMPL-1: $\beta = 0.23$, $p < 0.001$; IMPL-2: $\beta = 0.27$, $p < 0.05$), and Satisfaction (IMPL-1: $\beta = 0.35$, $p < 0.001$; IMPL-2: $\beta = 0.31$, $p < 0.05$). However, only IMPL-2 of the personalization strategy displays a significant relationship with Relevance ($\beta = 0.18$, $p < 0.05$). In

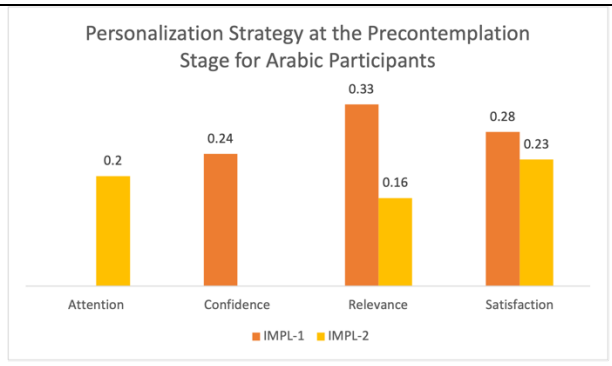
summary, at the Contemplation stage of the personalization strategy, for Arabic participants, IMPL-1 is significant for Attention, while both IMPL-1 and IMPL-2 are noteworthy for Relevance but at varying levels. Both implementations perform similarly in boosting Confidence, with no significant distinction. However, neither implementation is related to Satisfaction for Arabic participants. In contrast, for non-Arabic participants, the findings show significant correlations between both IMPL-1 and IMPL-2 with Attention, Confidence, and Satisfaction. However, only IMPL-2 exhibits a significant relationship with Relevance.

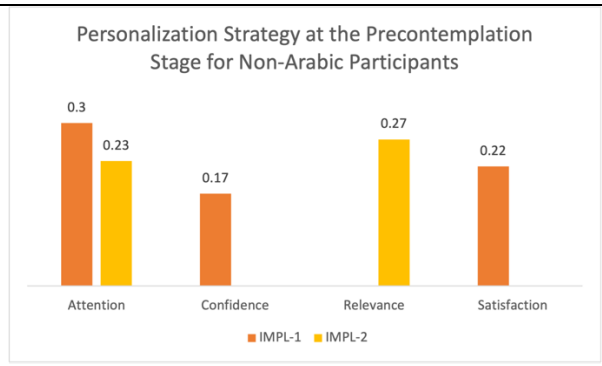
At the **Preparation stage**, within the context of the personalization strategy, there are notable differences between Arabic and non-Arabic participants. For Arabic participants, IMPL-1 is significantly associated with Attention ($\beta = 0.20$, $p < 0.05$), Confidence ($\beta = 0.16$, $p < 0.05$), and Relevance ($\beta = 0.51$, $p < 0.001$). Conversely, IMPL-1 and IMPL-2 are both effective at significantly increasing Satisfaction (IMPL-1: $\beta = 0.36$, $p < 0.05$; IMPL-2: $\beta = 0.13$, $p < 0.05$), but with varying degrees of effectiveness. On the other hand, among non-Arabic participants, both IMPL-1 and IMPL-2 are similarly associated with Attention (IMPL-1: $\beta = 0.24$, $p < 0.001$; IMPL-2: $\beta = 0.23$, $p < 0.05$). However, Confidence ($\beta = 0.11$, $p < 0.05$) and Relevance ($\beta = 0.37$, $p < 0.001$) are significantly related only to IMPL-1. Interestingly, both IMPL-1 and IMPL-2 significantly impact Satisfaction (IMPL-1: $\beta = 0.25$, $p < 0.05$; IMPL-2: $\beta = 0.39$, $p < 0.001$), but the extent of their impact varies. In summary, when assessing the personalization strategy at the Preparation stage, Arabic and non-Arabic participants exhibit differences in their associations. For Arabic participants, IMPL-1 significantly influences Attention, Confidence, and Relevance, while both IMPL-1 and IMPL-2 enhance Satisfaction with differing effectiveness. In contrast, among non-Arabic participants, both implementations similarly affect Attention, but only IMPL-1 significantly influences Confidence and Relevance. Both IMPL-1 and IMPL-2 impact Satisfaction, with varying degrees of impact.

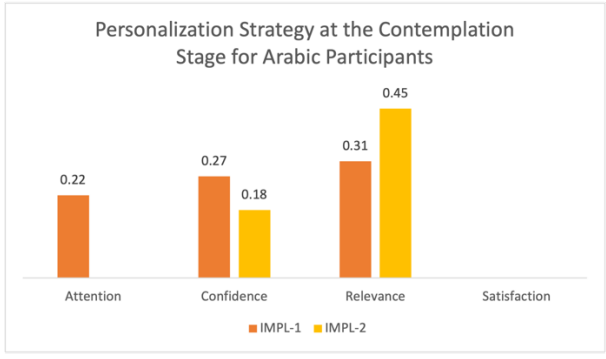
For the personalization strategy at the **Action stage** of behavior change, regarding Arabic participants, IMPL-1 is the sole implementation effective in capturing and maintaining Attention ($\beta = 0.30$, $p < 0.05$), while IMPL-2 is the only one significantly linked to Confidence ($\beta = 0.40$, $p < 0.05$). However, both IMPL-1 and IMPL-2 within the personalization strategy are significantly and similarly associated with the Relevance construct (IMPL-1: $\beta = 0.34$, $p < 0.001$; IMPL-2: $\beta = 0.23$, $p < 0.05$) and Satisfaction (IMPL-1: $\beta = 0.25$, $p < 0.05$; IMPL-2: $\beta = 0.18$, $p < 0.05$). For non-Arabic participants,

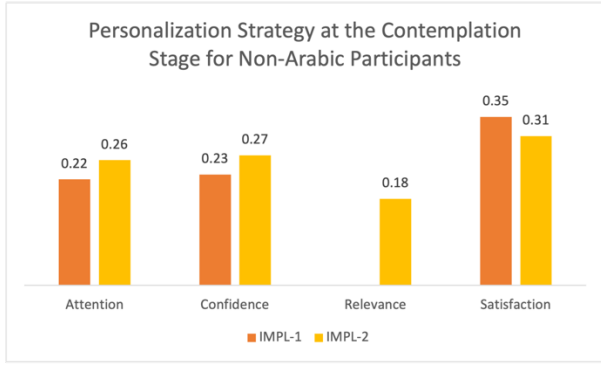
only IMPL-2 significantly correlates with Attention ($\beta = 0.32$, $p < 0.05$) and Relevance ($\beta = 0.36$, $p < 0.05$). In contrast, IMPL-1 is the sole implementation significantly associated with Confidence ($\beta = 0.24$, $p < 0.05$) and Satisfaction ($\beta = 0.52$, $p < 0.05$). In summary, during the Action stage of behavior change, for Arabic participants, IMPL-1 performs exceptionally well in attracting and maintaining Attention, while IMPL-2 significantly boosts Confidence. Both implementations are equally effective in enhancing Relevance and Satisfaction. Conversely, among non-Arabic participants, IMPL-2 stands out for capturing Attention and Relevance, whereas IMPL-1 is more effective in improving Confidence and Satisfaction.

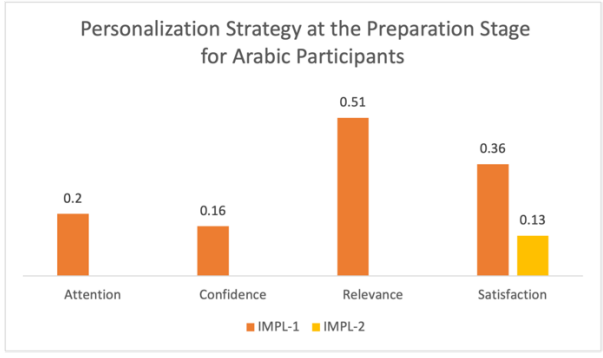
For the personalization strategy at the **Maintenance stage**, concerning Arabic participants, both IMPL-1 and IMPL-2 significantly enhance Relevance (IMPL-1: $\beta = 0.40$, $p < 0.001$; IMPL-2: $\beta = 0.26$, $p < 0.05$), but their levels of significance differ significantly. However, neither IMPL-1 nor IMPL-2 is linked to the Satisfaction construct. Moreover, both implementations are perceived as effective in capturing and maintaining Attention and boosting Confidence, as they are similarly and significantly associated with the Attention and Confidence constructs (IMPL-1: $\beta = 0.30$, $p < 0.001$; IMPL-2: $\beta = 0.20$, $p < 0.05$ and IMPL-1: $\beta = 0.24$, $p < 0.05$; IMPL-2: $\beta = 0.21$, $p < 0.05$ respectively). For non-Arabic participants, IMPL-1 is the only implementation significantly associated with Attention ($\beta = 0.30$, $p < 0.05$) and Satisfaction ($\beta = 0.33$, $p < 0.05$). In contrast, IMPL-2 is the sole implementation significantly related to Confidence ($\beta = 0.28$, $p < 0.05$) and Relevance ($\beta = 0.16$, $p < 0.05$). In summary, at the Maintenance stage of the personalization strategy, for Arabic participants, both IMPL-1 and IMPL-2 effectively enhance Relevance, but their effectiveness differs significantly. However, neither implementation is associated with Satisfaction, while both are perceived as equally effective in capturing Attention and boosting Confidence. For non-Arabic participants, IMPL-1 is more effective in attracting Attention and enhancing Satisfaction, whereas IMPL-2 is significantly linked to Confidence and Relevance.

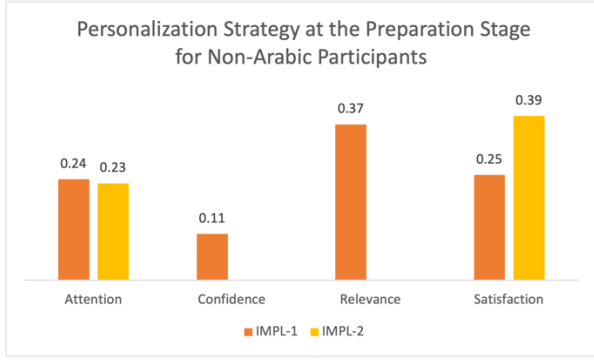

Personalization Strategy at the Precontemplation Stage for Arabic Participants
0.2
0.24
0.33
0.16
0.28
0.23
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2

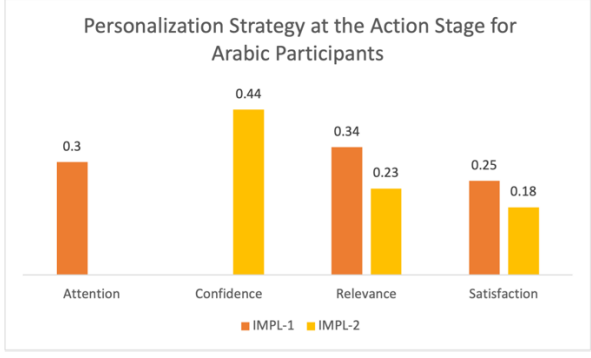

Personalization Strategy at the Precontemplation Stage for Non-Arabic Participants
0.3
0.23
0.17
0.27
0.22
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2


Personalization Strategy at the Contemplation Stage for Arabic Participants
0.22
0.27
0.18
0.31
0.45
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2


Personalization Strategy at the Contemplation Stage for Non-Arabic Participants
0.22
0.26
0.23
0.27
0.18
0.35
0.31
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2


Personalization Strategy at the Preparation Stage for Arabic Participants
0.2
0.16
0.51
0.36
0.13
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2


Personalization Strategy at the Preparation Stage for Non-Arabic Participants
0.24
0.23
0.11
0.37
0.25
0.39
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2


Personalization Strategy at the Action Stage for Arabic Participants
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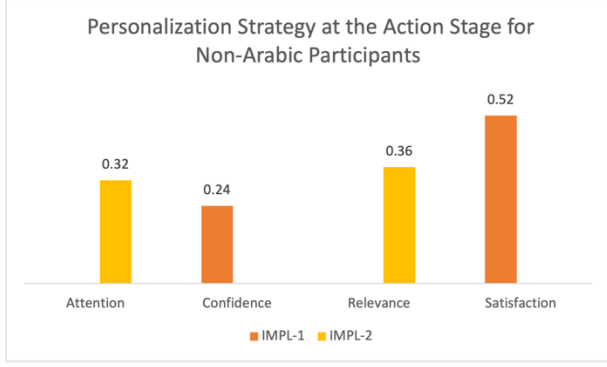
0.44
0.34
0.23
0.25
0.18
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2


Personalization Strategy at the Action Stage for Non-Arabic Participants
0.32
0.24
0.36
0.52
Attention
Confidence
Relevance
Satisfaction
IMPL-1
IMPL-2

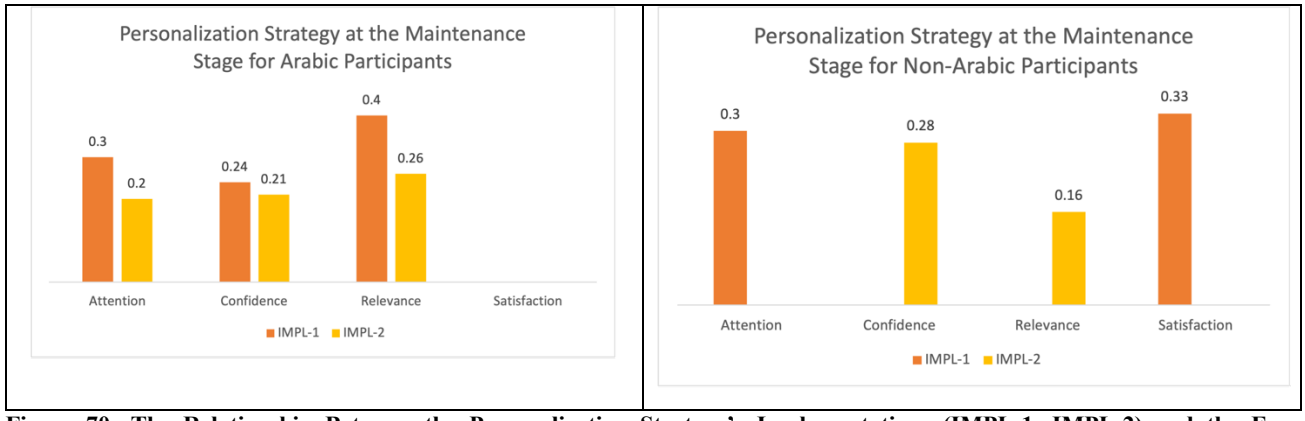


Figure 70: The Relationship Between the Personalization Strategy's Implementations (IMPL-1, IMPL-2) and the Four Motivational Constructs (Attention, Relevance, Confidence, Satisfaction) for Arabic and Non-Arabic Participants at Each Stage of Change (Precontemplation, Contemplation, Preparation, Action, Maintenance).

Figure 71 highlights the differences and similarities in the relationships between the implementations of the goal-setting strategy and the ARCS motivational constructs among Arabic and non-Arabic participants at various stages of change. In the context of the goal-setting strategy at the **Precontemplation stage** of behavior change, concerning Arabic participants, our findings indicate that IMPL-1 (**Default/System-based Goals**) and IMPL-2 (**Customized/User-Driven Goals**) significantly differ in their impact on motivating behavior change within the goal-setting strategy. Specifically, IMPL-1 is significantly associated with Confidence ($\beta = 0.19$, $p < 0.05$), while IMPL-2 has no significant relationship with Confidence. Additionally, IMPL-1 is perceived as more effective at capturing and maintaining Attention compared to IMPL-2 (IMPL-1: $\beta = 0.45$, $p < 0.05$; IMPL-2: $\beta = 0.22$, $p < 0.05$). However, IMPL-2 is perceived as more effective in increasing Relevance (IMPL-1: $\beta = 0.20$, $p < 0.05$; IMPL-2: $\beta = 0.35$, $p < 0.001$) and Satisfaction (IMPL-1: $\beta = 0.18$, $p < 0.05$; IMPL-2: $\beta = 0.30$, $p < 0.05$). For non-Arabic participants, IMPL-1 is the only implementation significantly associated with stimulating and maintaining Attention and enhancing Relevance ($\beta = 0.30$, $p < 0.05$; $\beta = 0.20$, $p < 0.05$, respectively). However, both IMPL-1 and IMPL-2 are significantly associated with increasing Confidence (IMPL-1: $\beta = 0.19$, $p < 0.05$; IMPL-2: $\beta = 0.33$, $p < 0.05$) but at significantly different levels. Furthermore, IMPL-1 and IMPL-2 of the goal-setting strategy are significantly and similarly associated with Satisfaction (IMPL-1: $\beta = 0.33$, $p < 0.05$; IMPL-2: $\beta = 0.43$, $p < 0.05$). In summary, during the Precontemplation stage of behavior change and the goal-setting strategy, for Arabic participants, IMPL-1 and IMPL-2 significantly differ in their impact. IMPL-1 is associated

with Confidence and capturing Attention, while IMPL-2 is more effective in increasing Relevance and Satisfaction. For non-Arabic participants, IMPL-1 stands out in capturing Attention and enhancing Relevance, while both IMPL-1 and IMPL-2 significantly boost Confidence and Satisfaction but at varying levels.

For the goal-setting strategy at the **Contemplation stage** of behavior change, regarding Arabic participants, both IMPL-1 and IMPL-2 within the goal-setting strategy demonstrate significant and comparable associations with Attention (IMPL-1: $\beta = 0.28$, $p < 0.05$; IMPL-2: $\beta = 0.26$, $p < 0.001$), Relevance (IMPL-1: $\beta = 0.36$, $p < 0.05$; IMPL-2: $\beta = 0.30$, $p < 0.05$), and Satisfaction (IMPL-1: $\beta = 0.24$, $p < 0.05$; IMPL-2: $\beta = 0.22$, $p < 0.05$). In contrast, IMPL-2 of the goal-setting strategy is the only implementation significantly linked to the Confidence construct ($\beta = 0.23$, $p < 0.05$). For non-Arabic participants, both IMPL-1 and IMPL-2 are significantly and comparably associated with Attention (IMPL-1: $\beta = 0.34$, $p < 0.001$; IMPL-2: $\beta = 0.29$, $p < 0.05$) and Confidence (IMPL-1: $\beta = 0.28$, $p < 0.05$; IMPL-2: $\beta = 0.20$, $p < 0.05$). Conversely, in this group, IMPL-1 of the goal-setting strategy is the only implementation significantly effective in enhancing Relevance and increasing Satisfaction ($\beta = 0.21$, $p < 0.05$; $\beta = 0.20$, $p < 0.05$, respectively). In summary, at the Contemplation stage of behavior change and within the goal-setting strategy, for Arabic participants, both IMPL-1 and IMPL-2 are equally effective in capturing Attention, enhancing Relevance, and providing Satisfaction. However, IMPL-2 stands out as the sole implementation associated with Confidence. For non-Arabic participants, both IMPL-1 and IMPL-2 significantly impact Attention and Confidence similarly, with IMPL-1 demonstrating superior performance in increasing Relevance and Satisfaction.

Regarding the goal-setting strategy during the **Preparation stage**, when considering Arabic participants, both IMPL-1 and IMPL-2 are significantly and similarly correlated with Attention and Confidence (IMPL-1: $\beta = 0.32$, $p < 0.05$; IMPL-2: $\beta = 0.37$, $p < 0.001$) as well as Relevance (IMPL-1: $\beta = 0.46$, $p < 0.001$; IMPL-2: $\beta = 0.29$, $p < 0.001$), respectively. However, IMPL-1 exhibits greater effectiveness in reinforcing Relevance, whereas IMPL-2 is significantly associated with enhancing Satisfaction (IMPL-1: $\beta = 0.23$, $p < 0.05$; IMPL-2: $\beta = 0.38$, $p < 0.05$). For non-Arabic participants, both IMPL-1 and IMPL-2 are significantly and comparably linked to Attention (IMPL-1: $\beta = 0.14$, $p < 0.05$; IMPL-2: $\beta = 0.21$, $p < 0.05$), Confidence (IMPL-1: $\beta = 0.20$, $p < 0.05$; IMPL-2: $\beta = 0.19$, $p < 0.05$), Relevance (IMPL-1: $\beta = 0.37$, $p < 0.001$; IMPL-2: $\beta = 0.28$, $p < 0.001$), and Satisfaction (IMPL-

1: $\beta = 0.25$, $p < 0.001$; IMPL-2: $\beta = 0.26$, $p < 0.05$). In summary, at the Preparation stage of the goal-setting strategy, both Arabic and non-Arabic participants find IMPL-1 and IMPL-2 effective in capturing Attention and Confidence but at different levels. However, for Arabic participants, IMPL-1 outperforms in reinforcing Relevance, while IMPL-2 is more effective in increasing Satisfaction. Conversely, for non-Arabic participants, both IMPL-1 and IMPL-2 significantly influence Relevance and Satisfaction.

In the context of the goal-setting strategy at the **Action stage** of behavior change, when considering Arabic participants, IMPL-2 stands out as the sole implementation significantly related to Attention ($\beta = .22$, $p < .05$) and Confidence ($\beta = .30$, $p < .001$). Conversely, both IMPL-1 and IMPL-2 of the goal-setting strategy are significantly and similarly related to Relevance (IMPL-1: $\beta = .30$, $p < .001$; IMPL-2: $\beta = .25$, $p < .05$) and Satisfaction (IMPL-1: $\beta = .19$, $p < .05$; IMPL-2: $\beta = .22$, $p < .05$). For non-Arabic participants, only IMPL-2 is significantly associated with Attention ($\beta = .23$, $p < .05$) and Relevance ($\beta = .68$, $p < .05$), establishing it as the most effective implementation for stimulating and preserving attention and enhancing relevance. However, IMPL-1 is the only implementation significantly linked to Confidence ($\beta = .31$, $p < .05$) and Satisfaction ($\beta = .45$, $p < .05$). In summary, at the Action stage of behavior change and within the goal-setting strategy, for Arabic participants, IMPL-2 stands out as the primary implementation significantly related to Attention and Confidence, while both IMPL-1 and IMPL-2 are both effective in enhancing Relevance and Satisfaction. In contrast, for non-Arabic participants, IMPL-2 is the most effective in stimulating and preserving Attention and enhancing Relevance, whereas IMPL-1 is the sole implementation significantly associated with Confidence and Satisfaction.

For the goal-setting strategy during the **Maintenance stage** of behavior change, concerning Arabic participants, IMPL-1 emerges as the sole implementation significantly associated with Attention ($\beta = .22$, $p < .001$). Conversely, IMPL-2 is the only implementation significantly related to Confidence ($\beta = .28$, $p < .001$). Furthermore, both IMPL-1 and IMPL-2 within the goal-setting strategy are significantly and similarly related to Relevance and Satisfaction: (IMPL-1: $\beta = .33$, $p < .001$; IMPL-2: $\beta = .31$, $p < .001$ and IMPL-1: $\beta = .26$, $p < .05$; IMPL-2: $\beta = .21$, $p < .001$, respectively). For non-Arabic participants, both IMPL-1 and IMPL-2 of the goal-setting strategy are significantly associated with capturing and preserving Attention (IMPL-1: $\beta = .25$, $p < .05$; IMPL-2: $\beta = .37$, $p < .05$) but at

significantly different levels. Furthermore, IMPL-2 is the sole implementation significantly linked to enhancing Confidence ($\beta = .16$, $p < .05$). On the other hand, IMPL-1 within the goal-setting strategy is the only implementation significantly effective in boosting Relevance ($\beta = .22$, $p < .05$). Moreover, both IMPL-1 and IMPL-2 are significantly associated with Satisfaction (IMPL-1: $\beta = .24$, $p < .05$; IMPL-2: $\beta = .40$, $p < .05$) but at significantly varying degrees. In summary, at the Maintenance stage of behavior change and within the goal-setting strategy, for Arabic participants, IMPL-1 is superior in capturing Attention, while IMPL-2 stands out as the primary implementation significantly related to Confidence. However, both IMPL-1 and IMPL-2 are effective in enhancing Relevance and Satisfaction. In contrast, for non-Arabic participants, IMPL-2 is the most effective in enhancing Confidence. Nonetheless, IMPL-1 is distinguished as the only implementation significantly effective in boosting Relevance, while both implementations significantly contribute to Attention and Satisfaction but to varying degrees.

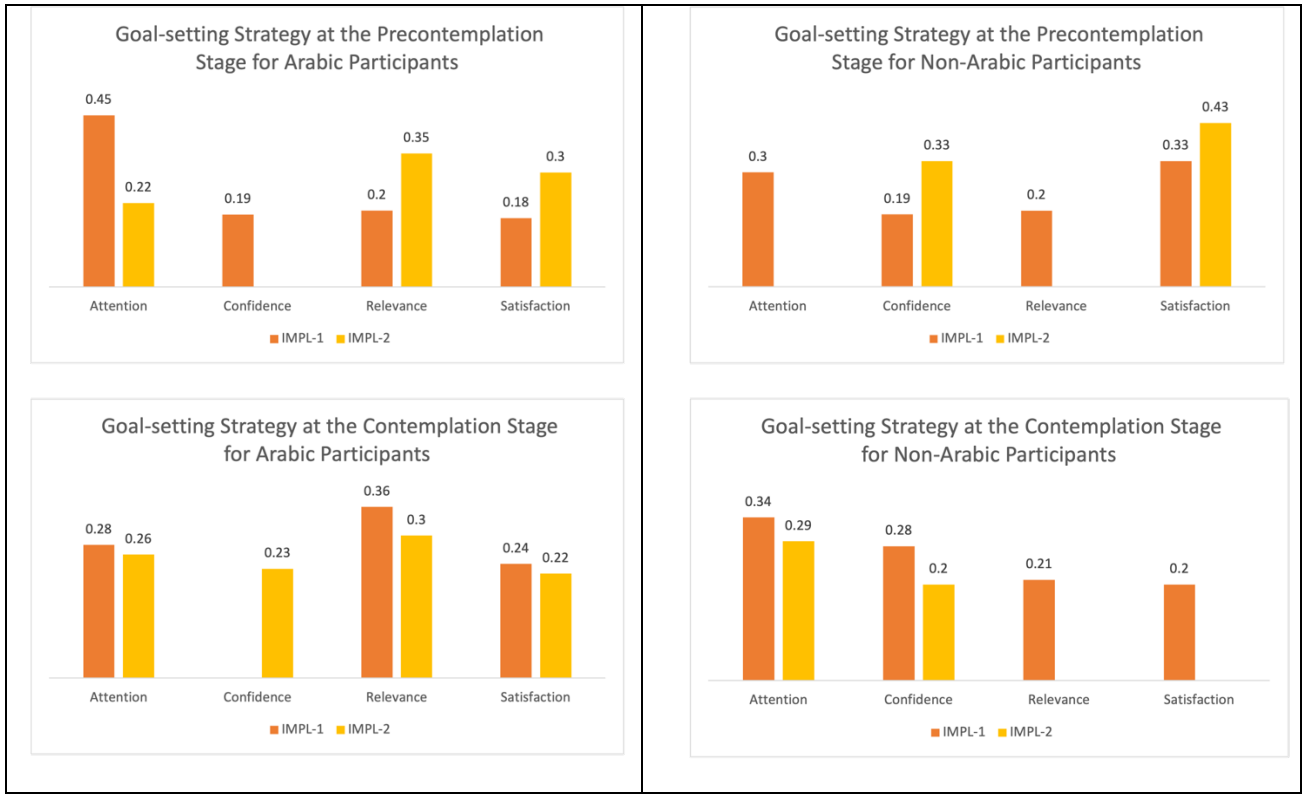


Figure 71: The Relationship Between Goal-setting Strategy Implementations (IMPL-1, IMPL-2) and the Four Motivational Constructs (Attention, Relevance, Confidence, Satisfaction) for Arabic and Non-Arabic Participants at Each Stage of Change (Precontemplation, Contemplation, Preparation, Action, Maintenance).

In summary, our findings reveal variations in the relationships and persuasiveness of each persuasive strategy's implementations concerning the four ARCS motivational constructs within each population (Arabic and non-Arabic) and between them at each stage of behavior change. I offer two strategies, personalization and goal-setting, as examples to illustrate how the current stage of change influences

participants' preferences and persuasiveness. These findings are applicable to all the remaining persuasive strategies and their respective implementations in our study.

6.4.4 Phase 4: Arabic and Non-Arabic Participants' Perspectives and Recommendations for Future App Design and Development

This section provides an exploration of the perspectives, preferences, opinions, and recommendations expressed by both Arabic and non-Arabic participants concerning future app design. Figure 72 and Figure 73 show sample codes and themes generated from phase 4.

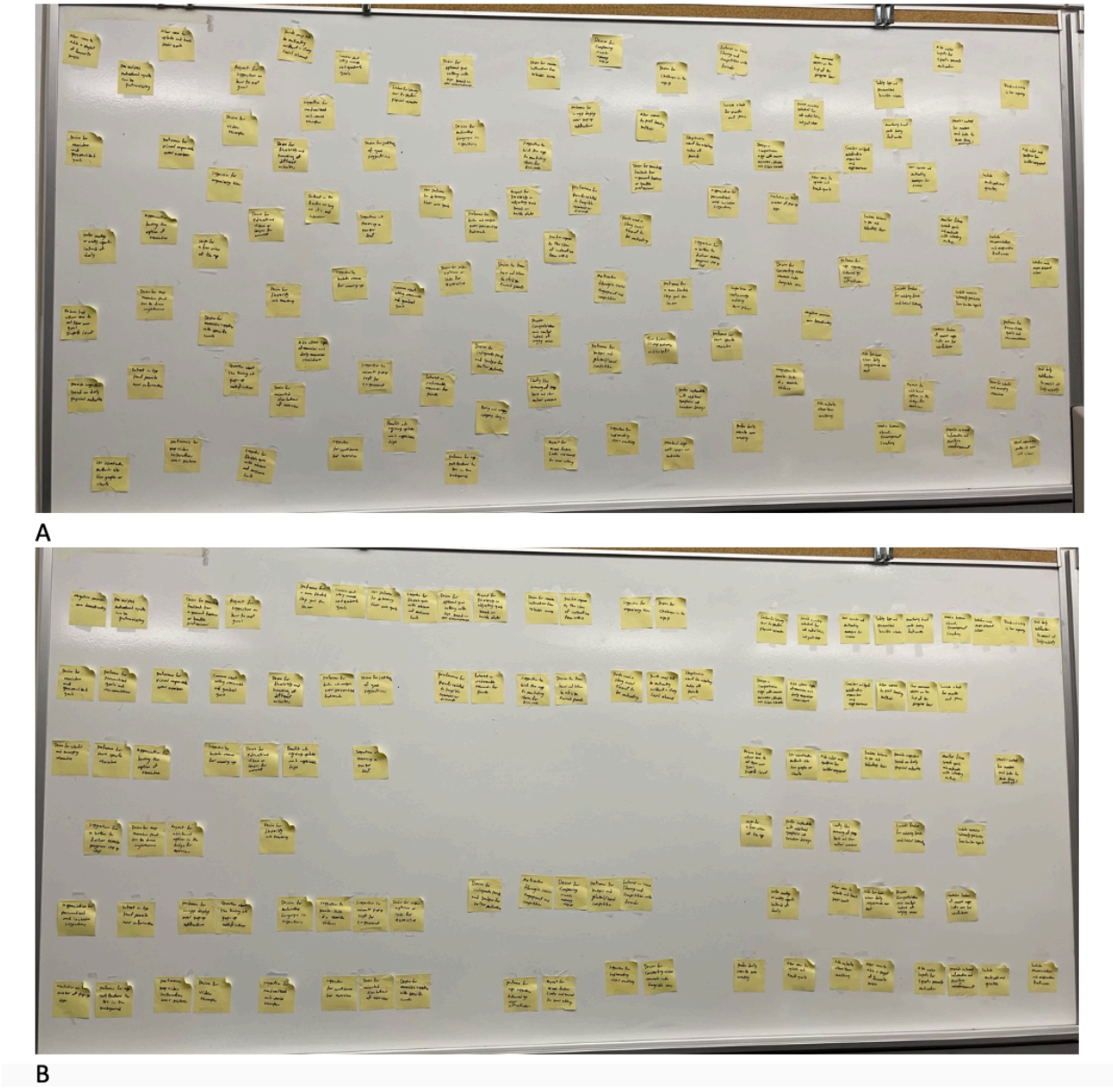


Figure 72: Codes Generated from Phase 4 of the Participants' Perspectives and Recommendations for Future App Design.

Figure 73: Themes Generated from Phase 4 of the Participants' Perspectives and Recommendations for Future App Design.

6.4.4.1 ARABIC PARTICIPANTS' PERSPECTIVES AND RECOMMENDATIONS FOR FUTURE APP DESIGN AND DEVELOPMENT

This section presents valuable insights gathered from Arabic participants. The overarching objective is to gain a thorough and comprehensive understanding of their perspectives, preferences, opinions, and recommendations concerning the design of future iterations of the app. By thoroughly exploring

these user-driven insights, our primary aim is to provide robust guidance and knowledge to shape the app's development, ultimately maximizing user engagement, satisfaction, and overall effectiveness.

6.4.4.1.1 Self-monitoring Strategy

For Arabic participants, concerning the self-monitoring strategy, participants offered several key recommendations for enhancing the PA app in IMPL-1 (**Textual and Numerical Feedback** such as textual representation). They proposed the inclusion of a feature for ***learning how to perform physical exercises***, such as ***leg and back exercises***. Additionally, they suggested providing a ***weekly schedule for all activities, not just steps***. Participants emphasized the significance of ***incorporating short, motivating messages and words of congratulations when users achieve their goals***, with the aim of encouraging them to do more. Safety considerations also included ***adding safety tips and monitoring heart rates during fast walks***. To boost user engagement and interaction, they recommended ***integrating elements like encouragement and coaching***.

To enhance the user experience, participants suggested ***utilizing more vibrant colors in the app's interface design*** and ***reducing the amount of blank white space***. Finally, they proposed ***sending daily notifications to remind users about the importance of staying active*** and taking care of their health.

Some recommendations from participants may introduce entirely different persuasive strategies or new features, such as rewards, reminders, and customization. To maintain clarity, I have associated and displayed the relevant persuasive strategy or feature with each respective comment. This approach will be consistently applied throughout the remaining sections of participants' recommendations and perspectives to further refine the design of the future PA app. Below are comments from Arabic participants corresponding to the suggested recommendations:

Theme 1: Educational Features

"*It is possible to add a feature for **learning how to perform physical exercises**, such as leg exercises or back exercises.*" [Ar.P – 28] (IMPL-1) – Rehearsal.

Theme 2: Comprehensive Activity Planning

"*It's better if the app provides **a weekly schedule for all activities**, not just steps.*" [Ar.P – 30] (IMPL-1).

Theme 3: Motivational and Concise Messaging

"*The more concise and containing short,* ***motivating messages*** *the app is, the more it will achieve tremendous success.*" [Ar.P – 49] (IMPL-1) – Praise.

Theme 4: Safety and Health Considerations

"***Safety tips*** *would add a lot in my opinion to the app and make it more personal based on the history of the user.* " [Ar.P – 505] (IMPL-1) – Personalization.

"***Heartbeat should also be monitored*** *when we do a fast walk. Is there any provisions on that.*" [Ar.P – 515] (IMPL-1).

Theme 5: User Engagement and Interaction

"*The app must be more than just presenting tracked data to elicit behavior change.* ***It needs a 'human' element to it***. ***Encouragement, coaching****, etc. --> this is missing.*" [Ar.P – 510] (IMPL-1) – Social Role and Praise.

Theme 6: Visual and Interface Design

"*The* ***interface needs more colors*** *to be* ***vibrant and attractive*** *to users*." [Ar.P – 501] (IMPL-1) – Liking.

"*The* ***black and white UI*** *is* ***less engaging*** *than a colorful design. There is a* ***lot of blank white wasted space***." [Ar.P - 511] (IMPL-1).

Theme 7: Health Notifications and Daily Reminders

"*It would be great if the app* ***sends me daily notifications to remind me of the importance of being active*** *on a daily basis.*" [Ar.P - 506] (IMPL-1) – Reminder.

Moreover, Arabic participants provided several essential recommendations for enhancing the PA app in IMPL-2 (**Numerical and Visual Feedback**, such as pie charts, graphs, and progress bars). Their suggestions included ***making the app more comprehensive by incorporating various exercises,*** creating personalized schedules based on specific PA goals, and integrating a daily calorie calculator ***to provide an all-in-one solution for movement***, fitness, and overall body health. They also stressed the importance of ***including daily exercise reminders***.

In addition, Arabic participants highlighted the ***significance of cost-effectiveness when compared to devices like the Apple Watch***. They recommended focusing on ***widgets, notifications, reminders, and overall app appearance***. Furthermore, they suggested ***offering flexibility for users to choose how they***

track their progress and improving the ***presentation of numerical values in summary progress reports***. Finally, they proposed providing ***more comprehensive charts for tracking progress over months and years***. Below are comments from Arabic participants corresponding to their recommendations:

Theme 1: Comprehensive Fitness App

"*It might be more fun **if the app is designed in a more comprehensive way**, including various exercises with a suitable schedule based on specific goals and integrated with a daily calorie calculator, **making it an all-in-one application for movement**, fitness, physical activity, and overall body health*." [Ar.P - 3] (IMPL-2) – Goal-setting.

"***Adding other types of exercises** and a feature for **daily exercise reminders**.*" [Ar.P - 96] (IMPL-2) – Reminder.

Theme 2: App Features and Integration

"***Apple Watch** offers features, **but it's expensive**.*" [Ar.P - 77] (IMPL-2).

"*What stands out the most in applications are **widgets, notifications, reminders, and appearance**.*" [Ar.P - 160] (IMPL-2) – Reminder and Liking.

"*The app would be better if it **allows users to pick what works better for them to track their progress** in different ways*." [Ar.P - 506] (IMPL-2).

"***Summary progress didn't show any numerical values** on the top of the bar. So exact walking steps are not predictable.*" [Ar.P - 528] (IMPL-2).

"*I would like to see the **chart for months and years**.*" [Ar.P - 503] (IMPL-2).

6.4.4.1.2 Personalization Strategy

Arabic participants, in relation to the personalization strategy, provided several key recommendations for improving the PA app in IMPL-1 (**Personalized Motivational Content**). They suggested ***including monthly or weekly reports***. Arabic participants recommended ***allowing users to update and track their goals***, while also proposing the ***incorporation of fun icons as rewards for meeting daily requirements***. They emphasized the importance of ***providing comforting and congratulatory messages instead of suggesting improvements***. Additionally, they highlighted the potential of

consolidating various app features into one comprehensive and enjoyable application that addresses a wide range of user needs. Below are comments that correspond to these recommendations:

Theme 1: Frequency of Results

"If there is a **Monthly or weekly report instead** of daily - 503." [Ar.P - 503] (IMPL-1) – Self-monitoring.

Theme 2: User Interaction and Feedback

"*It would be helpful* ***if the person updates and tracks their goals***." [Ar.P - 45] (IMPL-1) – Goal-setting, Customization, and Self-monitoring.

"It would be more enjoyable ***if fun icons appear when the daily requirements are met***." [Ar.P - 96] (IMPL-1) – Reward.

"*It should offer* ***congratulations and comfort*** *instead of* ***urging users to reach that goal***" [Ar.P - 262] (IMPL-1) – Praise.

Theme 3: Integration of Features

"*If all the features of various apps were* ***combined into one****, it would be* ***a useful and enjoyable app for everyone***." [Ar.P - 155] (IMPL-1).

Furthermore, Arabic participants provided several essential recommendations for enhancing the PA app in IMPL-2 (**Personalized Goal Recommendations**). They expressed ***a preference for daily results and tracking over weekly ones***, emphasizing the need for more frequent feedback. Participants also highlighted ***the importance of goal tracking and updates***, suggesting that the app should allow users to track their goals and ***provide insights into why personalized goals were adjusted.*** In terms of variety, participants recommended ***adding diverse activities beyond walking*** and the option ***to create playlists of favorite music for a more enjoyable experience***. The Arabic participants stressed the significance of motivational features, such as ***incorporating motivating sports personalities*** and ***providing relevant information on the benefits of exercise***. They also highlighted the ***importance of positive reinforcement, especially for beginners***. Lastly, participants suggested that ***the app should include both goal recommendations and motivational features***, and some recommended ***incorporating inspirational quotes for added motivation.*** Below are comments from the Arabic participants corresponding to their recommendations:

Theme 1: Frequency of Results

"***Daily results are better*** *than weekly ones.*" [Ar.P - 29] (IMPL-2) – Self-monitoring.

Theme 2: Goal Tracking and Updates

"***Allowing users to update and track their goals****, along with the app adding the required numbers weekly, would be beneficial.*" [Ar.P - 65] (IMPL-2) – Goal-setting and Self-monitoring.

"*I would want to* ***know the reasons why the personalized goal was increased****. If it can show me the numbers/algorithm behind it all, I'd be even more interested in meeting the new goal.*" [Ar.P - 510] (IMPL-2) – Verifiability.

Theme 3: Variety of Activities and Music

"***Add activities other than walking***." [Ar.P - 56] (IMPL-2).

"*It would be* ***fun to be able to add a playlist of my favorite music***." [Ar.P - 96] (IMPL-2) – Customization and Adding a Playlist of Music.

Theme 4: Motivational Features

"*I hope to* ***add voice inputs for a sports personality*** *that* ***motivates the trainee*** *to continue exercising.*" [Ar.P - 117] (IMPL-2) – Social Role, Expertise, and Add Audio Motivational Quotations.

"*There* ***should be more relevant*** *information* ***on why to continue*** *the exercises.*" [Ar.P - 207] (IMPL-2) – Verifiability.

"***For beginners****, it should provide* ***positive reinforcement and encouragement*** *instead of* ***pushing for improvement***." [Ar.P - 345] (IMPL-2) – Praise.

Theme 5: Enhancing the User Experience

"***Recommendations*** *are useful, and so is* ***motivation****. I believe the app* ***should have both features***." [Ar.P - 154] (IMPL-2).

"*Looks very simple* ***adding quotes much improve better*** *to use*." [Ar.P - 196] (IMPL-2) – Add Motivational and Inspirational Quotations.

6.4.4.1.3 Suggestion Strategy

For Arabic participants, concerning the suggestion strategy, participants offered valuable recommendations to improve the PA app in IMPL-1 (**Textual Suggestion Notifications**). They expressed ***a strong desire for reminders and motivational features*** to help them maintain an active

lifestyle and achieve their PA goals. Additionally, they suggested ***incorporating more vibrant and visually appealing messages***. Emphasizing the ***importance of specificity and user customization***, participants stressed ***the need for personalized reminders***. Furthermore, they highlighted ***the significance of educational resources***, such as ***information on warming up*** before exercising. Suggestions included ***the integration of videos, images, and regularly updated tips*** for a comprehensive user experience. Lastly, they emphasized the importance of ***maintaining a proper and balanced diet*** as an integral part of their PA journey within the app. Below are comments that related to these recommendations:

Theme 1: The Need for Reminders and Encouragement

"*We always need someone to **remind us to play or move**, to **remind us to achieve our goals**, to remind us of some small but important details... But **I wished that the message would appear in a more colorful and beautiful way**, so it would be **encouraging for the user** to read and receive the information.*" [Ar.P - 3] (IMPL-1) – Reminder and Liking.

"***It had to be more specific** and less general.*" [Ar.P - 505] (IMPL-1).

"*I would appreciate **having the option for this feature**, whether **I choose to use it or not***." [Ar.P - 503] (IMPL-1) – Customization.

Theme 2: Importance of Educational Content

"*It's possible to **add the reasons for the necessity of warming up** before exercising.*" [Ar.P - 13] (IMPL-1) – Verifiability.

"*It's nice, but **it would be better to have some educational videos or images** to demonstrate the warming-up process*." [Ar.P - 31] (IMPL-1) – Rehearsal.

"***Tips** are beneficial when **they are regularly updated** and **directly applicable to my activities***." [Ar.P - 136] (IMPL-1) – Expertise.

Theme 3: Emphasizing Proper Diet

"*It's important to **ensure a proper and suitable diet***." [Ar.P - 148] (IMPL-1) – Add Diet-related App Features.

Furthermore, Arabic participants offered several essential recommendations to enhance the PA app in IMPL-2 (**Visual Suggestion Notifications**). They suggested ***adding a button to access exercises and follow exercise programs step by step***. There was a particular emphasis on ***incorporating easy***

exercises that can be done anytime, anywhere. Additionally, they highlighted the importance of improving the design for ***a smoother transition between messages and exercises***. Lastly, Arabic participants expressed a strong interest in ***learning new exercise routines and receiving tips***, suggested that warm-up activities are ***varied, not overly repetitive, and non-intrusive***. Below are corresponding comments related to these provided recommendations:

Theme 1: Enhanced Exercise Features

"*It would be better **if there is a button that takes us to these exercises** and allows us to follow the program with us **to play them step by step through a follow button** after each exercise*." [Ar.P - 7] (IMPL-2) – Rehearsal.

"*It would be great to **add easy exercises** that can be done **anywhere and at any time***." [Ar.P - 96] (IMPL-2).

"*I also think that the design needs other options, such as **transitioning from the message to the exercise (mapping)***." [Ar.P - 152] (IMPL-2) – Reduction.

Theme 2: Rotation of Tips and Tricks

"***I enjoy receiving tips and exploring new exercise routines**. If these warm-up activities **change regularly, avoid repetition, and aren't intrusive***." [Ar.P - 342] (IMPL-2) – Expertise.

6.4.4.1.4 Goal-setting Strategy

Arabic participants, concerning the goal-setting strategy, provided valuable recommendations to enhance the PA app in IMPL-1 (**Default/System-based Goals**). They emphasized the importance of ***allowing individuals to set their own goals*** based on their physical abilities, with ***flexibility in goal limits and user choice regarding the number of steps***. Additionally, they suggested including the option to ***adjust goals according to health status or personal circumstances***, highlighting ***the need for a more flexible approach*** beyond the standard 10,000 steps. Arabic participants emphasized ***the need of having expert guidance during exercise*** and recommended ***the continued incorporation of instructions from reliable sources*** such as the World Health Organization. Lastly, they suggested implementing ***time management features to help users organize their daily activities*** and ***introducing challenges*** to enhance motivation and engagement. Below are Arabic participants' comments that correspond to their recommended features:

Theme 1: Flexibility in Goal Setting

"*It's better for the **user to determine their goal** based on **their physical ability***." [Ar.P - 2] (IMPL-1) – Customization.

"*It's better if the goal is **flexible**, meaning it has a **minimum and maximum limit***." [Ar.P - 16] (IMPL-1) – Customization.

"*The **user's choice of the number of steps would be better** because the user knows best what is suitable for them. I suggest **making it optional** for the user or **providing tips on the number of steps based on the user's circumstances**, including age, weight, and more.*" [Ar.P - 31] (IMPL-1) – Customization and Personalization.

"*It's okay to set a goal from the system, but **there should be flexibility** in terms of **reducing or increasing the goal** according to the **health status or other reasons***." [Ar.P - 38] (IMPL-1) – Customization.

"*10,000 is not always applicable. **More flexible number** of steps.*" [Ar.P - 32] (IMPL-1).

Theme 2: Inclusion of Expert Advice

"***I love having an expert** with me **when exercising***." [Ar.P - 504] (IMPL-1) – Social Role and Expertise.

"*The idea of **adding instructions from reliable sources** like the **World Health Organization** is a very **nice** idea*." [Ar.P - 117] (IMPL-1) – Authority and Third-Party Endorsements.

Theme 3: Time Management and Challenges

"*It might be good to organize my time by **counting the average of my activities and set a fixed time for daily activities** if the time differs from day to day.*" [Ar.P - 506] (IMPL-1) – Personalization and Reminder.

"*I suggest **introducing challenges**.*" [Ar.P - 87] (IMPL-1) – Competition.

Furthermore, Arabic participants provided valuable recommendations to enhance the PA app in IMPL-2 (**Customized/User-Driven Goals**). They suggested that the app could ***initially suggest goals and then allow users to customize them to their preferences***, emphasizing the importance of ***mixed features that provide both automatic and manual goal setting options***. Flexibility in goal customization was highlighted, with the suggestion of ***adding an automatic percentage increase in required steps weekly***. They emphasized the importance of ***incorporating both automatic and manual goal-setting options***, underlining the need for flexibility in goal customization. Additionally, they suggested ***adding an automatic percentage increase in required steps weekly***. Arabic participants stressed the importance of ***providing health-based recommendations tailored to individual needs***, including age, gender, and PA levels, and recommended the inclusion of a ***simple table specifying***

appropriate step counts for different profiles, with a preference for ***starting daily step count recommendations from 8,000 steps or more***. These recommendations aim to create a more personalized and adaptable PA experience for users. Below are comments from participants mapping the recommended features:

Theme 1: User-Centered Goal Setting

"*It's better **for the app to suggest**, and then **I can specify later**.*" [Ar.P - 6] (IMPL-2) – Suggestion and Customization.

"*Users may **like the freedom to adjust** the goals to their liking. **Mixed features (auto, manual)** for setting goals **give users the control** over their goal setting*." [Ar.P - 508] (IMPL-2) – Customization.

Theme 2: Goal Customization and Flexibility

"***Better** to be **flexible***." [Ar.P - 32] (IMPL-2) – Customization.

"***Adding an automatic percentage increase** in the required steps weekly would be a good idea*." [Ar.P - 45] (IMPL-2) – Suggestion.

Theme 3: Providing Health-Based Recommendations

"*A person needs to **know the appropriate number of steps for their health** and needs **based on age, gender, and their physical activities**. It's suggested to provide a simple table that **specifies how many steps a person needs** based on age, gender, and physical activities.*" [Ar.P - 21] (IMPL-2) – Personalization.

"*It's preferable to **start the daily step count** recommendation **from 8,000 steps or more**.*" [Ar.P - 40] (IMPL-2).

6.4.4.1.5 Reminder Strategy

Arabic participants, regarding the reminder strategy, provided valuable recommendations for improving the PA app system in IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**). They favored ***automatic reminders*** and suggested incorporating a feature that can ***automatically send reminders based on the user's typical engagement times for physical activity*** to enhance user convenience. They emphasized the importance of ***keeping reminders to a minimum***, with some participants preferring just one reminder and others emphasizing the need for ***notifications to avoid feeling nagging or intrusive***. Participants recommended ***making the app's design more creative with vibrant colors, fonts, and graphics*** to enhance motivation and user engagement. Additionally, they

expressed the desire for ***customizable reminder times to suit individual preferences***. These recommendations aim to make the app more effective, user-friendly, and visually appealing. Here are comments from Arabic participants illustrating the recommended features:

Theme 1: Automated and Personalized Reminders

"*I prefer automatic reminders, or it's possible to **add an automatic reminder feature** to the app **based on the time the user typically engages in physical activity**. For example, if a person is accustomed to working out at night, the app could **send an automatic reminder based on previous information** that the person exercises at that time*." [Ar.P - 34] (IMPL-1) – Personalization.

Theme 2: Minimal and Non-Intrusive Reminders

"*There should be **only one reminder***." [Ar.P - 68] (IMPL-1).

"*If there is a way for **notifications not to feel like nagging**, that would be best.*" [Ar.P - 510] (IMPL-1).

Theme 3: Creative Design and Customization

"*For reminders and motivation, I hope the **app's colors, fonts, and graphics** are **more creative** and filled with **bright colors***." [Ar.P - 151] (IMPL-1) – Liking.

"*I hope there is **time to set the reminder***." [Ar.P - 503] (IMPL-1) – Customization.

Moreover, Arabic participants offered recommendations primarily focused on reminders and scheduling features within the PA app for IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**). They suggested ***integrating the app with the phone's calendar to suggest workout times based on the user's working hours***. They appreciated the concept of a ***timetable system for planning activities***. Participants expressed a preference for ***having reminder settings readily available in the app's initial settings***, as they believed it would encourage consistent usage by eliminating the need for users to manually set reminders, ***particularly for those prone to forgetfulness***. These recommendations aim to streamline and enhance the user experience by integrating reminders and scheduling seamlessly into the app. Below are the corresponding comments from participants:

Theme 1: Integrating with Calendars and Scheduling

"*It would be great if the app suggests **times based on the working hours set in the phone's calendar***." [Ar.P - 6] (IMPL-2) – Personalization.

"*The **timetable** system is **excellent***." [Ar.P - 72] (IMPL-2).

Theme 2: Initial Reminder Setup

"*I might get lazy with setting reminders;* ***it would be better if it's in the settings at the beginning***." [Ar.P - 84] (IMPL-2) – Customization.

6.4.4.1.6 Reward Strategy

Arabic participants, concerning the reward strategy, provided recommendations to enhance the PA app in IMPL-1 (**Collecting of Virtual Reward Points**). They expressed varying opinions about the concept of accumulating points. Some found it motivating ***if the points could be exchanged for tangible benefits***, such as discounts on products and services, while others felt it would be more meaningful ***if the points were linked to practical rewards like App Store or Google Play credits***. Additionally, they highlighted the idea of ***connecting the app to external marketing stores*** to provide users with ***discounts on healthy meals or sports equipment*** to add a tangible and practical incentive for users to engage with the app. These recommendations aim to enhance user motivation and engagement by offering rewards that are meaningful and relevant to their PA journey. The following are comments from Arabic participants that correspond to these recommendations:

Theme 1: Point System and Rewards

"*Accumulating points in this case is not useful for me. The concept of earning and* ***using points should be related to businesses like telecom companies, supermarkets, and clothing stores to get discounts***." [Ar.P - 21] (IMPL-1).

"*I don't personally prefer this method* ***unless those points can be exchanged for something more tangible****, such as* ***credit*** *for the (App store or Google play), or* ***discount offers****, for instance*." [Ar.P - 501] (IMPL-1).

Theme 2: Linking to Discounts and Rewards

"*A great idea, and I believe* ***if the app could be linked to a marketing store to get discounts on healthy meals or sports equipment*** *as an official sponsor of the app*." [Ar.P - 117] (IMPL-1).

"*Points are OK, but* ***I'm wondering where they can actually be utilized?***" [Ar.P - 262] (IMPL-1).

Likewise, Arabic participants provided recommendations focused on improving user engagement and motivation through various means to enhance the PA app in IMPL-2 (**Collecting of Virtual Reward Badges**). They suggested ***integrating both points and badges systems within the app*** to create a more

comprehensive and appealing motivational framework. Additionally, participants highlighted the value of ***social sharing, global or local competitions, and comparisons with friends or peers*** as effective ways to encourage increased physical activity. They emphasized that the app should ***incorporate a social element to foster friendly competition***. Moreover, participants recommended ***converting virtual rewards into tangible incentives*** when achieving more badges and implementing ***a ranking system among all users*** to highlight individual achievements within the community. These recommendations aim to enhance user engagement, motivation, and a sense of accomplishment within the PA app. Below are the corresponding comments from participants:

Theme 1: Integration of Features

"***Both features are nice****, whether through points or badges, and* ***I think they can be integrated to make it even better***." [Ar.P - 31] (IMPL-2).

Theme 2: Social Integration and Competition

"*It would be really useful when* ***sharing with friends or on social media***." [Ar.P - 45] (IMPL-2) – Social Recognition.

"*I prefer this rewarding as badges,* ***global or local competition*** *based on location may help* ***better encourage people*** *to increase their activity.*" [Ar.P - 508] (IMPL-2) – Social Competition.

"*The rewarding system is always motivational. It would be better* ***if this is integrated*** *with some sort of* ***comparison to friends or people around my age***." [Ar.P - 509] (IMPL-2) – Social Comparison and Normative Influence.

"*If this was* ***made social, with others to compete with****, this could work for me.*" [Ar.P - 510] (IMPL-2) – Social Competition.

Theme 3: Tangible Rewards and Rankings

"*If virtual rewards were* ***converted into tangible rewards*** *when achieving more virtual badges, it would motivate people even more.*" [Ar.P - 117] (IMPL-2).

"*It would be significantly improved* ***if there were a ranking of all users****,* ***displaying your position among them****, rather than simply awarding medals*." [Ar.P – 462] (IMPL-2) – Social Recognition.

6.4.4.1.7 Praise Strategy

Arabic participants, regarding the praise strategy, emphasized the importance of ***varied and refreshing messaging*** within the PA app in IMPL-1 (**Textual Praise**). They suggested that the ***phrases used to praise and motivate users should be regularly updated and changed*** to prevent monotony and keep users engaged. This approach aims to maintain user interest and enthusiasm by ***delivering new and exciting motivational messages***, ultimately enhancing the overall user experience and encouraging consistent physical activity. Below is a sample comment from participants:

Theme 1: Varied and Refreshing Messaging

"*I suggest **refreshing the phrases and changing them** every time*." [Ar.P - 43] (IMPL-1).

Moreover, Arabic participants provided recommendations aimed at improving the PA app in IMPL-2 (**Audio and Visual Praise**). They appreciated the idea of using ***motivational audio and visual cues***, including ***motivational music and speech recognition systems like Siri***, as a way to enhance user motivation. Arabic participants emphasized ***the importance of authenticity and sincerity*** in the implementation of these features, suggesting that they should feel genuine. These recommendations aim to strike a balance between motivation, user experience, and authenticity in the use of audible and visual praise strategies within the app. Below are sample comments from participants that align with these recommendations:

Theme 1: Motivational Features

"*Another **commendable feature**, and if possible, **add a feature to play motivational music or songs***." [Ar.P - 117] (IMPL-2) – Add a Playlist of Motivational Music and Song.

"*I think this idea is excellent and motivating. **Siri and other speech production/recognition systems can be used***." [Ar.P - 152] (IMPL-2) – Add Speech Production and Recognition Features.

Theme 2: Authenticity and Sincerity

"*If there was a way for it **to be more sincere/genuine**, that would be beneficial.*" [Ar.P - 510] (IMPL-2).

6.4.4.1.8 Reduction Strategy

Arabic participants, concerning the reduction strategy, provided recommendations for improving the walking program within the PA app in IMPL-1 (**Reduction as a List of Different Predefined Options**

for Nearby Activities). They suggested ***continuously adding new walking locations*** to keep the program fresh and engaging. They recommended ***including a walking list alongside the weekly plan***, with the addition of ***nearby walking locations (combining the two implementations)***. Additionally, they suggested ***allowing users to contribute additional walking places not present in the program***, which could then be shared with others. Lastly, Arabic participants highlighted the importance of ***receiving notifications about these walking places during their exercise***, suggesting the use of ***sound notifications*** as a convenient option. These recommendations aim to enhance the walking program by adding variety, user involvement, and convenient notifications to improve the user experience. The following are comments from participants mapping these suggested features:

Theme 1: Continuous Updates and Variety

"***Good*** *if* ***new*** *places are* ***continuously added***." [Ar.P - 16] (IMPL-1) – Expertise.

Theme 2: Integration with Weekly Plans

"***Good****, and it's even better to* ***have a walking list alongside the weekly plan****, with the* ***addition of nearby walking locations*** *at the same time*." [Ar.P - 29] (IMPL-1).

Theme 3: User-Generated Content and Sharing

"*A* ***beautiful idea*** *that would be even* ***better if users could add additional walking places that may not be present in the program****, and the program distributes them to others*." [Ar.P - 30] (IMPL-1).

Theme 4: Consideration of Notifications

"***I don't think*** *I will have* ***time to check out the app*** *while exercising. However, maybe a* ***notification*** *of those places* ***by sound may be something I would consider***." [Ar.P - 504] (IMPL-1) – Tunneling.

Furthermore, Arabic participants provided recommendations for improving the walking plans feature within the PA app in IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**). They preferred ***multiple choices for walking plans over pre-set plans*** that might be inconvenient or inaccessible, suggesting the inclusion of ***daily suggestions for added variation***. They emphasized the importance of ***allowing users to select locations without system specifications*** to give them more control over their walking experience. Additionally, while finding the feature useful, ***they suggested its integration alongside the previous feature (IMPL-1)***. Finally, participants suggested ***incorporating safety and weather considerations when suggesting walking locations*** to ensure a safe and pleasant experience.

These recommendations aim to provide users with more flexibility, control, and safety in their walking plans within the app. Below are sample comments from participants related to these suggested features:

Theme 1: Flexibility in Walking Plans

"*There **should be several options**, and it might be nice if there were a daily suggestion **rather than a set plan** as a form of variation.*" [Ar.P - 30] (IMPL-2) – Suggestion.

Theme 2: User-Controlled Location Selection

"*It's better to **allow location selection without the system's specification**.*" [Ar.P - 38] (IMPL-2) – Customization.

Theme 3: Integration of Features

"*This feature is useful, but I think it **should be present alongside the previous feature**.*" [Ar.P - 154] (IMPL-2).

Theme 4: Safety and Weather Considerations

"*I like exercising freely and wandering around, maybe, but around my area. **Maybe based on the weather and the time, they might suggest some places for safety**.*" [Ar.P - 504] (IMPL-2) – Suggestion and Personalization.

6.4.4.1.9 Competition Strategy

Arabic participants, regarding the competition strategy, provided recommendations to enhance the PA app in IMPL-1 (**Competition as a Leaderboard**). They expressed ***a strong preference for competing with people they know, such as friends and family***, highlighting the importance of personal connections and suggesting ***the introduction of walking groups*** and ***communication between members***. They expressed enthusiasm for ***the idea of family competitions***. They suggested that ***participation in competition should be optional rather than mandatory*** and ***questioned whether the competition would be based on their friends' list or include random individuals***. This might suggest the need for customizable competition settings where users can choose their preferred competition participants. These recommendations emphasize the importance of offering flexible competition options to accommodate users who enjoy social competition with friends and family within the app. Below are comments from participants mapping these recommended features:

Theme 1: Preference for Competition with Friends and Family

"*If the app **introduces new friends** and allows competition with them, I agree. **Competing with people I don't know is not important to me***." [Ar.P - 36] (IMPL-1).

"*I **prefer** the panel to be specific to **friends and close ones***." [Ar.P - 45] (IMPL-1).

"Agreed if there are ***walking groups***." [Ar.P - 137] (IMPL-1) – Social Cooperation.

"***Allowing communication** between members would be **great***." [Ar.P - 138] (IMPL-1).

"*And if there is a **family competition**, it would be **AWESOME** 💞💞💞 !!!*" [Ar.P - 32] (IMPL-1).

Theme 2: Flexibility and Inclusivity in PA App Competition

"*I **prefer** this to be **an optional feature** rather than mandatory.*" [Ar.P - 468] (IMPL-1) – Customization.

"*Considering social competition is **a great idea**. I'm curious **whether it's based on my friends' list or includes strange random people***." [Ar.P - 512] (IMPL-1).

Likewise, Arabic participants presented several essential recommendations to enhance the PA app in IMPL-2 (**Displaying a Progress Bar for Each Competitor**). They expressed ***the desire for graphical representation of motivation***, suggesting that visual elements could enhance the effectiveness of motivational features. They highlighted the importance of ***enabling users to connect with friends and family using the same app***, recognizing the potential for fostering ***competition and motivation*** through social connections. Lastly, participants recommended ***keeping progress and competition results separate when viewing***, emphasizing the need for clear differentiation between these aspects to avoid confusion. These recommendations aim to improve motivation, social interaction, and clarity within the app. Here are some sample comments from Arabic participants regarding these recommendations:

Theme 1: Visual Presentation for Motivation

"*It would be **better** if it is **presented graphically** to increase users' **motivation***" [Ar.P - 38] (IMPL-2) – Liking.

Theme 2: Social Connections for Competition and Motivation

"*The **ability to connect with friends or family** using the same app can be **a big help in competition and motivation***." [Ar.P - 114] (IMPL-2).

Theme 3: Separation of Progress and Competition Results

"*The **progress and competition results** should be **separate in viewing***." [Ar.P - 508] (IMPL-2).

6.4.4.1.10 Tunnelling Strategy

Arabic participants, with regard to the tunneling strategy, provided recommendations to improve the PA app in IMPL-1 (**Tunneling as Textual/Written Instructions**). They suggested ***incorporating visual maps and informative signs along the walking paths*** to clarify routes and distances, emphasizing the ***importance of visual aids over textual*** descriptions. Participants ***preferred voice notifications for directions***, as they suggested it would provide a more user-friendly and convenient experience. They recommended ***reducing the time spent reading information*** while using the app and walking. Lastly, participants expressed ***a preference for simplified information, such as distance completed,*** rather than detailed directions. These recommendations aim to enhance the clarity, convenience, and user-friendliness of the app's navigation and information presentation during walking activities. Here are corresponding comments on these recommendations:

Theme 1: Visual Mapping and Clarification

"***It is difficult** to determine **the distance without a visual map or informative signs** on the walking path to clarify the intended route."* [Ar.P - 31] (IMPL-1).

"***Showing** an **interactive with visual aids** would work **better than text***." [Ar.P - 508] (IMPL-1).

"*I **favor** using **Google Maps or any mapping application** that displays the route visually, as opposed to relying on textual descriptions.*" [Ar.P - 492] (IMPL-1).

Theme 2: Voice Notifications for Guidance

"***Voice notification** will be **better and suitable***." [Ar.P - 504] (IMPL-1).

"*I **prefer** the **directions** to be provided in **spoken form***." [Ar.P - 146] (IMPL-1).

Theme 3: Minimizing Reading Time

"***Time** spent to **read** can **be avoided***." [Ar.P - 505] (IMPL-1).

Theme 4: Simplified Information

"*I don't require directions; I simply want to **know how far I've traveled in miles***." [Ar.P - 512] (IMPL-1).

Likewise, Arabic participants offered several recommendations to enhance the PA app in IMPL-2 (**Tunneling as Map Visualization for Walking Routes**). They favored ***allowing users to determine their own locations*** rather than relying solely on pre-set ones. They emphasized the importance of ***carefully selecting and inputting walking paths for suitability and safety***. Additionally, they expressed ***interest in discovering their local area through maps and potentially connecting with other users***. Lastly, they indicated ***a preference for having a step count report for tracking and motivation during walks***. These recommendations aim to provide users with increased autonomy, improved quality, and more exploration opportunities within the app while also offering valuable tracking information. Here are the corresponding comments on these proposed features:

Theme 1: User Autonomy in Location Determination

"*I **prefer** to **determine** my **own locations***." [Ar.P - 4] (IMPL-2) – Customization.

Theme 2: Emphasis on Quality Walking Paths

"***It will be truly useful** if walking paths are **carefully entered**, ensuring that there are **suitable routes for walking***." [Ar.P - 45] (IMPL-2).

Theme 3: Interest in Exploring the Local Area

"***I'd like to learn** about the **local area, explore maps,** and possibly **connect with other users***." [Ar.P - 233] (IMPL-2) – Social Support.

Theme 4: Step Tracking and Reporting

"*I would **prefer** having **a report that shows the number of steps I took** during this walk.*" [Ar.P - 503] (IMPL-2) – Self-monitoring.

6.4.4.1.11 Cooperation Strategy

For Arabic participants, concerning the cooperation strategy, participants provided recommendations for enhancing the PA app in IMPL-1 (**Message Exchange via Social Cooperation Networks**). They appreciated the idea of group activities but ***suggested inviting users to join a group before starting to chat*** and ***introducing daily walking goals for the group***. They also proposed ***including a summary of walking information for each group member*** and the ***option to invite the group for a walk at a specific location***. Arabic participants also recommended ***adding an option to send invitations based***

on the type of exercise, allowing for more tailored group activities. They ***preferred a notification-based approach*** for social cooperation, where users ***receive notifications to agree or disagree to join a group***. These recommendations aim to improve the user experience and engagement in group activities while accommodating individual preferences and exercise types. Below are sample comments from participants corresponding to the suggested recommendations:

Theme 1: Group Activities and Daily Walking Goals

"***Good****, but I prefer* ***inviting the person to join the group before starting chatting****, with* ***a daily walking goal for the group****. It can also* ***include a summary of walking information*** *for each person, and there can be* ***an invitation for group walking at a specific location****, if possible.*" [Ar.P - 29] (IMPL-1) – Goal-setting and Self-monitoring.

Theme 2: Customized Invitations Based on Exercise Type

"*This is helpful if you can* ***add an option of invitation based on the type of exercise****.*" [Ar.P - 504] (IMPL-1) – Customization.

Theme 3: Notification-Based Social Cooperation

"*While a social cooperation strategy is beneficial, implementing* ***a notification system for users to either accept or decline group invitations*** *would be* ***more effective***." [Ar.P - 429] (IMPL-1).

Furthermore, Arabic participants provided a recommendation emphasizing the importance of voluntary participation in IMPL-2 (**Cooperation as Teamwork**) of the PA app. They suggested that ***users should have the option to choose whether or not they want to participate*** in a particular activity or group challenge while ensuring that the app ***respects user autonomy and preferences***. This recommendation aims to create a user-centered experience that allows individuals to tailor their interaction with the app according to their comfort and interests. Below is a sample comment that corresponds to the recommended feature:

Theme 1: Voluntary Participation

"*Also* ***should be optional*** *for all if* ***they want to participate or not****.*" [Ar.P - 405] (IMPL-2) – Customization.

6.4.4.1.12 Simulation Strategy

Arabic participants, regarding the simulation strategy, provided recommendations for improving the PA app's features and design in IMPL-1 (**Simulation as Battery Charging**). They emphasized the importance of ***setting motivating walking goals to keep users engaged*** and suggested including ***customizable settings for greater user control***. Additionally, they recommended ***incorporating icons and graphics to improve the app's visual appeal***. Lastly, participants suggested ***utilizing a simulated charging battery image to make a more significant impact across various health domains***, including diet, nutrition, sleep, mental wellness, and self-compassion. These recommendations aim to enhance motivation, user experience, aesthetics, and context sensitivity within the PA app. Below are sample comments categorized into themes that correspond to the recommended features:

Theme 1: Emphasis on Motivation

"*It's **better** to have **a motivating walking goal**.*" [Ar.P - 29] (IMPL-1) – Goal-setting.

Theme 2: Customization and User-Controlled Settings

"*This **should be included in the settings** and **can be changed later**.*" [Ar.P - 36] (IMPL-1) – Customization.

Theme 3: Aesthetics and Visual Design

"***Icons and graphics** will make the app **look great**.*" [Ar.P - 155] (IMPL-1) – Liking.

Theme 4: Contextual Use of Battery Images

"*I believe that using a **simulated charging battery image** would be **more impactful** in other **health areas** like diet, nutrition, sleep and napping, mental wellness, and self-compassion*." [Ar.P – 257] (IMPL-1).

Likewise, Arabic participants offered recommendations for improving health assessment metrics and features within the PA app in IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**). They proposed the ***inclusion of additional metrics, such as body mass, body fat, and water content***, to offer users a more comprehensive view of their health. Furthermore, they suggested adding ***a feature to calculate and monitor daily water consumption*** to promote better hydration. Finally, participants expressed ***a preference for a simpler card display without images*** and recommended the ***incorporation of daily motivational quotes*** to enhance motivation within the app. These recommendations aim to offer users more comprehensive health insights, improved hydration tracking, and a visually appealing and motivating user experience. The following are corresponding comments related to the recommended features:

Theme 1: Alternative Metrics for Assessing Health

" It's **better** to give the person **other metrics**, such as **body mass, body fat, and water content**." [Ar.P - 2] (IMPL-2) – Self-monitoring.

Theme 2: Tracking Water Consumption

"***It would be great*** *to have a feature to* ***calculate and track*** *the amount of* ***water consumed during the day***." [Ar.P - 96] (IMPL-2) – Self-monitoring and Add Water Consumption Feature.

Theme 3: Display Preferences and Motivation

"I'd prefer a **simple card without images** here and **motivating quotes** every day." [Ar.P - 32] (IMPL-2) – Liking and Praise.

6.4.4.2 NON-ARABIC PARTICIPANTS' PERSPECTIVES AND RECOMMENDATIONS FOR FUTURE APP DESIGN AND DEVELOPMENT

This section offers valuable insights derived from feedback provided by non-Arabic participants. Our main objective is to attain a comprehensive and in-depth understanding of their perspectives, preferences, opinions, and recommendations concerning the design of future iterations of the app. By thoroughly exploring these user-generated insights, our aim is to provide strong guidance and expertise to inform the app's development, ultimately leading to improved user engagement, satisfaction, and overall effectiveness.

6.4.4.2.1 Self-monitoring Strategy

For non-Arabic participants, concerning the self-monitoring strategy, they provided recommendations to enhance the user experience and functionality of the PA app in IMPL-1 (**Textual and Numerical Feedback such as textual representation**). They emphasized the need to ***simplify text***, ***allow users to set their own goals***, and ***provide user-friendly layouts***. They also suggested ***minimizing the use numerical contents for step counts*** and including ***distance in kilometers*** in the summary progress table. Additionally, non-Arabic participants recommended the ***use of colors and graphs*** for better data representation. They expressed a desire for more data, such as ***tracking sedentary time*** and ***providing daily calorie burn suggestions***. They highlighted ***the importance of goal setting and tracking for***

motivation. Lastly, participants ***stressed the need for context and meaningful feedback*** to help users better understand their PA progress. These recommendations aim to enhance user-friendliness, visualization, data incorporation, motivation, and meaningful feedback in the app's design and features.

It should be emphasized that some recommendations from participants may introduce completely different persuasive strategies or new features, such as praise, personalization, and rewards. Consequently, I have linked each comment with its relevant persuasive strategy or feature. This methodology will be consistently applied in the subsequent sections to refine the design of the future PA app based on participants' feedback and perspectives. Below are comments from non-Arabic participants that correspond to their suggested recommendations:

Theme 1: Simplification and User-Friendly Design

"*Also, there is **far too much text surrounding** today's steps.*" [En.P - 2] (IMPL-1).

"*I would want to be **able to set my own goals**.*" [En.P - 32] (IMPL-1) – Goal-setting and Customization.

"*I want the layout to **be simple and user-friendly**.*" [En.P - 266] (IMPL-1) – Liking.

Theme 2: Effective Visualization and Graphical Presentation

"***Numerical contents** to represent the step count **induce cognitive load** in the user's mind. A **better visualization** method like a **line graph or chart** would be **better** to **help the user see** their progress.*" [En.P - 302] (IMPL-1) – Liking.

"*Some **color/different graphics** would make the app **more interesting/captivating**. For B, I think a **graph** would be more effective than a table.*" [En.P - 326] (IMPL-1) – Liking.

Theme 3: Incorporating Additional Data and Features

"*I would want the **summary progress** table to **have distance in km, not just steps**.*" [En.P - 310] (IMPL-1).

"***Would be nice to see sedentary time included too** so that can be decreased.*" [En.P - 314] (IMPL-1).

"*It would be better if the **app gives suggestions on how many calories should be burnt every day**, after analyzing my daily physical activities.*" [En.P - 419] (IMPL-1) – Suggestion.

Theme 4: Motivation and Goal Alignment

"***I like to monitor*** *my fitness and* ***to create goals****. If an app finds an interesting way for me to do this,* ***I'm very interested****.*" [En.P - 196] (IMPL-1) – Goal-setting.

"*I think it would motivate me to move more by* ***comparing yesterday's steps to today*** *and by showing me where I was in meeting my daily/weekly goals.*" [En.P - 337] (IMPL-1).

Theme 5: Contextual Information and Meaningful Feedback

"***Like numbers on a scale****, without tangible context, they are* ***just numbers which do not have any meaning to me*** *in terms of levels of fitness.*" [En.P - 348] (IMPL-1).

Similarly, non-Arabic participants offered recommendations to enhance various aspects of the PA app in IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**). They expressed ***a desire for a free version of the app*** to browse its features and ***appreciated graphical implementations***, ***visually appealing designs***, and ***creativity in the interface's presentation***. They also ***sought clarity on how progress bars are determined*** and ***preferred specific counts over percentages***. They suggested ***adding the functionality to connect with friends nearby*** for a more interactive experience. Finally, participants ***praised the app for helping them understand their exercise intensity*** and recommended ***expanding on the exercise intensity guidelines provided by health experts***. These recommendations aim to improve the app's accessibility, visual appeal, informativeness, social interaction, and guidance on exercise intensity. Below are comments corresponding to the recommended features:

Theme 1: Request for a Free Version

"*I'm looking forward to this app.* ***I hope there is a free version****.*" [En.P - 85] (IMPL-2).

Theme 2: Preference for Graphics and Visual Appeal

"*I* ***like*** *this* ***implementation better*** *because of the* ***additional graphics****...*" [En.P - 144] (IMPL-2) – Liking.

"*Screen A is really good at communicating to the user how they are doing.* ***I find it visually appealing and helpful****.*" [En.P - 302] (IMPL-2) – Liking.

"*If the design is* ***more creative*** *it will* ***look nice****!*" [En.P - 419] (IMPL-2) – Liking.

Theme 3: Clarity on Progress Bars and Data Representation

"*The* ***progress bars*** *suggest that there is a goal that I must hit. However,* ***what is the way to determine the maximum value of a progress bar?*** *Is it arbitrarily assigned?*" [En.P - 304] (IMPL-2).

"*I **like** to **see specific counts** instead **of percentages***." [En.P - 337] (IMPL-2).

"***Instead of just showing percentages** on screen A, it **would be more interesting** to also know **the actual number***." [En.P - 473] (IMPL-2).

Theme 4: Social and Competitive Features

"*I think it will be a **good experience** if there is a function of **adding friends to people nearby**...*" [En.P - 358] (IMPL-2) – Social Competition and Cooperation.

Theme 5: Suggestion for Enhanced Exercise Intensity Guidelines

"*The app has helped me understand my body and get me up to the level of momentum I need for the day, and **I suggest adding to the health experts' exercise intensity guidelines***." [En.P - 347] (IMPL-2) – Expertise and Social Role.

6.4.4.2.2 Personalization Strategy

Non-Arabic participants, regarding the personalization strategy, provided recommendations related to motivational messages and personalized feedback within the PA app in IMPL-1 (**Personalized Motivational Content**). They expressed concerns that ***insincere or generic motivational messages could negatively impact their motivation*** and engagement with the app. They emphasized the ***importance of avoiding patronizing or insincere messages***. They desired ***more personalized feedback and interactions*** within the app. They suggested features such as ***having personal trainers or health professionals review users' weekly logs*** and ***provide specific, relevant tips*** based on individual circumstances. Additionally, non-Arabic participants expressed ***a desire for guidance on how many additional steps they should take*** to meet their goals, highlighting the importance of ***tailored recommendations***. These recommendations aim to create a more user-centric and motivating experience by avoiding insincere messages and providing personalized feedback and guidance. Here are corresponding comments to these recommendations:

Theme 1: Negative Impact of Insincere Motivational Messages

"***Messages would affect** me if **they were negative** (i.e., if I performed **poorly**).*" [En.P - 335] (IMPL-1) – Avoid Punishment and Negative Reinforcement.

"*Features such as these feel patronizing, insincere, and unhelpful, **the graphs and tables are clear enough when goals are or are not being met**, being fed pre-scripted motivational quotes from an AI bot is enough to make me quit the program.*" [En.P - 338] (IMPL-1) – Self-monitoring.

Theme 2: Desire for Personalized Feedback

"*To truly be motivating, the weekly log would be **reviewed by a personal trainer or health professional**, and you would be **sent a quick genuinely personalized comment** which related to your specific situation with **relevant tips** you could actually use.*" [En.P - 342] (IMPL-1) – Social Role, Expertise and Personalization.

"*There should be **a feature that will tell me how many steps** I should have taken more to complete my goal*." [En.P - 473] (IMPL-1) – Self-monitoring, Suggestion, and Reminder.

Additionally, non-Arabic participants offered recommendations concerning various aspects of the PA app in IMPL-2 (**Personalized Goal Recommendations**). They expressed ***a desire for personalized reminders and goals*** to enhance motivation and engagement. They indicated a ***preference for graphical representations of data over numerical displays***. They emphasized the importance of ***setting reasonable and gradual goals*** to prevent discouragement. They advocated for ***flexibility in goal-setting and tracking activities beyond just walking or running***. Lastly, participants ***preferred data-driven feedback*** and ***desired more justification and information behind suggested goals***. These recommendations aim to enhance user engagement, goal-setting, and data presentation within the app. The following are sample comments from participants that correspond to these recommendations:

Theme 1: Desire for Reminders and Personalized Goals

"*I would want to **make reminders and personalized goals**.*" [En.P - 62] (IMPL-2) – Reminder and Goal-setting.

"*I would like my recommendations to be: **'At least I worked out today.'***" [En.P - 107] (IMPL-2) – Praise and Positive Reinforcement.

Theme 2: Preference for Visual Over Numeric Representation

"*I **like** that the **numbers are in green**, but I would still **prefer a graphic demonstration**.*" [En.P - 324] (IMPL-2) – Self-monitoring and Liking.

Theme 3: Concerns About Overly Ambitious Goals

"*I feel that this would help aid in **motivation**, however, there would **need to be a limit to ensure negative results do not emerge from increasing the goal**.*" [En.P - 325] (IMPL-2) – Add Safety Tips and Elements.

"*This is **good**, as long as the new goals are **set gradually**. If the app **suggested large increases** from week to week, it **could feel discouraging**. I think this is a good feature as long as the new goals are **reasonable and don't push people past** what they currently feel capable of.*" [En.P - 326] (IMPL-2).

Theme 4: Preference for Flexibility and Multimodal Activity Tracking

"***What if I decide to go for a swim instead?** I think this **focuses too much** on **walking or running** and not on other types of cardio*." [En.P - 327] (IMPL-2).

Theme 5: Preference for Data Over Personalized Feedback

"*I **prefer** to **see** the **stats/facts** and **analyze/monitor** myself.*" [En.P - 328] (IMPL-2) – Self-monitoring.

"*Although it states to increase my steps to 7000, **it doesn't say why I should do that**, is it necessary? Is it recommended? **Needs justification of the suggestion**.*" [En.P - 335] (IMPL-2) – Verifiability.

6.4.4.2.3 Suggestion Strategy

Non-Arabic participants, concerning the suggestion strategy, provided valuable recommendations to enhance the PA app in IMPL-1 (**Textual Suggestion Notifications**). Firstly, participants expressed their ***appreciation for personalized and inclusive suggestions***, emphasizing the ***importance of tailoring recommendations based on users' individual profiles***, including disabilities and injuries. Additionally, participants ***showed interest in receiving varied and novel tips to keep the content engaging***. They noted a ***preference for in-app display of content over pop-up notifications***, finding the latter annoying and disruptive. Finally, they suggested ***improving engagement*** by using ***more inviting language***, providing ***informative links or videos for warm-up techniques***, ***animating pop-up text***, and ***offering options for users to learn proper techniques***. These recommendations aim to enhance the app's user experience, personalization, and engagement. Below are sample comments from non-Arabic participants mapping their suggested features:

Theme 1: Appreciation for Personalized and Inclusive Suggestions

"*I like these suggestions because **remembering to limber up to prevent injury is vital**, especially for me. **You could have people put their types of disabilities, or injuries into their profile** so the app could **personalize** the suggestions.*" (99) [En.P - 99] (IMPL-1) – Personalization.

Theme 2: Interest in Varied and Novel Tips

"***It would depend on the tip***. *If they were* ***mostly new information*** *to me, I would find it* ***more interesting***." [En.P - 314] (IMPL-1).

Theme 3: Preferences for In-App Display Over Pop-Up Notifications

"*The suggestion is good* ***but pop-up notifications are very annoying***. *I would* ***prefer if this content were only shown in the app***." [En.P - 326] (IMPL-1).

"***Does this pop-up*** *come* ***before*** *I'm going for a walk? In that case,* ***how would it know that I'm going for a walk***?" [En.P - 335] (IMPL-1).

Theme 4: Suggested Improvements for Enhancing Engagement

"*I would find it* ***more motivating*** *if it was* ***'You could try...'*** *or* ***'Did you know it could be helpful to stretch...' type language***. *The 'do not' really puts me off*." [En.P - 328] (IMPL-1).

"***Providing a link in the notification to a 5 min*** *stretching warm up session* ***video that you could follow along on your phone*** *before you begin walking would be more helpful than just telling people to stretch*." [En.P - 338] (IMPL-1) – Rehearsal.

"*The pop-up text* ***should be animated*** *to stimulate people's interest.*" (357) [En.P - 357] (IMPL-1) – Rehearsal.

"*Maybe a* ***video option or link to a video*** *if I need/want to access it.*" [En.P - 535] (IMPL-1) – Rehearsal.

Moreover, non-Arabic participants provided recommendations related to the app's notifications and exercise instructions in IMPL-2 (**Visual Suggestion Notifications**). They expressed ***a desire to limit the number of pop-up tips*** to avoid annoyance and maintain a smooth user experience. Participants indicated ***a preference for video demonstrations over static images*** to motivate and guide them through exercises. Additionally, they highlighted the ***importance of incorporating randomized and varied exercise examples*** to maintain user engagement and prevent monotony. Lastly, they suggested that the ***app's effectiveness and user engagement*** in warm-up and stretching routines could be enhanced through ***interactive elements, countdowns, animations, and specific exercise recommendations***. Below are comments corresponding to these recommendations:

Theme 1: Limitations on Pop-Up Notifications

"*These types of tips would be useful* ***but the amount of pop ups need to be limited***. *If it's something where I'm exercising and* ***it notices my heart rate is too low or something, then a pop up would suffice***. *But it's popping up with tips throughout the day, then I'd delete the app*." [En.P - 11] (IMPL-2) – Self-monitoring.

"*I don't want pop-up tips,* ***I only want to think about the app when I open it****. otherwise,* ***I want it all in the background***." [En.P - 43] (IMPL-2).

Theme 2: Preference for Video Instructions

"*I don't think just a picture will motivate me to do the exercise.* ***Videos are better***." [En.P - 322] (IMPL-2) – Rehearsal.

"*If it is a* ***video*** *that* ***will be better***." [En.P - 323] (IMPL-2) – Rehearsal.

Theme 3: Randomized and Varied Exercise Examples

"*I* ***like*** *that examples are given of the type of exercises (to match the tip)* ***but it's a little messy****. Would be* ***better to show 2/3*** *and then have* ***different/randomized examples shown*** *with each time that particular tip comes up.*" [En.P - 328] (IMPL-2) – Liking.

Theme 4: Interactive Features and Countdowns

"*Giving* ***countdown*** *for these exercises will be motivating.*" [En.P - 419] (IMPL-2).

"*Instead of just fixed images,* ***there should be animation*** *simulating those exercises.*" [En.P - 473] (IMPL-2) – Rehearsal.

"*This would be* ***very helpful****.* ***Maybe a suggestion of how many of each warm-up I should be doing***." [En.P - 535] (IMPL-2).

6.4.4.2.4 Goal-setting Strategy

For non-Arabic participants, in the context of the goal-setting strategy, participants offered recommendations relating to the customization and effectiveness of goal-setting features in the app in IMPL-1 (**Default/System-based Goals**). They expressed ***a preference for personalized goals based on their current PA level, age, and health condition***. However, some participants also expressed ***skepticism and trust concerns regarding goal recommendations***, suggesting the ***need for transparent and trustworthy sources*** for these recommendations. They expected ***the app to increase goals as they become more active***, which would, in turn, boost user engagement and satisfaction. Additionally, they emphasized the ***importance of tailoring goals to individual health needs***, particularly for those with chronic illnesses. Lastly, participants ***suggested that motivation could be enhanced through rewards and smaller goals***, indicating that recognizing and rewarding achievements, even with small goals,

would boost motivation and engagement. These recommendations aim to create a user-centric, trustworthy, adaptable, and motivating goal-setting system for a wide range of users. Below are comments from non-Arabic participants that align with the suggested recommendations:

Theme 1: Customization of Goals

"*Although the system provides me with the system-generated goal, **I would prefer customized goal setting** based on my current **stamina and ability**.*" [En.P - 306] (IMPL-1) – Customization.

"***It would be nice to see recommended and personalized goals**, in case the goal suggested is too much.*" [En.P - 314] (IMPL-1) – Personalization.

"*I like this feature - 10,000 steps is always used as the benchmark **but if there is a more appropriate goal for my body type, age, etc.** I would like to know and use that instead. **But, I would only like this if you can still adjust it after getting the recommendation**.*" [En.P - 333] (IMPL-1) – Personalization and Customization.

Theme 2: Skepticism and Trust in Goal Recommendations

*"I **appreciate** that the app has **the ability to set the goal(s) for me** and communicate the goals effectively. **I would prefer not to know** that the recommendation(s) is **provided by WHO** (I don't trust this organization as much as other, more reputable institutions).*" [En.P - 120] (IMPL-1) – Trustworthiness and Authority.

"*I **don't think I will take goal advice** from the app. **Unless the app has all my medical info** and recommended **by a doctor** or something.*" [En.P - 321] (IMPL-1) – Social Role and Expertise.

Theme 3: Need for Gradual Goal Progression

"***I'm hoping** it would **increase my goals** as I become more active.*" [En.P - 337] (IMPL-1) – Personalization.

"*One thousand steps a day, **with a sense of purpose!!!!!***" [En.P - 474] (IMPL-1) – Verifiability.

Theme 4: Goal Adjustments Based on Health Conditions

"*The problem facing many people for whom physical activity is required to improve their health in light of **a diagnosis of chronic illness** is that the textbook definitions of **what they should be able to do physically are not appropriate**. **Too often, obese and health-challenged individuals** are given cookie cutter guidelines which are **too challenging** and this sets them up for frustration, physical illness, and depression.*" [En.P - 338] (IMPL-1) – Personalization.

Theme 5: Motivation Through Rewards and Smaller Goals

"*I think there are **some rewards** for **achieving goals!***" [En.P - 345] (IMPL-1) – Reward.

"*People are **more motivated** by a **small goal** each day*." [En.P - 357] (IMPL-1).

Moreover, non-Arabic participants offered recommendations concerning goal setting and tracking within the PA app in IMPL-2 (**Customized/User-Driven Goals**). They emphasized the importance of ***setting personalized step goals that align with their individual needs and preferences***. They favored a ***balance between system-generated recommendations and the ability to adjust goals based on their unique circumstances***. They sought ***guidance and information to make informed decisions about their goals***. They also suggested to enhance the user experience, including through ***automated step tracking and reminders for activities like drinking water***. They emphasized the importance of ***flexibility in goal setting*** and accommodating ***various forms of physical activity***. Lastly, participants recommended ***to ensure that other users can adapt their goals over time to suit their evolving PA levels and preferences***. These recommendations collectively aim to provide users with a more tailored and informed goal-setting experience within the app. Here are the corresponding comments to these recommendations:

Theme 1: Customized Goal Setting

"*The ability to set my step goal is good, **but it should have more information about goals** that would be helpful for me to set.*" [En.P - 24] (IMPL-2) – Customization and Verifiability.

"*I like setting my own goals but would still be nice **if it would put the burnt calorie count** and **maybe miles that amount of steps** would be under or next to the step amount.*" [En.P - 130] (IMPL-2) – Customization and Self-monitoring.

"*Being able to set a personal step goal is better, **however, could the app encourage more steps** if the **individual exceeds their goal on a regular basis**.*" [En.P - 311] (IMPL-2) – Customization and Personalization.

Theme 2: Combining Personalized Suggestions with Customization

"*I think a **combination of suggested and personalized goals** would be best.*" [En.P - 314] (IMPL-2) – Customization and Personalization.

"***Both features are helpful** as sometimes **I may need to do less or more** than what the system suggests.*" [En.P - 320] (IMPL-2) – Customization and Personalization.

"***This feature is exactly what I imagine being used in conjunction with the previous feature*** *so that you can get a recommendation but then adjust it* ***if you feel it's too low or high realistically*** *for your lifestyle.*" [En.P - 333] (IMPL-2) – Customization and Personalization.

Theme 3: Access to Ideal Goals and Guideline Information

"*I like the option to set your own goal. I do think* ***there should be some guidelines/info available*** *so that users can make an informed decision on what their goal should be*." [En.P - 326] (IMPL-2) – Customization and Verifiability.

"*Although it's good to set my own goals,* ***it'd still be useful to see what should be my ideal goal*** *so that I can work towards that*." [En.P - 335] (IMPL-2) – Personalization.

Theme 4: Automation and Reminders

"*Personally, I think this arrangement* ***would be better if*** *there were an* ***online system*** *that* ***automatically recognized the number of steps taken***." [En.P - 358] (IMPL-2) – Self-monitoring.

"*A* ***reminder*** *to* ***drink water*** *can also be* ***a great feature*** *in this app*." [En.P - 419] (IMPL-2) – Reminder and Add Water Consumption Feature.

Theme 5: Personalized Fitness Goals and Competitive Engagement

"*It's really useful to have* ***Science-suggested goals*** *shown when choosing (****based on me as a person*** *- gender, activity, age etc)* ***but I'd still want to be able to set my own****. Goals being attainable but aspirational are crucial for repeated return and actually keeping to goals* ***but that differs for everyone's circumstances***." (328) [En.P - 328] (IMPL-2) – Personalization and Customization.

"*You can have a daily* ***sports competition*** *on the App*." [En.P - 345] (IMPL-2) – Social Competition.

Theme 6: Gradual Goal Adjustments

"*Being able to set my own goal is much better than being assigned a goal.* ***I wonder if it is possible to let other people to set my goals*** *and, in a unit, other than steps*." [En.P - 327] (IMPL-2) – Social Support.

7.4.4.2.5 Reminder Strategy

For non-Arabic participants, concerning the reminder strategy, participants offered recommendations regarding reminders and notifications to improve the PA app in IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**). Participants emphasized the importance of ***allowing users to***

configure reminders to suit their preferences. They suggested that ***notifications should be contextually relevant and timed appropriately***. Additionally, they expressed ***a preference for positive affirmations and motivational content in notifications***. Finally, participants ***cautioned against excessive or overly frequent reminders*** to prevent annoyance. These recommendations aim to make reminders more user-friendly, motivating, and less intrusive. Below are comments from participants corresponding to the recommended features:

Theme 1: Customization and Configurability

"*Nice feature, **as long as it can be configured**.*" [En.P - 303] (IMPL-1) – Customization.

"*It is **recommended** to **replace the pop-up** default auto-reminder **with a customizable one**.*" [En.P - 357] (IMPL-1) –Customization.

Theme 2: Timing and Context of Notifications

"***Random notifications might be annoying**, it might be **better if they appeared** randomly **in some set time ranges** where **I'm less** likely to be **busy**.*" [En.P - 312] (IMPL-1) – Personalization.

"*If the app can **detect me sitting down** and walking regularly and **give me appropriate notification**, then I might use the app.*" [En.P - 321] (IMPL-1) – Personalization.

"*If they are **contextualized** i.e., **sent in proper contexts such as during my regular schedule for walking** etc. then they can be useful.*" [En.P - 342] (IMPL-1) – Personalization.

Theme 3: Positivity and Motivation

"*Reminders are great, **but new ways of reminding people would be good**. People begin to easily ignore them, so perhaps **a funny note, inspirational quote** to keep interest?*" [En.P - 317] (IMPL-1) – Add Humorous and Inspirational/Motivational Messages and Quotations.

"***Positive affirmations** create change and **help to motivate** individuals.*" [En.P - 331] (IMPL-1) – Praise and Positive Reinforcement.

"***Guilt-trip notifications** would **not be the way to motivate** me to do anything, quite the contrary, I would delete the app from my phone*." [En.P - 338] (IMPL-1) – Avoid Punishment and Negative Reinforcement.

"*I feel **explaining the consequences of my choice** would be effective.*" [En.P - 535] (IMPL-1) – Verifiability and Expertise.

Theme 4: Frequency and Avoidance of Annoyance

"*Although it's good at first,* ***such notifications become annoying*** *with time and get ignored.*" [En.P - 335] (IMPL-1).

"*Reminders are helpful* ***but I just hope they're not too frequent****.*" [En.P - 336] (IMPL-1).

Likewise, non-Arabic participants provided recommendations regarding reminders to improve the app in IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**). Participants suggested that ***reminders should be based on activity tracking*** and ***adapt to users' behavior***. They desired the ***ability to set reminders according to their specific schedules and preferences***. Participants ***preferred gentle suggestions over rigid time-based reminders***. Lastly, they recommended ***incorporating motivational content with reminders*** to keep users engaged and motivated. These recommendations aim to make reminders more personalized, adaptable, and motivating for app users. Below are the corresponding comments from participants, categorized into themes:

Theme 1: Contextual and Automated Reminders

"*I guess I wish they weren't default reminders* ***but instead based on them tracking how much you've moved*** *in the past 1-2 hours or something.*" [En.P - 75] (IMPL-2) – Self-monitoring and Personalization.

"*This could be more of a hassle for some people since schedules can change daily and they would just have to keep resetting the notifications depending on the day and what they are doing. I****t would be better to have them automated and sense when you have been sitting for too long at once****.*" [En.P - 334] (IMPL-2) – Personalization.

Theme 2: Customized and Flexible Reminder Scheduling

"***Great*** *feature, can be even* ***better if had both hourly reminders plus customized times*** *to work with my schedule, i.e., reminder does not occur when in a meeting or different hourly reminders, i.e., 09:10, 10:05, 16:35, etc.*" [En.P - 311] (IMPL-2) – Customization and Personalization.

"***Scheduled time*** *can be* ***determined*** *according to* ***the needs of users****.*" [En.P - 462] (IMPL-2) – Customization and Personalization.

Theme 3: Suggestion-Based Reminders

"*Instead of saying that I must do an activity at a specific time,* ***it should provide a suggestion instead****. For example, it could say that I should be walking at some point today instead of at a specific time.*" [En.P - 327] (IMPL-2) – Suggestion.

Theme 4: Motivational Content with Reminders

"***Some motivational quotes*** *along with reminders will look great.*" [En.P - 419] (IMPL-2) – Add Inspirational/Motivational Messages and Quotations.

6.4.4.2.6 Reward Strategy

For non-Arabic participants, regarding the reward strategy, participants expressed various recommendations regarding the use of points rewards to improve the PA app in IMPL-1 (**Collecting of Virtual Reward Points**). Participants expressed ***skepticism and concerns about the arbitrary nature of points***, with some questioning their value and motivation potential. They emphasized the ***importance of points serving as incentives and rewards***, expressing interest about whether ***points could be redeemed for desirable items or benefits***. Furthermore, participants ***pointed out the significance of a social and competitive element***, suggesting that fostering a sense of community and competition among friends could enhance motivation. Lastly, participants ***emphasized the need for reward customization***, favoring the ***ability to redeem points*** for either ***in-app content or real-world rewards***. Below are comments corresponding to the suggested recommendations:

Theme 1: Skepticism and Arbitrary Nature of Points

"***I'm not a huge fan of points systems like this****, but they can be handy in some contexts.* ***It just seems like an arbitrary thing to me****, to say that X steps are worth Y points.*" [En.P - 19] (IMPL-1).

"*If they are* ***just numbers or some sort of ranking, I would not be interested****.*" [En.P - 114] (IMPL-1).

"***Unless*** *there was* ***a really strong social element*** *to the app that made collecting points motivational* ***and many of my friends*** *were using the app,* ***arbitrary points wouldn't really motivate*** *me to be more active.*" [En.P - 333] (IMPL-1) – Social Competition.

Theme 2: Points as Incentives and Rewards

"*As long as I can* ***redeem the points for something that I want****, I would love to use this.*" [En.P - 30] (IMPL-1).

"*I would need to know ahead of time* ***what the rewards would be*** *and if they* ***would be worth my while to use****.*" [En.P - 31] (IMPL-1).

"*It is a good idea* ***to use incentives*** *to reach a goal.*" [En.P - 37] (IMPL-1).

"*Perhaps **suggesting possible rewards that people** could use when reaching certain point levels **would be a nice addition***." [En.P - 317] (IMPL-1).

"*If I can **redeem these points for customizable content or real-world rewards**, that would be **the ultimate motivator***." [En.P - 328] (IMPL-1).

Theme 3: Social and Competitive Element

"***If** the app was **really popular and a lot of friends used it** and there was a **leaderboard**, it might be slightly motivating, for my **competitive side***." [En.P - 75] (IMPL-1) – Social Competition.

"***Unless there was a really strong social element to the app** that made collecting points **motivational and many of my friends** were using the app, arbitrary points wouldn't really motivate me to be more active*." [En.P - 333] (IMPL-1) – Social Competition.

"*I bet it would be a great idea if those **virtual points could be used to sign up for competitions** in app events!*" [En.P - 345] (IMPL-1) – Social Competition.

Theme 4: Reward Customization

"*If I can **redeem these points for customizable content** (e.g., **new backgrounds in-app, new messages to select**) or **real-world rewards**, that would be the ultimate motivator.*" [En.P - 328] (IMPL-1) – Customization.

Furthermore, non-Arabic participants offered several recommendations concerning the implementation of badges to enhance the PA app in IMPL-2 (**Collecting Virtual Reward Badges**). Firstly, they highlighted the ***potential value of badges as a form of recognition***, suggesting that ***they could be meaningful when displayed within a community of users*** and ***earned more frequently***, such as on a daily or weekly basis. Some participants ***questioned the utility of badges and proposed that more tangible rewards***, like gift cards, might be more motivating. Additionally, participants discussed the ***importance of the frequency and availability of badges***, emphasizing ***the satisfaction of receiving daily rewards*** and the need for ***transparency regarding available badges***. Lastly, participants ***highlighted the competitive aspect of badges***, suggesting that ***incorporating competition within the app*** could enhance their effectiveness as motivators. Overall, participants recommended making badges more frequent, valuable, and competitive while also considering tangible rewards to maximize their motivational impact. Below are sample comments mapping these recommendations:

Theme 1: Badges as a Form of Recognition

"*This will be helpful. Additionally,* ***badges can be displayed in a community of users***." [En.P - 302] (IMPL-2) – Social Recognition and Social Comparison.

"***The badges are a good idea****, but to motivate people they would* ***have to be daily or weekly*** *so people could earn them more than once.*" [En.P - 334] (IMPL-2).

"*Although it's better than just getting points,* ***if such badges can be displayed in the profile****, that would be useful.*" [En.P - 335] (IMPL-2) – Social Recognition and Social Learning.

Theme 2: Value and Utility of Badges

"*The awards badges have less value for me;* ***perhaps something more tangible like a gift card would be better***." [En.P - 316] (IMPL-2).

"*I won't be interested in earning badges as these will be of no use in the end.* ***You can provide coupons which can be used for online shopping*** *as this feature can* ***really motivate people***." [En.P - 473] (IMPL-2).

Theme 3: Frequency and Availability of Badges

"***I like the badges idea****. And* ***using those to access avatars*** *would be fun.*" [En.P - 320] (IMPL-2).

"*Depends on how far apart the badges come.* ***A daily reward would be more satisfying***." [En.P - 534] (IMPL-2).

"***Is there a limit on the badges?*** *Will I be able to see the badges that I can collect?*" [En.P - 535] (IMPL-2).

Theme 4: Competitive Aspect of Badges

"***This would work well if you were competing with someone****, so add that option to the app.*" [En.P - 99] (IMPL-2) – Social Competition.

6.4.4.2.7 Praise Strategy

For non-Arabic participants, regarding the praise strategy, participants offered recommendations to enhance the PA app in IMPL-1 (**Textual Praise**). Firstly, some participants suggested ***that incorporating visual elements like "pretty pictures" or celebrity endorsements*** might be more effective. Additionally, ***there was a consensus that feedback should be more interactive*** to enhance its usefulness. Secondly, participants highlighted ***the importance of incorporating emojis, quotes, and praise*** as motivational tools while emphasizing ***the need for moderation in delivering*** such positive

reinforcement. Overall, the participants' recommendations emphasized the importance of tailoring feedback to individual preferences and incorporating interactive and motivational elements to enhance its impact. Below are sample comments that align with these recommendations:

Theme 1: Personalized and Interactive Feedback

"*Maybe some **pretty pictures or celebrity speech** would work for some people*." [En.P - 114] (IMPL-1) – Liking and Positive Reinforcement.

"*It **should** be **more interactive***." [En.P - 473] (IMPL-1).

Theme 2: Positive Reinforcement and Motivation

"***Emojis, quotes** will be an added bonus*." [En.P - 302] (IMPL-1) – Liking and Add Motivational and Inspirational Quotations.

"*I think it is **nice** to get some praise, **in moderation***." [En.P - 314] (IMPL-1).

Furthermore, non-Arabic participants offered several recommendations to improve the PA app in IMPL-2 (**Audio and Visual Praise**). Firstly, participants expressed ***a desire for the ability to personalize the sounds and images*** associated with motivational feedback, ***underscoring the importance of user control in this context***. Secondly, participants stressed ***the significance of making the motivational feedback novel and exciting***, emphasizing that it ***should feel like a rewarding celebration*** to maximize its effectiveness. Thirdly, the consideration of ***user preferences and the potential resonance with social media features*** were discussed, with some participants suggesting that this implementation might not be universally appealing and ***should be optional***. Finally, participants offered ***feedback on the design*** of the implementation, ***suggesting improvements to make it more engaging and enjoyable***. These recommendations collectively highlight the need for a customizable, exciting, and user-centric approach to motivational feedback design. Below are comments from participants that match the recommended features:

Theme 1: Customization and Control

"***As long as I have some control over the volume and length of the sounds**, I'd be okay with it.*" [En.P - 49] (IMPL-2) – Customization.

"*What would make this better **would be the ability to customize the sound played**. Maybe **the image, too***." [En.P - 144] (IMPL-2) – Customization.

"***Gifs, memes can be customized*** *with the* ***user's name and sent***." [En.P - 302] (IMPL-2) – Personalization.

Theme 2: Novelty and Excitement

"*I do like this, like I mentioned in the previous response. But* ***I would hope they'd make it as novel and exciting*** *as possible, so* ***it actually feels like a reward or celebration***." [En.P - 75] (IMPL-2) – Reward and Gamification.

Theme 3: User Preferences and Social Media Resonance

"***I'm just not sold on the actual hearing motivation****, maybe if I was vision impaired,* ***perhaps just make this an option***." [En.P - 99] (IMPL-2) – Customization.

"*This feature* ***reminds me of social media websites like Facebook****. Although this might be beneficial, I personally just want my app to be like Facebook*." [En.P - 327] (IMPL-2) – Add Social Media Support Elements.

Theme 4: Design Considerations

"*Reminds me of Duolingo audio and visual praises.* ***They do make progress/praise for progress a bit more fun***." [En.P - 333] (IMPL-2) – Liking and Gamification.

"*The design* ***can be better***." [En.P - 419] (IMPL-2) – Liking.

6.4.4.2.8 Reduction Strategy

For non-Arabic participants, concerning the reduction strategy, participants provided insightful recommendations to enhance the PA app in IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**). Firstly, there was a strong emphasis on personalization and control, with participants expressing ***a preference for user-initiated interactions rather than unsolicited notifications***. They desired ***more dynamic and customizable options***, such as the ***ability to select different activity choices or locations beyond system-generated ones***. Secondly, participants highlighted the importance of ***evaluation and performance tracking***, endorsing the idea of ***storing activity history for self-assessment*** and suggesting ***the need for better route planning features***. Lastly, participants ***welcomed the concept of exploration and attraction***, particularly when ***linked to badges and daily goals***, though some expressed ***curiosity about how this concept would function in rural areas***. Overall, these recommendations highlight the significance of user-centric personalization, robust performance tracking, and the integration of exploration elements to enhance the proposed

implementation's appeal and effectiveness. Below are comments from participants that align with the recommended features:

Theme 1: Personalization and Control

"*Now, this I like! However,* ***I don't want it popping up at me unasked for***." [En.P - 43] (IMPL-1) – Customization.

"*Although, system-generated locations* ***based on my current location sounds interesting*** *for me,* ***I would like to try or play with other options dynamically****, apart from the only ones listed based on my recommendation.*" [En.P - 306] (IMPL-1) – Personalization and Customization.

"*I live in a rural area with already known walking trails.* ***Other attractions would be more useful for me****. Or the* ***option to select my activity choice***." [En.P - 535] (IMPL-1) – Suggestion and Customization.

Theme 2: Evaluation and Performance Tracking

"***Storing an activity history is a good*** *thing to* ***evaluate my overall performance*** *areas of my presence, etc.*" [En.P - 259] (IMPL-1) – Self-monitoring.

"*It is* ***necessary*** *to* ***plan your own sports route*** *better.*" [En.P - 367] (IMPL-1) – Suggestion and Customization.

Theme 3: Exploration and Attraction

"*I love this idea. Specially* ***linked to badges that you get when you've done a particular local route?*** *Linking exploration and 'hidden' exercise* ***with daily goals*** *is perfection for me.*" [En.P - 328] (IMPL-1) – Rewards, Gamification, and Goal-setting.

"*It would be* ***curious*** *to see* ***how this would work in rural*** *Nova Scotia.*" [En.P - 311] (IMPL-1).

Moreover, non-Arabic participants offered recommendations focused on the concept of user-friendliness and simplicity in IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**). They highlighted the importance of ***ensuring that notifications are not intrusive and should not appear unsolicited***. Several participants suggested ***simplifying the implementation by reducing the number of options or streamlining its functionality*** to make it more straightforward and user-friendly. Additionally, ***there was support for combining the proposed implementation (IMPL-2) with a previous one (IMPL-1)*** to create a more cohesive and user-centric experience. Collectively, these recommendations emphasize the need for a streamlined, non-intrusive, and user-friendly approach in

designing the notification system. Below are comments that correspond to these recommendations:

Theme 1: User-Friendly Notifications and Simplicity

"*I like this **as long as it's not popping up unsolicited**.*" [En.P - 43] (IMPL-2) – Customization.

"*This just seems a little more convoluted to me and too much **- simplify it and take out some of the options**.*" [En.P - 68] (IMPL-2) – Liking.

"*This is also **good** to have, **I think a combination of this and the last one** is the way to go.*" [En.P - 335] (IMPL-2).

6.4.4.2.9 Competition Strategy

For non-Arabic participants, concerning the competition strategy, participants provided diverse recommendations to improve the PA app in IMPL-1 (**Competition as a Leaderboard**). Some participants ***favored receiving tangible rewards rather than virtual ones***. Others recommended ***a focus on comparing their progress to aggregate statistics***. On the other hand, some participants believed that ***competing with friends and family could be a valuable way*** to boost app engagement. Overall, these recommendations reflect the diversity of user preferences and the need for a balanced approach that allows for competition but also ***encourages users to prioritize their individual well-being and listen to their bodies***. Below are sample comments from non-Arabic participants mapping their suggested features:

Theme 1: Enhancing User Motivation and Engagement

"***The rewards are an interesting aspect**, but if they're just virtual rewards, that's not as compelling as **something more tangible**.*" [En.P - 19] (IMPL-1) – Reward.

"*Unless the app **teams up with different businesses** to give away **free things** like **free Starbucks, etc. to the winner**.*" [En.P - 130] (IMPL-1) – Reward.

"*I would like to **compare myself against aggregate statistics**.*" [En.P - 304] (IMPL-1) – Self-monitoring.

"***Good**, but with a **reminder** to folks that **use it as motivation but to listen to their bodies**, do what works for them and **not to get too caught up** in comparing themselves to others*." [En.P - 317] (IMPL-1) – Reminder and Suggestion.

"***Competing with friends and family** might encourage the use of the app more.*" [En.P - 321] (IMPL-1).

Furthermore, non-Arabic participants offered recommendations centered around visualizing competition and involving friends to enhance the PA app in IMPL-2 (**Displaying a Progress Bar for Each Competitor**). They ***appreciated the concept of visualizing competition among known individuals and friends***, suggesting that this feature ***could be valuable if integrated with their social media connections***. Additionally, participants highlighted the ***importance of including badges in the visualization to make it more visually appealing***. Some participants suggested that ***to mitigate direct comparisons*** between users, it might be beneficial ***not to display the exact number of step goals***. Overall, the recommendations emphasize the potential benefits of incorporating social elements and visual enhancements to engage users and encourage friendly competition within the app while also considering privacy and sensitivity to user preferences. Below are comments from participants that correspond to these suggested recommendations:

Theme 1: Visualizing Competition and Involving Friends

"*This assumes I know who the other people are. If so, this is **a good visualization of the competition** between us and has value*." [En.P - 49] (IMPL-2) – Liking.

"*It looks nice. **If it includes my social media friends** this will be **awesome***." [En.P - 119] (IMPL-2) – Social Support.

"***If badges are also shown**, then it will be **more visually appealing***." [En.P - 302] (IMPL-2) – Reward and Liking.

"*Maybe to **avoid comparison** between people, the **exact number of your step goal could not be shown***." [En.P - 333] (IMPL-2).

"*You can also **add friends**, right?*" [En.P - 358] (IMPL-2) – Customization.

6.4.4.2.10 Tunnelling Strategy

For non-Arabic participants, concerning the tunneling strategy, participants provided diverse recommendations regarding the feature of written directions for walking routes to enhance the PA app in IMPL-1 (**Tunneling as Textual/Written Instructions**). Some participants ***preferred Google Maps directions*** but recommended that ***directions should not appear unsolicited***. Others believed that ***audible directions through headphones would be more intuitive***, particularly for users on the move,

eliminating the need for constant text checking. Participants ***emphasized the significance of optional, detailed step-by-step navigation, especially for users with varying needs***, such as those with visual impairments. Usability and contextual relevance were highlighted, with participants suggesting that ***the feature should be toggleable***, as it could be ***beneficial in unfamiliar areas but potentially irritating in familiar ones***. Lastly, participants recommended ***enhancing the app's user interface and design*** to create a more ***dynamic and vibrant experience*** while still recognizing its overall excellent functionality. Below are the corresponding comments from participants:

Theme 1: Navigation Preferences

"***I prefer the Google Maps directions*** *from a few questions ago, but this is ok,* ***as long as it's not popping up unsolicited***." [En.P - 43] (IMPL-1) – Liking and Customization.

"*I don't really like this at all. If something's going to give me directions,* ***I'd rather it gives them audibly into my headphones or something****. Written directions seem counter-intuitive if the app wants you to be moving.* ***I wouldn't want to have to keep checking them*** *to make sure I didn't get lost.*" [En.P - 144] (IMPL-1) – Customization and Add Audio Instructions and Guidance.

Theme 2: Accessibility and User Diversity

"***Such a detailed step by step navigation*** *should be* ***shown optionally****, i.e., only if the user opts for it.*" [En.P - 302] (IMPL-1) – Customization.

"*This is irrelevant to me, but could be very useful for other people, especially* ***if it's optimized for people with hard of sight***." [En.P - 303] (IMPL-1).

"*The feature is similar to GPS, and* ***I am assuming it is being used on a mobile device*** *and not a smartwatch as the smartwatch screen would be way too small for my aging eyes. However, I do think it would be very useful when visiting a new route,* ***not sure how it would work in rural*** *Nova Scotia.*" [En.P - 311] (IMPL-1).

Theme 3: Usability and Contextual Relevance

"*Annoying if I am familiar with the area but* ***helpful if the area is new****.* ***Would it be an on/off feature?***" [En.P - 320] (IMPL-1) – Customization.

"***There's just too much reading to do while I'm walking*** *down the street. Would rather* ***prefer a more visually guided option*** *where I don't have to continuously keep looking at my phone.*" [En.P - 336] (IMPL-1) – Liking.

"*Text would not be helpful if I was actively walking and trying to follow along* ***- a GPS voiceover with the directions would be more helpful.***" [En.P - 338] (IMPL-1).

Theme 4: User Interface and Design:

"*Everything is perfect so far, but* ***the design of this app can be more dynamic and vibrant***." [En.P - 419] (IMPL-1) – Liking.

Likewise, non-Arabic participants provided recommendations related to visual maps for walking routes within the app in IMPL-2 (**Tunneling as Map Visualization for Walking Routes**). They generally ***appreciated the inclusion of visual maps***, especially ***when linked with the option to choose a walking route***, as it allowed them to visualize the distance and surroundings. Some participants ***preferred the visual maps over textual directions***, but others emphasized the ***importance of having both options available (combining IMPL-1 and IMPL-2)*** for flexibility. Participants also noted the potential ***benefit of visual maps for individuals with reading limitations*** and raised the idea of ***a sound version for the hearing impaired***. While many found ***visual maps useful*** for reviewing routes at home, some ***cautioned against using them while walking to maintain safety***. Overall, the recommendations suggest a preference for customizable, visually informative maps that address various user needs, along with considerations for accessibility and safety features. Here are comments from non-Arabic participants corresponding to the recommended features:

Theme 1: User Preferences for Visual Maps in Walking Apps

"***I like this a lot with the map****, as long as it only comes up when I go looking for it. SUPER underpaid HIT*." [En.P - 43] (IMPL-2) – Customization.

Theme 2: Comparison with Maps in Other Fitness Apps

"*I* ***like*** *the* ***maps*** *on Runkeeper.*" [En.P - 71] (IMPL-2).

Theme 3: Accessibility Considerations for Visual Maps

"*Assuming the app is on a mobile device and not a smartwatch, the visualization would benefit individuals with reading limitations.* ***Have you considered a sound version for the hearing impaired?***" [En.P - 311] (IMPL-2) – Add Audio Instructions and Guidance.

Theme 4: Safety and the Responsible Use of Visual Maps

"***Good*** *to have to review when home* ***but encourage people to not use while walking***." [En.P - 317] (IMPL-2) – Suggestion.

Theme 5: Flexibility in Mapping Options

"***I like the visual map****, but also* ***having the option for the text is important***." [En.P - 318] (IMPL-2).

"***Seeing it visually is more useful*** *when linked with the* ***'choose a walking route' option*** *as mentioned before. Like 'oh that's not that far' or 'oh, that's what's there!' type thing.*" [En.P - 328] (IMPL-2) – Customization and Personalization.

Theme 6: Visual vs. Audio Guidance for Active Users

"*This is* ***quite better*** *than the last one* ***as it's visual****, and that was just textual,* ***but I would still prefer audio-guided directions*** *so that I can focus on walking/running and won't have to keep on looking at my phone.*" [En.P - 3236] (IMPL-2) – Add Audio Instructions and Guidance.

Theme 7: Text and Image Switching for Navigation Flexibility

"***I want it to be text and image switching*** *so I can use* ***text on familiar roads*** *and* ***pictures in unfamiliar places***." [En.P - 345] (IMPL-2) – Customization.

6.4.4.2.11 Cooperation Strategy

For non-Arabic participants, concerning the cooperation strategy, participants provided recommendations related to social interaction and communication features within the PA app in IMPL-1 (**Message Exchange via Social Cooperation Networks**). Some participants had ***reservations about using the app for social interaction during PAs***, and they ***preferred other communication methods like texting***. On the other hand, some participants were ***more open to the idea***, especially ***if the app's social functions resembled those of familiar platforms like WhatsApp***. Some participants ***mentioned existing social features in apps like Strava but indicated that they had not used them extensively***. There was also a suggestion to ***establish various communities within the app to address different age groups and interests***, ***allowing users to connect with like-minded individuals*** who share similar hobbies or PA goals. In summary, the recommendations emphasize the need for user-friendly and diverse social interaction options within the app to accommodate various preferences for social

engagement during PAs. Below are the corresponding comments from non-Arabic participants, sorted into themes:

Theme 1: Social Interaction and Communication

"*I don't really like doing fitness activities with others, so this isn't something I would be compelled to use.* ***I have other means of communicating with friends that I would probably prefer to use, like just texting them***." [En.P - 19] (IMPL-1).

"*I feel like if I needed people to walk with,* ***I would find my own friends***." [En.P - 266] (IMPL-1).

"***Strava has some social functions too*** *(i.e., can display that you did an activity with someone else)* ***but I've never used them*** *or seen anyone else use them.*" [En.P - 333] (IMPL-1).

"***If this works as WhatsApp****, it will be* ***easy and desirable***." [En.P - 320] (IMPL-1) – Liking and Surface Credibility.

"***If can establish different communities will be better*** *because* ***the age*** *is not the same as the topic of communication have* ***different hobbies****,* ***hope to have a wide variety of community****, for the activists to join,* ***hope to different ways of movement can recommend different community****, this match to* ***friends*** *will and they have* ***more similarities****, happy can also meet in private.*" [En.P - 358] (IMPL-1) – Normative Influence, Personalization, Customization, and Add Social Support and Interaction Elements.

Furthermore, non-Arabic participants provided recommendations to improve the PA app in IMPL-2 (**Cooperation as Teamwork**). Firstly, there was uncertainty and curiosity about the purpose and utility of the points system within the app, with ***participants expressing the need for clarity on what these points represent and their potential benefits***. Secondly, participants expressed ***a desire for fun and flexible challenges within the app***, emphasizing the importance of cooperative elements and ***the ability to accommodate varying walk times***. Finally, some participants suggested enhancing the points system by ***allowing users to exchange virtual points for real-life rewards, such as sports equipment***, which they believed would be a more appealing and motivating incentive. These recommendations collectively emphasize the importance of transparent communication regarding the points system, creating engaging and flexible challenges, and exploring opportunities for tangible rewards to maximize user engagement and motivation. Below are comments from participants that match the recommended features:

Theme 1: Uncertainty About the Purpose and Utility of Points

"***It really depends on what these points are for****, they're the one thing about the app that hasn't made sense to me so far.* ***Points might be an effective incentive depending on what they do****, but I would probably find them intrusive regardless.*" [En.P - 312] (IMPL-2) – Reward.

Theme 2: Desire for Fun and Flexibility in Challenges

"*I think* ***a challenge would be fun and cooperative*** *while allowing* ***flexibility in walk times****.*" [En.P - 314] (IMPL-2) – Customization.

Theme 3: Suggestions for Real-Life Rewards and an Improved Point System

"*Would be more useful if you* ***could do something with the points to get a real-life reward*** *of some sort.* ***Better and safer idea than the first****.*" [En.P - 334] (IMPL-2) – Reward and Add Privacy and Safety Features.

"***I hope that when the virtual points*** *reach a certain amount, they* ***can be exchanged for some simple sports equipment****, which is undoubtedly the best.*" [En.P - 358] (IMPL-2) – Reward.

6.4.4.2.12 Simulation Strategy

For non-Arabic participants, concerning the simulation strategy, participants provided recommendations to enhance the PA app in IMPL-1 (**Simulation as Battery Charging**). Firstly, some participants expressed ***skepticism about the effectiveness of comparing one's energy or progress with a battery icon***, suggesting that this ***comparison might not provide meaningful self-measurement***. They indicated ***a preference for more intuitive visual representations such as pie charts or progress bars*** for tracking progress effectively. Secondly, some participants raised ***concerns about the similarity between the app's icons and their phone's battery icon***, highlighting ***the need for distinct and easily distinguishable visual elements*** within the app to avoid confusion. These recommendations emphasize the importance of using clear and user-friendly visual representations for self-measurement and ensuring that app icons are distinct to prevent any visual confusion. Below are comments that correspond to these recommendations:

Theme 1: Ineffective Comparison with Battery for Self-Measurement

"*I just don't see how comparing it with a battery would help me properly measure myself up. I could do it on my own too, don't need an app for that.* ***People can get confused with how much progress has been made*** *and*

how much energy they've got left. ***I would rather prefer a pie chart or a progress bar****."* [En.P - 336] (IMPL-1) – Liking and Self-monitoring.

Theme 2: Concerns About Visual Icon Similarity

"*The* ***icons are too close*** *to* ***my phone battery icon*** *and* ***should be something different****."* [En.P - 535] (IMPL-1) – Liking.

Furthermore, non-Arabic participants offered valuable recommendations to improve the PA app in IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**). Firstly, there was ***skepticism regarding the effectiveness of walking alone for achieving significant health impacts***, with participants suggesting that the app should consider a ***more holistic approach by incorporating dietary information*** and encouraging users to ***progress from walking to more intensive PAs like jogging***. Secondly, participants emphasized the importance of context and education, stating that while the feature related to weight management is valuable, ***it should be accompanied by educational resources to help users make informed choices and avoid unhealthy weight management practices***. Lastly, participants expressed ***a desire for personalized weight information***, highlighting the need for the app ***to consider individual factors such as height when providing weight-related guidance***, thus promoting a more tailored approach to health management. In summary, the recommendations emphasize the significance of a comprehensive and educational approach to health and weight management within the app, along with personalized guidance based on individual characteristics. Below are comments that correspond to the suggested recommendations:

Theme 1: Skepticism about the Effectiveness of Walking Alone

"*I'd be pretty skeptical that merely walking would be an effective means of having such an impact.* ***This feature might make sense if the app took a more holistic look at health*** *and* ***included dietary information*** *and* ***nudged the user to go from walking to jogging****."* [En.P - 312] (IMPL-2) – Add Diet-related App Features, Reminders, and Suggestion.

Theme 2: Emphasis on Context and Education

"***Good*** *to have, but again,* ***need context and educational resources for people to make the best use of it****. Anything with a focus on weight needs to be carefully managed.*" [En.P - 317] (IMPL-2) – Verifiability and Expertise.

Theme 3: Desire for Personalized Weight Information

"***Different heights, corresponding to different appropriate weight****, this is very careful,* ***let yourself know what the best weight*** *is to maintain.*" [En.P - 358] (IMPL-2) – Personalization and Expertise.

6.4.4.3 Overall Comparison Between Arabic and Non-Arabic Participants' Perspectives and Recommendations for Future App Design

Our study provides an overall comparison of the perspectives, preferences, opinions, and recommendations for future PA app design between Arabic and non-Arabic participants. It highlights both similarities and differences among these two participant groups (see Table 28 and Table 29). Our findings reveal that some of the feedback and recommendations provided by participants in each group directly align with specific persuasive strategies (e.g., rewards, self-monitoring) and their corresponding implementations (e.g., IMPL-1, IMPL-2). However, some of their feedback and recommendations are focused on providing insights and ideas related to entirely different strategies and features, which may either align with the twelve strategies included in our study or introduce new strategies and features. Consequently, I examined the differences and similarities in the recommended strategies and features by participants from both the Arabic and non-Arabic populations, whether they fall within our twelve study strategies or not. Accordingly, based on our findings, which include participants' perspectives and comments, quantitative results, and the guidelines presented in this chapter, I have developed two versions of our future PA app, 'Walk4Wellness,' tailored for Arabic and non-Arabic users, as illustrated in Chapter 7.

When considering the recommended strategies and features that align with our twelve study strategies, it is noteworthy that neither Arabic nor non-Arabic participants mentioned a simulation strategy in their feedback. However, both groups recommended common strategies such as rewards, praise, reminders, personalization, suggestion, goal-setting, self-monitoring, social competition, and social cooperation. Additionally, Arabic participants suggested tunneling and reduction strategies, while non-Arabic participants did not recommend any other strategies that align with the twelve strategies included in our study. Figure 74 presents the strategies recommended by Arabic and non-Arabic participants that align with our twelve study strategies.

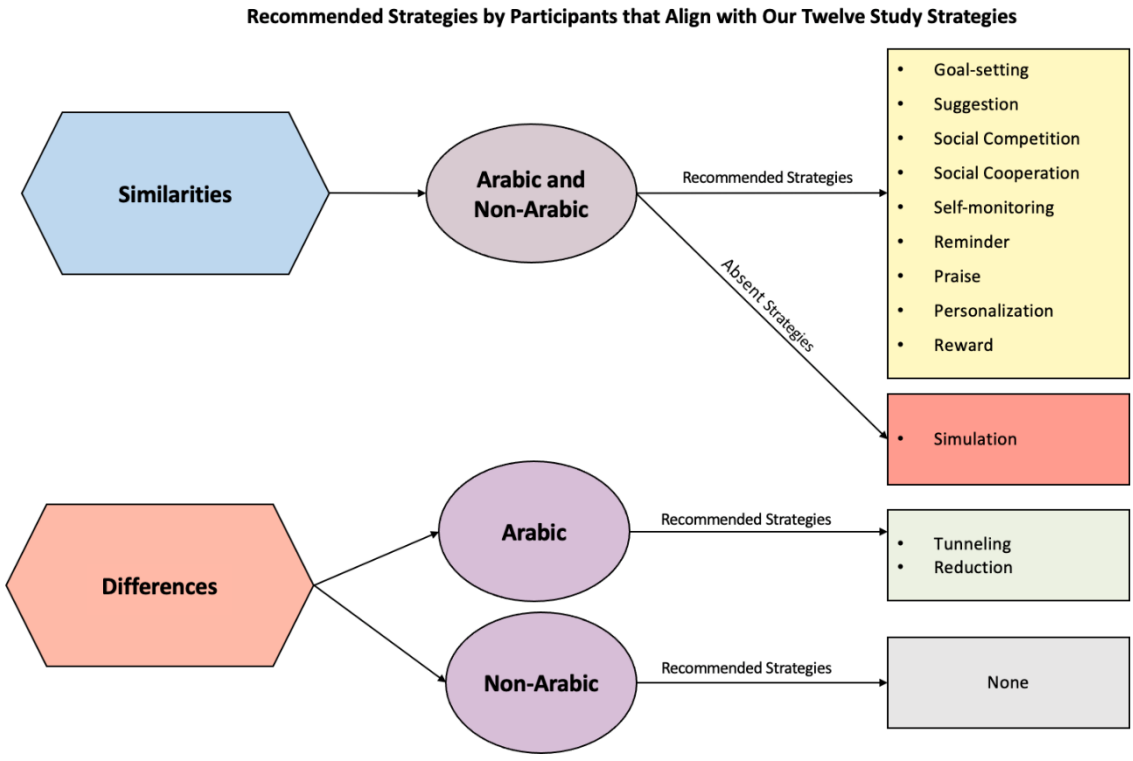


Figure 74: Strategies Recommended by Participants that Align with Our Twelve Study Strategies.

When considering the recommended strategies and features that are not included in our twelve study strategies, the findings reveal that both Arabic and non-Arabic participants shared some common recommendations. These included strategies and features such as rehearsal, customization, expertise, verifiability, social role, liking, social recognition, social comparison, authority, and normative influence as well as the addition of diet-related app features, water consumption tracking, inspirational/motivational messages and quotations, and social support and interaction elements.

Furthermore, Arabic participants extended their recommendations to include third-party endorsements, the incorporation of music playlists, audio motivational quotations, playlists of motivational music and songs as well as speech production and recognition features. In contrast, non-Arabic participants expanded their recommendations to include trustworthiness, positive reinforcement, surface credibility, gamification elements, social learning, the avoidance of punishment and negative reinforcement, safety tips and features, audio instructions and guidance, social media support elements, privacy and safety features, and humorous and inspirational/motivational messages

and quotations. Figure 75 presents the additional strategies and features recommended by Arabic and non-Arabic participants that are not included in our twelve study strategies.

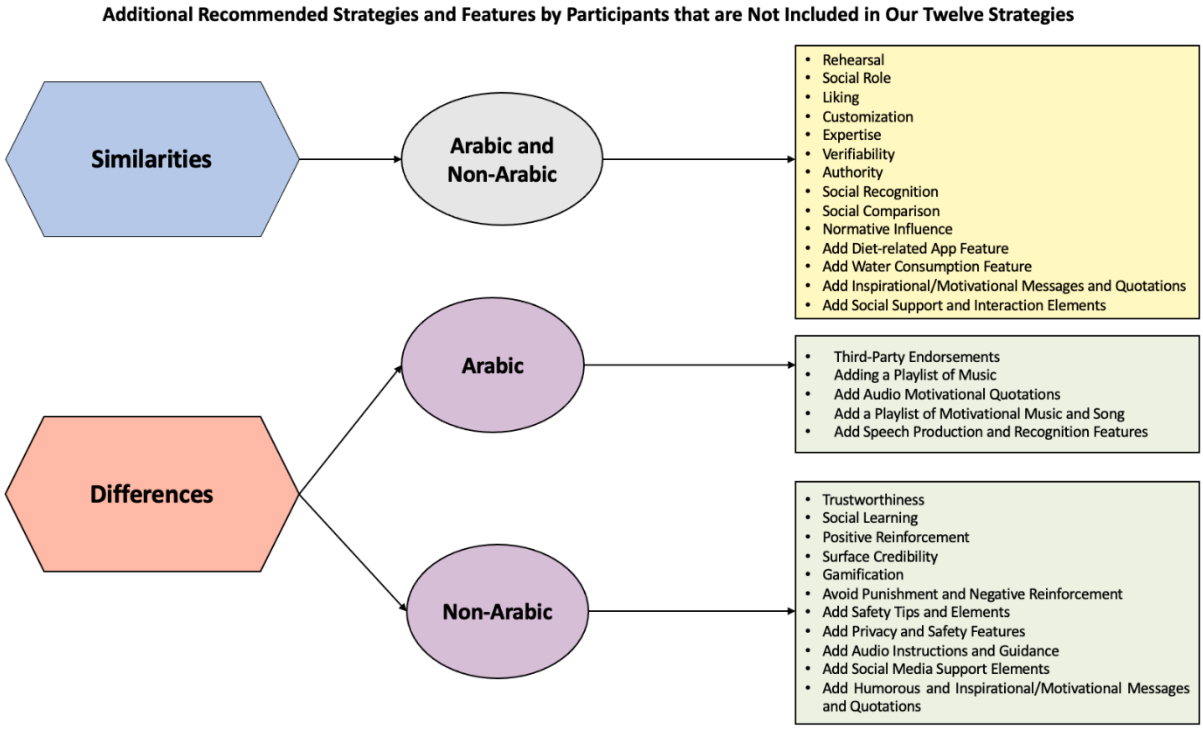


Figure 75: Comparing Additional Strategies and Features Recommended by Arabic and Non-Arabic Participants Not Included in Our Twelve Study Strategies.

6.5 Discussion

This section provides comprehensive insights and discusses the findings from the four major phases of our study. It begins by examining the overall persuasiveness of strategies and proceeds to evaluate the persuasiveness of individual implementations. Additionally, it explores the relationship between strategy implementations and the ARCS motivational constructs across various stages of change. Furthermore, this section presents recommendations and design guidelines tailored for both Arabic and non-Arabic populations.

6.5.1 Phase 1: Investigating the Overall Persuasiveness of Persuasive Strategies Among Arabic and Non-Arabic Populations

In this study, I investigated and compared the preferences for persuasive strategies among two different populations: Arabic and non-Arabic individuals. Our examination uncovers the employment and popularity of various persuasive strategies within each group, with the objective of revealing potential cultural and demographic influences that may impact decision-making and behavior. Through this analysis, I emphasized interesting aspects of these preferences while identifying the six most favored persuasive strategies out of the twelve employed in our study within each population.

Among Arabic participants, the tunneling strategy emerges as the predominant and most preferred persuasive strategy, indicating these participants' preference for guidelines aimed at attaining desired behaviors, such as providing instructions through walking routes. Following closely are the goal-setting and self-monitoring strategies, revealing a strong preference toward tracking performance (self-tracking and self-assessment) and goal-oriented features among this population. Additionally, Arabic participants have shown preferences for reminder, simulation, and reward strategies, highlighting their effectiveness in enhancing users' awareness (attention); realizing the cause and effect of their PA performance; and increasing engagement, motivation, and satisfaction through incentive-based approaches, respectively. Interestingly, the reduction strategy ranks as the least preferred, indicating a possible lack of appeal with this population. Furthermore, while the competition strategy does not rank among the six most favorable strategies, it still demonstrates greater favorability compared to other remaining ones, including personalization, praise, suggestion, and cooperation.

On the other hand, among non-Arabic participants, the self-monitoring strategy emerges as the most favored persuasive strategy, highlighting their preference for self-tracking and self-assessment. This is followed by the goal-setting and reward strategies, which emphasize goal-oriented features and provide encouragement through incentives. Similar to the Arabic population, the reminder strategy holds a significant place in their preferences, emphasizing its importance in increasing awareness and engagement in increasing PA levels, such as step counts, for both populations. Interestingly, the simulation strategy ranks as the least preferred among non-Arabic participants, indicating minimal influence on their behavior change.

When comparing the two populations, it becomes evident that Arabic participants consistently reveal a different range of preferences for persuasive strategies compared to their non-Arabic counterparts. This divergence highlights potential cultural and demographic influences on decision-making processes. Arabic participants demonstrate a stronger inclination toward instructional guidelines for behavior change, tracking performance, goal-oriented features, reminders, simulations, and motivational reward strategies, whereas non-Arabic participants show a greater preference for self-monitoring (tracking performance), goal-oriented features, motivational rewards, reminders, and personalized suggestion strategies, with less interest in the simulation strategy.

To summarize the six most favored strategies within each population, for the Arabic population, they are, in descending order: tunneling, goal-setting, self-monitoring, reminders, simulation, and rewards. Conversely, for the non-Arabic population, the six most preferred strategies, in descending order, are self-monitoring, goal-setting, rewards, reminders, suggestion, and personalization (see Figure 61 and Figure 62).

Our findings indicate that Arabic participants demonstrated a stronger preference for all twelve persuasive strategies compared to non-Arabic participants. I believe that Arabic participants preferred all the persuasive strategies more than non-Arabic participants for two potential reasons. First, our findings indicate that many Arabic participants were primarily at the Preparation stage of behavior change (28.4%), followed by the Contemplation stage (23.1%) (see Figure 57). Individuals at the Preparation stage have decided to start engaging in physical activity (PA) and have taken initial steps to achieve this goal, while those at the Contemplation stage are planning to start PA within the next six months. This suggests that Arabic participants were in stages characterized by enthusiasm, excitement, and a strong intention to adopt healthy behaviors, which likely influenced their preferences and persuasiveness ratings of the strategy implementations in our study. In contrast, non-Arabic participants were mostly at the Action stage of behavior change (30%) and the Maintenance stage (18.9%) (see Figure 58). Individuals at these stages have been consistently engaging in PA for six months or more and, thus, may not have been as strongly influenced by the persuasive strategy implementations, as they already possess a high level of awareness and have maintained healthy PA behaviors over an extended period. Second, Arab individuals tend to hold more positive views toward surveys compared to individuals from non-Arab countries. These favorable perceptions of surveys

may influence Arab respondents' attitudes and their actual behavior when participating in surveys [100].

In conclusion, this comparative analysis emphasizes considerable differences in the preferences for persuasive strategies between Arabic and non-Arabic populations. While both groups reveal different preferences, this study highlights the importance of tailoring persuasive strategies to align with the cultural and demographic backgrounds and needs of the target audience. Understanding and adapting to these variations can significantly enhance the effectiveness of persuasive systems in motivating at maintaining or adopting healthier behavior changes, such as increasing or maintaining step counts, and mitigating or avoiding risky ones, such as prolonged sitting.

6.5.2 Phase 2: Investigating the Implementation Preferences of Persuasive Strategies Among Arabic and Non-Arabic Populations

This section thoroughly explores and examines the persuasiveness of distinct implementations for each persuasive strategy within our study among both Arabic and non-Arabic populations. The outcomes clearly reveal distinct preferences, thereby highlighting the crucial significance of tailoring interventions to meet cultural and context-specific requirements. Table 24 and Table 27 show summary comparisons between persuasive strategies' implementations for Arabic and non-Arabic participants.

Table 24: Comparing Implementations' Preferences of Persuasive Strategies Among Arabic and Non-Arabic Participants.

Persuasive Strategies	Implementations	Arabic	Non-Arabic
Self-monitoring	IMPL-1	-	-
	IMPL-2	√	√
Personalization	IMPL-1	√	-
	IMPL-2	-	√
Suggestion	IMPL-1	-	-
	IMPL-2	√	√

Goal-setting	IMPL-1	-	-
	IMPL-2	√	√
Reminders	IMPL-1	√	-
	IMPL-2	-	√
Rewards	IMPL-1	-	-
	IMPL-2	√	√
Praise	IMPL-1	-	√
	IMPL-2	√	-
Reduction	IMPL-1	√	-
	IMPL-2	-	√
Social Competition	IMPL-1	√	√
	IMPL-2	-	-
Tunneling	IMPL-1	-	-
	IMPL-2	√	√
Social Cooperation	IMPL-1	√	-
	IMPL-2	-	√
Simulation	IMPL-1	-	√
	IMPL-2	√	-

6.5.2.1 Self-monitoring Strategy

When examining the preferences of Arabic and non-Arabic participants in the self-monitoring strategy, a significant finding emerged: both groups clearly favored IMPL-2 (**Numerical and Visual Feedback such as pie charts, graphs, and progress bars**) over IMPL-1 (**Textual and Numerical Feedback such as textual representation**). Both groups preferred the visual elements but with slightly different reasons for their choices.

Arabic participants significantly favored IMPL-2 due to its visually appealing aspects, such as pie charts, graphs, and progress bars, which were easy to understand and highly motivating. IMPL-1 was criticized for being dull, lacking attractive features, and failing to engage or motivate users.

Similarly, non-Arabic participants strongly preferred IMPL-2 for its visual representation of progress, finding it motivating to engage more in PA. They appreciated the user-friendly design, intuitive graphical interface, and engaging features, while IMPL-1 faced criticism for the complexity and distracting layout of its interface design.

In summary, graphical and visual data tracking and representation (IMPL-2) was the preferred choice for both Arabic and non-Arabic participants in the self-monitoring strategy. Visual elements like charts and graphs proved to be more persuasive and engaging for both groups. Arabic participants emphasized the importance of visual appeal and motivation, while non-Arabic participants focused on the clarity and goal-oriented nature of visual representations. These insights are valuable for designing effective self-monitoring tools that accommodate diverse user preferences.

6.5.2.2 Personalization Strategy

In an examination of a personalization strategy among Arabic and non-Arabic populations, distinct preferences emerged, emphasizing the need for cultural and context-specific tailoring.

Among Arabic participants, IMPL-1 (**Personalized Motivational Content**) was the preferred choice. These participants valued motivational content and positive messaging, considering them vital for maintaining motivation and self-confidence in their PA journey. The sense of belonging and support provided by personalized motivations within the app was highly appreciated. IMPL-2 (**Personalized Goal Recommendations**) received criticism for its repetitive content and directive tone.

In contrast, non-Arabic participants favored IMPL-2, mentioning its role as a personal motivation guide and trainer. They appreciated the optimistic language and goal-driven approach, finding it engaging and energizing. However, IMPL-1 received some criticisms, with some participants finding it annoying and ineffective.

In conclusion, there are significant variations in personalization strategy preferences between Arabic and non-Arabic populations. Arabic participants prioritize motivational content and personalized encouragement (IMPL-1), while non-Arabic participants prefer goal-driven approaches (IMPL-2). These findings highlight the importance of tailoring personalization strategies to specific cultural and user contexts to enhance user engagement and satisfaction.

6.5.2.3 Suggestion Strategy

In evaluating the effectiveness of a suggestion strategy among Arabic and non-Arabic populations, both groups preferred IMPL-2 (**Visual Suggestion Notifications**) over IMPL-1 (**Textual Suggestion Notifications**). This preference emphasized the crucial role of visual elements in enhancing user interaction and motivation.

Among Arabic participants, IMPL-2 was the clear favorite due to its incorporation of motivating images and visual instructions, making exercises easier to understand and reducing the risk of injuries. IMPL-1 faced criticism for being dull, being repetitive, and lacking visualization and motivation.

Similarly, non-Arabic participants also strongly favored IMPL-2, finding it motivating and engaging to see characters demonstrating exercises and providing clear guidance. The visual elements captured their attention, increased their curiosity, and enhanced their likelihood of using the app. IMPL-1 received reduced preference due to motivation issues and concerns about repetitiveness.

In summary, both Arabic and non-Arabic participants clearly favored visual suggestion notifications (IMPL-2) of the suggestion strategy, highlighting the importance of visual elements, demonstrations, and clear guidance. This preference surpassed cultural differences among Arabic and non-Arabic populations and emphasized the need for effectively incorporating visual elements to enhance user interaction and motivation.

6.5.2.4 Goal-setting Strategy

In the evaluation of goal-setting strategies among Arabic and non-Arabic populations, both groups strongly favor IMPL-2 (**Customized/User-Driven Goals**) over IMPL-1 (**Default/System-based Goals**), emphasizing the importance of customization to enhance user motivation and engagement.

Among Arabic participants, IMPL-2 outperforms IMPL-1 due to its customization feature. Arabic users highly value the opportunity to set their own goals tailored to their unique circumstances, preferences, and health conditions. Flexibility in goal setting is essential to them, preventing frustration and fostering motivation. Customization is empowering, giving users control over their goals. IMPL-1 is less favored due to its perceived lack of appeal, motivation, and flexibility in goal setting.

Similarly, non-Arabic participants also strongly prefer IMPL-2 for similar reasons. They value empowerment and customization in goal setting, allowing them to align PA goals with their individual preferences and circumstances. Customization reduces pressure and promotes a tailored approach to fitness. IMPL-1 is less preferred as non-Arabic participants emphasize their concerns about inflexibility, a lack of suitability for goals, and their desire for user-driven goal setting and customization.

In conclusion, both Arabic and non-Arabic participants share a common preference for customized/user-driven goals (IMPL-2) over default/system-based goals (IMPL-1) in the goal-setting strategy. The key factor is the importance of customization and flexibility in goal setting to avoid frustration and promote motivation and engagement. These findings highlight the universal appeal of user-driven goal setting and the significance of incorporating customization features in PA applications to tailor to diverse user preferences and needs.

6.5.2.5 Reminder Strategy

In examining Arabic and non-Arabic populations' preferences for the reminder strategy, a significant contrast emerges. Arabic participants favor IMPL-1 (**Automatic/System-based Reminders - Push Reminders)**, while non-Arabic participants prefer IMPL-2 (**Customized/User-Driven Reminders - Pop-up Reminders)**, highlighting the impact of culture and individual factors on user attitudes towards PA application reminders.

Within the Arabic population, IMPL-1 significantly outperforms IMPL-2. Arabic participants appreciate IMPL-1's value in countering inactivity and maintaining motivation, especially during prolonged periods of inactivity. However, some Arabic participants express a lack of desire for scheduled reminders (IMPL-2) due to annoyance and its perceived unnecessary nature, attributed to their busy lifestyle and random availability.

Conversely, among non-Arabic participants, IMPL-2 is significantly more persuasive compared to IMPL-1. Non-Arabic participants favor IMPL-2 for its customization, scheduling flexibility, motivation, and accountability. Customized reminders empower individuals to manage their activity schedules and stay motivated, but some express negative attitudes towards automatic push notifications (IMPL-1), mentioning annoyance and concerns about autonomy.

In conclusion, there is a clear difference in reminder strategy preferences between Arabic and non-Arabic populations. Arabic participants favor automatic push reminders (IMPL-1), valuing system-based reminders, while non-Arabic participants prefer scheduled pop-up reminders (IMPL-2) for their customization and flexibility. Tailoring a reminder strategy to cultural and individual preferences is essential for enhancing user engagement and satisfaction in PA applications.

6.5.2.6 Reward Strategy

In assessing the preferences of both Arabic and non-Arabic populations regarding the reward strategy, a noteworthy agreement emerges as both groups strongly favor IMPL-2 (**Collecting Virtual Reward Badges**) over IMPL-1 (**Collecting Virtual Reward Points**). This preference highlights the effectiveness of gamification elements and visually appealing rewards in enhancing user motivation and engagement, regardless of cultural background.

Among Arabic participants, IMPL-2 significantly surpasses IMPL-1, primarily driven by the motivating factor of virtual badges. Arabic participants consider badges as powerful motivators symbolizing achievable goals and challenges, while virtual points are perceived as less motivating.

Similarly, among non-Arabic participants, IMPL-2 is also significantly preferred over IMPL-1 due to the gamified and positively reinforced approach it offers. Virtual badges are seen as highly motivational, resembling achievements in video games and creating an enjoyable experience. Non-

Arabic participants consider badges as visually engaging symbols of accomplishment and quantifiable goals in their PA journey. However, they perceive point-based rewards (IMPL-1) as less motivating.

In conclusion, both Arabic and non-Arabic participants demonstrate a shared preference for badge-based rewards (IMPL-2) in the reward strategy. Participants highly value the gamification aspect, visual appeal, and sense of achievement associated with virtual badges. These findings emphasize the importance of integrating gamification elements and visually engaging rewards into PA apps to reinforce user motivation and engagement, regardless of cultural and demographic boundaries.

6.5.2.7 Praise Strategy

When examining the preferences of Arabic and non-Arabic populations regarding the praise strategy in PA applications, a significant cultural difference emerges.

Among Arabic participants, IMPL-2 (**Audio and Visual Praise**) is slightly favored over IMPL-1 (**Textual Praise**) due to its novelty and excitement. Arabic participants appreciate the unique features such as clapping sounds, fireworks, and visually appealing effects that celebrate their achievements, finding them motivational and enjoyable. In contrast, IMPL-1 is less favored among Arabic participants, as it is seen as annoying, repetitive, and non-motivational.

Conversely, among non-Arabic participants, IMPL-1 significantly outperforms IMPL-2. Non-Arabic participants value IMPL-1 for its role in providing appreciation and motivation through compliments and positive reinforcement, delivered as motivational textual messages. Textual praise enhances user engagement, especially benefiting beginners by reinforcing their commitment to PA. However, non-Arabic participants show less preference to IMPL-2 due to the annoyance caused by auditory announcements, especially in public places.

In conclusion, a cultural difference in the perception of a praise strategy is evident. Arabic participants prefer the novelty and excitement of audio and visual praise (IMPL-2), while non-Arabic participants value the motivational impact of textual praise (IMPL-1). This contrast highlights the importance of considering cultural context and individual preferences when designing persuasive strategies within PA apps, with some users prioritizing novelty and visual appeal while others preferring more traditional textual praise for motivation and engagement.

6.5.2.8 Reduction Strategy

When examining the preferences of Arabic and non-Arabic populations in the context of the reduction strategy, distinct differences become evident. Arabic participants prefer IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) for its convenience and variety, while non-Arabic participants slightly favor IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) for its monitoring and motivation features. These differences reflect varying priorities and needs in selecting PA plans within PA applications.

Among Arabic participants, IMPL-1 significantly outperforms IMPL-2 in persuasiveness. Arabic participants appreciate IMPL-1's convenience, usability, and practicality for location selection, exploration, and variety of nearby activities. The integration of Google Maps and location-tracking features is well-received. IMPL-2 is less favored due to its complexity, perceived lack of suitability, usability issues, and inflexibility, as Arabic participants desire simpler and more user-friendly options.

Conversely, among non-Arabic participants, IMPL-2 is slightly more preferred than IMPL-1, with qualitative feedback highlighting its monitoring and motivation features for walking plans. Non-Arabic participants value the convenience, ease of monitoring, organization, clarity, and customization options offered by IMPL-2. Some express skepticism about IMPL-1, perceiving it as not significantly superior to existing alternatives like Google Maps and raising privacy concerns.

In summary, distinct preferences and priorities in the reduction strategy exist between Arabic and non-Arabic participants. Arabic participants prioritize convenience and variety, favoring IMPL-1 for its location-based activity options. Non-Arabic participants appreciate IMPL-2 for its monitoring and motivation features, finding it user-friendly and customizable. These differences emphasize the importance of tailoring a reduction strategy in PA apps to meet the specific needs and preferences of different user groups while considering cultural and individual variations to enhance user engagement and satisfaction.

6.5.2.9 Competition Strategy

In the context of the competition strategy in PA apps, both Arabic and non-Arabic populations show a noteworthy agreement. They significantly prefer IMPL-1 (**Leaderboard Competition**) due to its effectiveness in motivating users through competition and visual representations of achievements.

Among Arabic participants, IMPL-1 outperforms IMPL-2 (**Progress Bar for Each Competitor**) in terms of persuasiveness. Arabic participants prefer IMPL-1 for its ability to provoke their competitive spirit and motivate them through leaderboards, badges, and trophies. They also value the sense of community that group competitions foster. In contrast, IMPL-2 is less favored due to concerns about visual appeal, motivation, privacy, and anxiety related to sharing personal data and competing against unknown individuals.

Similarly, non-Arabic participants significantly prefer IMPL-1. They appreciate the competitive aspect of IMPL-1 for sustaining motivation and fostering friendly competition in aiming to top leaderboards. Visual representations of achievements are seen as positive. However, they show reduced interest in IMPL-2, expressing privacy concerns and a lack of enthusiasm about competitive features involving rankings, comparisons, and sharing PAs with peers. Some non-Arabic participants prefer individual progress tracking and visual enhancements for self-motivation.

In summary, both Arabic and non-Arabic participants favor leaderboard competition (IMPL-1) as a motivating competitive feature in PA apps. They enjoy the sense of achievement and motivation it provides. Furthermore, both groups of participants express concerns about privacy and visual appeal when considering progress bars (IMPL-2) of the competition strategy. Balancing competition and privacy is crucial when implementing competitive features in PA applications.

6.5.2.10 Tunnelling Strategy

In examining preferences for the tunneling strategy in PA apps among both Arabic and non-Arabic populations, a clear agreement emerges. Both groups significantly prefer IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) over IMPL-1 (**Tunneling as Textual/Written Instructions**). Map visualization (IMPL-2) is universally favored for its clarity, user-friendliness, engagement, and motivational value. Practicality, safety, and readability concerns during exercise are shared by both groups, highlighting the importance of clear and visually engaging navigation in PA apps.

Arabic participants favor IMPL-2 due to its integration of map technology, providing clearer and more understandable layouts. Visual maps are preferred for route decisions, especially in unfamiliar places, and satellite imagery is seen as valuable. IMPL-1 is less preferred due to its complexity and ineffectiveness, with textual instructions considered challenging during workouts.

Similarly, non-Arabic participants find IMPL-2 more persuasive, appreciating its visual guidance and clarity. Visual directions are easier to follow and more engaging than textual ones, adding excitement to workouts. IMPL-1 is less favored due to boredom, redundancy, safety concerns, and a preference for visual guidance.

In summary, both Arabic and non-Arabic participants prefer map visualization (IMPL-2) over textual instructions (IMPL-1) for navigational assistance in PA apps. Visual maps are universally favored for their clarity and engagement, emphasizing the importance of clear and visually engaging tunneling strategies in PA apps for enhancing user experiences and safety across different demographics.

6.5.2.11 Cooperation Strategy

When evaluating the cooperation strategy in PA apps for both Arabic and non-Arabic populations, distinct preferences emerge. Arabic participants strongly prefer IMPL-1 (**Message Exchange via Social Cooperation Networks**), as they mentioned its persuasive qualities associated with social chat, group activities, and community-building. Conversely, non-Arabic participants show preference toward IMPL-2 (**Cooperation as Teamwork**) due to teamwork and challenges features. These distinctions reflect cultural preferences among both groups.

Arabic participants favor IMPL-1 due to its motivating social features, including chat and group activities. They appreciate the support and friendships it fosters, which make PAs more enjoyable. Building relationships and meeting new people through PAs are also valued aspects. However, Arabic participants do not find team challenges (IMPL-2) appealing or interesting.

Non-Arabic participants, on the other hand, prefer IMPL-2 because of the motivation and sense of responsibility it offers through teamwork. They enjoy challenges, especially when shared with friends, adding a positive dimension to PAs. Teamwork enhances relationships and introduces engaging competition. However, non-Arabic participants express concerns about interacting with strangers in IMPL-1 and perceive chat rooms as a waste of time.

In summary, Arabic participants favor social elements (IMPL-1) of the cooperation strategy in PA apps, while non-Arabic participants favor teamwork and challenges (IMPL-2). These differences emphasize the significance of considering cultural and individual variations when designing PA apps to accommodate diverse user preferences and needs.

6.5.2.12 Simulation Strategy

When analyzing the preferences for the simulation strategy in PA apps among both Arabic and non-Arabic populations, significant differences become evident. Arabic participants strongly favor IMPL-2 (**Simulation as Educational Tips/Images with Current and Target Body-Shape Images**) due to its motivational aspects and the ability to visualize their target body shape. In contrast, non-Arabic participants lean towards IMPL-1 (**Simulation as Battery Charging**) for its positive visual metaphor—a battery indicator—representing PA progress. These variations highlight the influence of cultural and personal preferences in PA app design of the simulation strategy.

Arabic participants prefer IMPL-2 primarily because of its motivational features related to visualizing their target body shape and setting personal goals, which aid in improving awareness and accountability, particularly among women. IMPL-1 is less preferred due to perceived ineffectiveness, boredom, a lack of relevance, and confusion.

Conversely, non-Arabic participants favor IMPL-1, appreciating the engaging positive visual metaphor of a battery indicator to track PA progress. The progress bar serves as a useful monitoring tool, fostering a sense of accomplishment and motivation. Concerns about body shaming, unrealistic expectations, and compatibility with wellness goals lead to reservations about IMPL-2, particularly its 3D body image feature. Non-Arabic participants emphasize the importance of a comprehensive approach to health that promotes body positivity and diverse wellness goals.

In summary, a contrast in preferences exists between Arabic and non-Arabic participants regarding the simulation strategy in PA apps. Arabic participants are motivated by visualizing their target body shape for accountability and awareness, while non-Arabic participants prefer the positive visual metaphor of a battery indicator for engagement and motivation. Furthermore, concerns raised by non-Arabic participants regarding the potential negative impacts of a 3D body image feature highlight the need for responsible and inclusive design. These findings emphasize the significance of considering cultural and individual differences when designing PA apps to accommodate diverse user preferences and promote comprehensive wellness goals.

Table 25: Comparison Between Persuasive Strategies' Implementations for Arabic and Non-Arabic Participants.

			Arabic	Non-Arabic

Serial Number	Persuasive Strategies	Preference	(IMPL-1 or IMPL-2) Justifications and Reasons	(IMPL-1 or IMPL-2) Justifications and Reasons
1	Self-monitoring	Less preference	Arabic participants show *less preference* for **IMPL-1 (Textual and Numerical Feedback)** for the following reasons: **Theme 1: Lack of Visual Appeal and Engagement** - Lack of colors and attractive user elements. - Insufficient audience engagement elements like colors and graphics. - Preference for more colors and motivating emojis. - The black and white UI was less engaging than a colorful design and had too much white space. **Theme 2: Lack of Novelty and Motivation** - Perceived lack of newness in content, with similar ideas existing in other step-tracking apps. - Dull app design and similarity to other apps. - Monitoring activity was seen as good but not necessarily motivating behavior change.	Non-Arabic participants show *less preference* for **IMPL-1 (Textual and Numerical Feedback)** for the following reasons: **Theme 1: Usability and User Experience Issues** - Difficulty interpreting the content. - Desire for more captivating elements like color and different graphics. - Distracting layout with too much text and unclear associations between icons and text. - Preference for a better visualization method, such as a line graph or chart, to represent step counts and reduce cognitive load. **Theme 2: Lack of Motivation and Engagement** - The app was not engaging for some users. - Lack of interest in fitness-related content. - Desire for compelling visuals like graphs to boost motivation.
		More preference	Arabic participants show *more preference* for **IMPL-2 (Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)** for the following reasons: **Theme 1: Visual Appeal and Clarity** - Preference for an aesthetically pleasing and easily comprehensible design. - Appreciation for colorful components and a goal-focused approach. - Faster access to information through graphical representations. **Theme 2: Utility and Motivation** - Meeting the desire for an Arabic app to track PA and provide motivation. - Expectation of improved exercise habits, particularly when exercising alone.	Non-Arabic participants show *more preference* for **IMPL-2 (Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)** for the following reasons: **Theme 1: Visual Aid for Progress Tracking** - Real-time visual aids like bars and charts help track progress effectively. **Theme 2: Motivation and Clear Understanding of Goals** - The app provides clear information on progress, motivating users to reach their goals. - Weekly updates offer insights into areas needing improvement. **Theme 3: User-Friendly and Engaging Design**

				- The app's visual appeal, readability, and engagement make it user-friendly. - Participants find the colorful and well-formatted design appealing and look forward to using the app.
2	Personalization	Less preference	Arabic participants show *less preference* for **IMPL-2 (Personalized Goal Recommendations)** for the following reasons: **Theme 1: Repetitiveness and a Lack of Clarity and Relevance** - Repetitive daily content. - Difficulty understanding suggested content. - Worries about automatic activity level goal increases. - Desire for more relevant exercise information. **Theme 2: Lack of Motivation and Personalization** - Unmotivating and brief information. - Unfavorable "command-like" messages in the interface.	Non-Arabic participants show *less preference* for **IMPL-1 (Personalized Motivational Content)** for the following reasons: **Theme 1: Negative Perception of Motivational Messages** - Ineffectiveness of vague feedback and preference for specific goals. - Annoyance with frequent app reminders. **Theme 2: Skepticism about Motivational Impact** - Skepticism about the motivational impact of AI-generated content. - Objection to inanimate objects trying to provide encouragement. **Theme 3: Concerns About Privacy and Intrusiveness** - Concerns about the loss of privacy with an interactive agent monitoring exercise. **Theme 4: Desire for More Personalization** - A desire for more personalized and unique messages rather than generic ones.
		More preference	Arabic participants show *more preference* for **IMPL-1 (Personalized Motivational Content)** for the following reasons: **Theme 1: Motivational Content and Positive Messaging** - Appeal of motivational words and messages. - Praise as a stimulus for staying active and achieving goals. - Boosting self-confidence, providing user-friendly exercise guidance, and enhancing performance.	Non-Arabic participants show *more preference* for **IMPL-2 (Personalized Goal Recommendations)** for the following reasons: **Theme 1: Personal Motivation and Guidance** - The app provides personal motivation and guidance, making it feel like a personal trainer. **Theme 2: Positive Wording and Imagery** - Participants appreciate the positive wording and encouraging imagery in the app.

			Theme 2: Sense of Belonging and Support - Feeling a sense of belonging. - Appreciation for personal support and motivation features within the app.	**Theme 3: Effort and Energy Boost** - The app motivates users to increase their stamina and energy, boosting their efforts. **Theme 4: Goal-Driven Approach** - Users appreciate the app's goal-driven approach with manageable steps for achieving targets.
3	Suggestion	Less preference	Arabic participants show less preference for **IMPL-1 (Textual Suggestion Notifications)** for the following reasons: **Theme 1: Lack of Motivation and Visualization** - Lack of motivation, with comments like "Not motivating at all." - Dull wordings that failed to inspire motivation. - Preference for visual content like images or video tutorials over textual pop-up suggestions. **Theme 2: Ineffectiveness and Annoyance** - Boring and repetitive suggestions. - Concerns about constant reminders being discouraging. - Some participants found the approach more annoying than helpful.	**IMPL-1 (Textual Suggestion Notifications)** Non-Arabic participants show less preference for the implementation for the following reasons: **Theme 1: Lack of Motivation and Appeal in Textual Format** - The textual format lacked motivation and appeal, described as dull and unengaging. - Some participants found it artificial and overly excessive. - The absence of specific stretching guidance was a drawback for certain users. **Theme 2: Irritation and Annoyance with Pop-Up Notifications** - Pop-up notifications were considered annoying and disruptive by some participants. - Some users expressed a strong dislike for pop-up notifications, even to the extent of considering app deletion. - Concerns were raised about the potential irritation caused by pop-up texts with tips. **Theme 3: Concerns About Repeated or Repetitive Content** - Participants had concerns about helpful hints becoming repetitive and possibly annoying over time. - The repetition of messages, particularly those already known, was seen as a potential source of irritation.
		More preference	Arabic participants show *more preference* for **IMPL-2 (Visual Suggestion Notifications)** for the following reasons:	Non-Arabic participants show *more preference* for **IMPL-2 (Visual Suggestion Notifications)** for the following reasons:

			Theme 1: Motivational Content and Positive Messaging - Appeal of motivational words and messages. - Praise as a stimulus for staying active and achieving goals. - Boosting self-confidence, providing user-friendly exercise guidance, and enhancing performance. **Theme 2: Sense of Belonging and Support** - Feeling a sense of belonging. - Appreciation for personal support and motivation features within the app.	**Theme 1: Engagement and Visual Guidance** - Seeing character demonstrations for stretches was motivating. - Visual elements provided a clear guideline for exercises, enhancing engagement. - Graphic representation of warm-up activities drew users in and sparked curiosity. **Theme 2: Education and Learning** - The implementation could teach proper stretching and exercise techniques. - Visual reminders were preferred, especially by visual learners. **Theme 3: Safety and Proper Form** - Users appreciated reminders about the importance of warm-ups. - Detailed instructions and visual demonstrations were valued for proper warm-up behavior.
4	Goal-setting	Less preference	Arabic participants show *less preference* for **IMPL-1 (Default/System-based Goals)** for the following reasons: **Theme 1: Lack of Appeal in User Interface** - Unappealing and unattractive user interface. - Boring design that lacked motivation. - A dull overall look. - Concerns about potential frustration when not meeting preset step goals. **Theme 2: Desire for Flexibility in Goal Setting** - Participants preferred suggestions over specific goals. - They wanted flexibility in goal setting with minimum and maximum limits. - Users expressed a preference for setting their own goals.	Non-Arabic participants show *less preference* for **IMPL-1 (Default/System-based Goals)** for the following reasons: **Theme 1: Desire for Customization and Control Over Goals** - Preference for setting personal goals rather than having them imposed. - Concerns about inflexible, one-size-fits-all goals that may not suit individual activity levels. **Theme 2: Negative Perception of Imposed Goals** - Dislike for automatic and general goal recommendations. - Unwillingness to accept system-imposed activity goals. **Theme 3: Need for Personalization and Context** - Desire for recommended and personalized goals, especially if the suggested goal is too challenging. - Concerns about auto goals not being suitable for individuals with sedentary lifestyles or health issues.

				- Reluctance to follow goal advice from the app without comprehensive medical information and doctor recommendations.
		More preference	Arabic participants show *more preference* for **IMPL-2 (Customized/User-Driven Goals)** for the following reasons: **Theme 1: Customization and Personalization** - Preference for customization to align with personal life. - Appreciation for the ability to set personalized goals. - Setting goals according to individual circumstances, including older users with health conditions. **Theme 2: Logical and Achievable Goals** - Acknowledgment that the required number of steps should vary based on individual activity levels. - Recognition of the importance of setting daily goals that consider people's diverse abilities and circumstances.	Non-Arabic participants show *more preference* for **IMPL-2 (Customized/User-Driven Goals)** for the following reasons: **Theme 1: Empowerment and Personalization** - Participants find the ability to control and customize empowering. - They appreciate the flexibility to adjust their step goals based on their daily energy and preferences. **Theme 2: Control and Engagement** - Feeling in control of fitness goals is important, and the app's goal-setting feature keeps users engaged and motivated. **Theme 3: Adaptability and Lifestyle-Friendly** - Users value the adaptability of the app, which allows them to start at their own fitness level and make changes to meet their specific goals. **Theme 4: Flexibility and Pressure Reduction** - The app's flexibility in goal customization reduces unnecessary pressure on users, making its use a more relaxed experience.
5	Reminders	Less preference	Arabic participants show *less preference* for **IMPL-2 (Customized/User-Driven Reminders (Pop-up Reminders))** for the following reasons: **Theme 1: Resistance to and Annoyance with Reminders** - Reluctance to use the reminder feature. - Some participants found reminders a bit annoying. - Limited and random activity times made scheduled reminders unnecessary and unhelpful. - Dislike for audible alarms or ringing.	Non-Arabic participants show *less preference* for **IMPL-1 (Automatic/System-based Reminder (Push Reminders))** for the following reasons: **Theme 1: Negative Attitudes Towards Push Notifications and Reminders** - Irritation caused by push notifications. - General annoyance with notifications, particularly default ones. - Concerns about excessive pushiness. **Theme 2: Preference for Autonomy and Control Over Goals**

			- Discomfort with alarm/snooze/stop features. - Tendency to close notifications due to annoyance despite scheduling.	- Desire to set personal goals and plans without the need for push notifications. **Theme 3: Concerns About Negative Emotional Impact** - Worries that the application could have negative emotional effects, especially for those concerned about their health.
		More preference	Arabic participants show *more preference* for **IMPL-1 (Automatic/System-based Reminder (Push Reminders))** for the following reasons: **Theme 1: Automatic Reminders** - Appreciation for reminders based on the user's daily activity, which makes them more relevant and effective. - Recognizing the usefulness of reminders, especially for individuals with sedentary work habits. **Theme 2: User Engagement and Motivation** - Monitoring and frequent nudges were seen as helpful for user engagement and motivation. - The system's reminders were viewed as a motivation to overcome laziness or distractions and take action.	Non-Arabic participants show *more preference* for **IMPL-2 (Customized/User-Driven Reminders (Pop-up Reminders))** for the following reasons: **Theme 1: Personalization and Control** - Control over notifications was preferred for a better user experience. - Personalized notifications felt more relevant and less annoying. **Theme 2: Scheduling Flexibility** - Setting reminders based on personal schedules improved organization. - Enhanced ability to allocate time for work and physical activity. **Theme 3: Motivation and Accountability** - Future goal reminders were seen as a powerful tool. - Reminders were relied upon for daily activity tracking. **Theme 4: User-Friendly Approach** - Scheduled reminders were favored over random ones, especially for those with monotonous routines.
6	Rewards	Less preference	Arabic participants show *less preference* for **IMPL-1 (Collecting of Virtual Reward Points)** for the following reasons: **Theme 1: Lack of Motivation from Incentives**	Non-Arabic participants show *less preference* for **IMPL-1 (Collecting of Virtual Reward Points)** for the following reasons: **Theme 1: Lack of Motivation of Points Reward** - A reward point system was not motivating. - Random rewards did not provide motivation.

			- Primitive point rewards that were not motivating. - Virtual points were not considered effective incentives. **Theme 2: Lack of Significance of Virtual Points** - The insignificance of point rewards. - Virtual points were seen as ineffective in increasing active time. **Theme 3: Unclear Benefits of Virtual Points** - Participants were uncertain about how to use the points. - Questions about the practical utilization of accumulated points. **Theme 4: Desire for Tangible Rewards** - Preference for tangible rewards, such as app store credits or discount offers, over virtual points.	**Theme 2: Desire for Tangible Rewards** - Points were considered useless unless they could be converted to gift cards or redeemed for something tangible. **Theme 3: Lack of Clarity and Utility** - Uncertainty about the purpose of virtual points and their utility. - Points were seen as pointless if their use was unclear.
		More preference	Arabic participants show *more preference* for **IMPL-2 (Collecting Virtual Reward Badges)** for the following reasons: **Theme 1: Motivation through Badges and Rewards** - Badges were seen as excellent motivators, representing achievable goals and challenges. - Badges and titles were considered more effective than points, drawing inspiration from their success in gym systems and gaming consoles like PlayStation and Xbox.	Non-Arabic participants show *more preference* for **IMPL-2 (Collecting Virtual Reward Badges)** for the following reasons: **Theme 1: Gamification and Motivation** - Participants enjoyed badges representing quantifiable goals, as they provided a sense of accomplishment. - Virtual badge rewards motivated them to achieve more and set tougher goals, fostering a sense of achievement. - The concept of earning badges for different goals reminded them of video game achievements, which served as motivation to achieve similar milestones.

7	Praise	Less preference	Arabic participants show *less preference* for **IMPL-1 (Textual Praise)** for the following reasons: **Theme 1: Annoyance with Textual Alerts** - Annoyance with alerts may lead to disabling the feature. - Repetitive alerts were found irritating. **Theme 2: Ineffectiveness of Textual Messages** - Doubts about the messages making a difference. - Preference against text messages due to boredom and perceived artificiality. **Theme 3: Preference for Visual Feedback** - Desire for more visual feedback to celebrate achievements.	Non-Arabic participants show *less preference* for **IMPL-2 (Audio and Visual Praise)** for the following reasons: **Theme 1: Annoyance and Disinterest in Audio Feedback** - Anticipation of audio being annoying. - Lack of interest and motivation from audio feedback. **Theme 2: Privacy and Social Concerns** - Concerns about auditory announcements in situations where the phone needs to be silenced. - Annoyance and potential awkwardness in public settings. **Theme 3: Preference for Simplicity and Age-Related Factors** - Preference for simple visual rewards over audible ones. - Personal preference based on age. **Theme 4: Ineffectiveness and Short-Term Motivation** - Ineffectiveness due to their phone being on mute most of the time. - Perceived ineffectiveness of praise as a motivator.
		More preference	Arabic participants show *more preference* for **IMPL-2 (Audio and Visual Praise)** for the following reasons: **Theme 1: Novelty and Positive Feedback** - Positive feedback, including praise and celebratory effects like clapping sounds and fireworks, enhances the experience and enjoyment. - Enthusiasm for the novel concept and the opportunity to try something new.	Non-Arabic participants show *more preference* for **IMPL-1 (Textual Praise)** for the following reasons: **Theme 1: Positive Encouragement as Motivation** - Participants felt motivated and appreciated, comparing the positive encouragement to a friendly compliment. - Positive encouragement made them feel good and encouraged them to work towards their goals. **Theme 2: Enhancing User Engagement and Satisfaction** - Seen as ideal for beginners in athletics.

				- Language-based encouragement enhanced determination and activity during sports.
8	Reduction	Less preference	Arabic participants show *less preference* for **IMPL-2 (Reduction as a Set of Predefined PA Plans/Goals)** for the following reasons: **Theme 1: Desire for Flexibility and Variation** - Desire for multiple options and daily suggestions instead of a fixed plan. - Preference for a list of nearby walking activity locations. **Theme 2: Lack of Interest and Suitability** - Lack of interest in the implementation. - It was not suitable for some participants. - Issues with scheduling and timing. **Theme 3: Preference for Simplicity and Usability** - Confusion regarding the interface. - A preference for a simpler and more user-friendly UI.	Non-Arabic participants show less preference for **IMPL-1 (Reduction as a List of Different Predefined Options for Nearby Activities)** for the following reasons: **Theme 1: Skepticism and Existing Alternatives** - Belief that other apps perform the same function better. - A preference for using Google Maps for finding locations. **Theme 2: Privacy Concerns and Data Sharing** - Concerns about providing personal location data to the app. - Worries about privacy issues related to requesting data from Google. **Theme 3: Preference for User-Generated Options** - Interest in having dynamic and user-generated location options. **Theme 4: Mixed Reactions and Limited Usefulness** - Perceived as a nice additional feature but not a primary selling point. **Theme 5: Lack of Relevance to Individual Activities** - Lack of relevance to participants living in small towns or rural areas with known walking trails.
		More preference	Arabic participants show *more preference* for **IMPL-1 (Reduction as a List of Different Predefined Options for Nearby Activities)** for the following reasons: **Theme 1: Convenience and Location Selection**	Non-Arabic participants show *more preference* for **IMPL-2 (Reduction as a Set of Predefined PA Plans/Goals)** for the following reasons: **Theme 1: Convenience and Ease of Monitoring**

			- The app eliminates the dilemma of choosing walking places, making it more convenient. - Appreciation for the Google Maps location feature. - The app's practicality and convenience, including the ability to access walking directions through the app. **Theme 2: Exploration and Variety** - Participants liked having multiple options for sports and walking locations, especially when exploring new areas. **Theme 3: Motivation and Breaking Routine** - Knowing distances encouraged participants to set and break new records, adding motivation. - The app was seen as a tool to break out of monotonous routines and promote a more active lifestyle.	- Easy and effective monitoring for daily activities. - Organizing daily activities became simple and efficient. **Theme 2: Motivation and Variety** - Provides variety in workouts without the need to guess distance and efficiency. - Keeps workouts interesting by avoiding repetition in the same locations. **Theme 3: User-Friendly and Customizable** - Appreciated the availability of options. - Flexibility to establish a weekly plan with different locations and control over location choices. **Theme 4: Time and Environment Considerations** - Offers different walking targets, which saves time and energy. - Provides an easy way to exercise while promoting environmental sustainability.
9	Social Competition	Less preference	Arabic participants show *less preference* for **IMPL-2 (Displaying a Progress Bar for Each Competitor)** for the following reasons: **Theme 1: Visual Presentation** - Negative perception of the visual appearance. **Theme 2: Negative Perception of Competitive and Comparison** - Concerns about potential frustration and feeling inadequate in comparison to others. - Worries about shaming or bullying due to performance disparities. **Theme 3: Lack of Motivation** - Less motivating; progress bars were considered less effective than badges.	Non-Arabic participants show *less preference* for **IMPL-2 (Displaying a Progress Bar for Each Competitor)** for the following reasons: **Theme 1: Lack of Interest in Competition** - Disinterest in comparison and ranking with others during walking activities. **Theme 2: Lack of Visual Appeal** - Dislike of progress bars as a ranking system and the lack of visual appeal. **Theme 3: Privacy Concerns** - Concerns about privacy and not wanting others to monitor their activity. **Theme 4: Negative Impact on Motivation and Discouragement**

			Theme 4: Privacy and Information Sharing Concerns - Concerns about sharing too much information and discomfort with others knowing personal details.	- Expectation of added pressure and potential discouragement from the progress bar and competition. **Theme 5: Prefer Individual Progress Tracking** - Preference for tracking individual progress and the suggestion of adding badges for visual appeal.
		More preference	Arabic participants show *more preference* for **IMPL-1 (Competition as a Leaderboard)** for the following reasons: **Theme 1: Visual Appeal and Presentation** - Preferred presentation format over a visual bar. - Appreciation for the visual appeal of badges and trophies. **Theme 2: Motivation and Competition** - Motivation from leaderboard rankings, striving to reach the top. - Likening the ranking system to a game, making exercise more engaging. - Competition through the leaderboard was seen as a strong motivational factor. **Theme 3: Community and Social Interaction** - Belief that the implementation fosters a sense of community.	Non-Arabic participants show *more preference* for **IMPL-1 (Competition as a Leaderboard)** for the following reasons: **Theme 1: Competition and Motivation** - Friendly competition on the leadership board motivated everyone to aim for the top. - Awareness of the gap between oneself and others provided additional motivation. - The friendly competition aspect was fun and motivating, encouraging participants to push themselves harder. **Theme 2: Sense of Achievement and Celebration** - Seeing results brought happiness. - Celebrating achievements was a pleasant experience. - Participants gained a sense of accomplishment and motivation to complete their exercise goals.
10	Tunneling	Less preference	Arabic participants show *less preference* for **IMPL-1 (Tunneling as Textual/Written Instructions)** for the following reasons: **Theme 1: Complexity and Difficulty** - Difficulty and complexity of the feature. - Challenges in understanding the textual instructions and navigation during workouts. - Lack of clarity and ease of use.	Non-Arabic participants show *less preference* for **IMPL-1 (Tunneling as Textual/Written Instructions)** for the following reasons: **Theme 1: Boredom and Redundancy with Existing Apps** - Perception of the app as bland and boring. - The belief that existing apps like Google Maps serve the same purpose effectively. **Theme 2: Safety and Distraction Concerns**

			Theme 2: Ineffectiveness and a Lack of Motivation - Perceived ineffectiveness and a waste of time. - Lack of motivation and a boring approach. **Theme 3: Preference for Visual Information** - Unappealing written instructions. - Preference for visual information over text-based instructions. **Theme 4: Practical and Usability Issues** - Difficulty reading long text while exercising. - Inconvenience of holding/reading a phone during physical activity. - Weather conditions in Arab countries pose challenges. - Lack of visual maps or informative signs on walking paths for clarity.	- Concerns about reading too much text while walking on the street. - Perceived confusion in directions and a boring presentation. **Theme 3: Preference for Visual Directions** - Desire for a more interactive feature. - Personal preference for visual map directions over written descriptions. **Theme 4: Age Considerations** - Belief that older individuals may not use written word descriptions effectively.
		More preference	Arabic participants show *more preference* for **IMPL-2 (Tunneling as Map Visualization for Walking Routes)** for the following reasons: **Theme 1: Integration of Maps Technology** - Greatly appreciated the integration of maps technology. - Liked the use of satellite imagery in directions. - Found maps technology helpful for exploring the surroundings. **Theme 2: Clearer and Easier Layout** - Preferred the clearer and easier layout. - Valued seeing the route through a map rather than a written description. **Theme 3: Suitable Walking Paths** - Emphasized the importance of carefully inputting walking paths for suitable routes. - Liked the map visualization for walking routes.	Non-Arabic participants show *more preference* for **IMPL-2 (Tunneling as Map Visualization for Walking Routes)** for the following reasons: **Theme 1: Visual Guidance and Clarity** - The visual aspect of the implementation was visually appealing and provided clear directions using a map. - A map layout was preferred as it made it easier to follow and understand compared to just text. **Theme 2: Motivation and Exploration** - Participants found data displayed on a map more motivating, encouraging them to explore new places while exercising. **Theme 3: User-Friendly Design and Accessibility** - The visual map was considered intuitive. - The map visualization was the preferred method for following directions, making it more useful and user-friendly.

11	Social Cooperation	Less preference	Arabic participants show *less preference* for **IMPL-2 (Cooperation as Teamwork)** for the following reasons: **Theme 1: Lack of Interest in Challenges and Teams** - Not suitable or interested in challenges. - Challenges were not appealing. - Disinterest in socializing or team activities. - Lack of time for social interaction. - Concerns about one person's laziness affecting the team. **Theme 2: Complexity and Confusion** - Overwhelmed by the complexity of team members and points rewarding, with multiple motivating factors causing confusion.	Non-Arabic participants show less preference for **IMPL-1 (Message Exchange via Social Cooperation Networks)** for the following reasons: **Theme 1: Preference for Solo Exercise** - Personal preference for exercising alone without the need for chat rooms or communication with others. **Theme 2: Safety and Privacy Concerns** - Safety concerns about strangers inviting each other, particularly for women or teenagers. **Theme 3: Skepticism About Practicality** - Doubts about the practicality and effectiveness of the feature, including concerns about people walking at different speeds. **Theme 4: Use of Existing Communication Channels** - Belief that existing communication methods like texting friends are sufficient. **Theme 5: Concerns and Critiques of Online Chat Rooms** - Perception of chat rooms as a waste of time. - Recognition of the need for monitoring chat rooms for inappropriate behavior.
		More preference	Arabic participants show *more preference* for **IMPL-1 (Message Exchange via Social Cooperation Networks)** for the following reasons: **Theme 1: Motivation and Social Support** - Walking with others was seen as motivating. - The feature of being part of a motivating team was considered wonderful and boredom-breaking.	Non-Arabic participants show *more preference* for **IMPL-2 (Cooperation as Teamwork)** for the following reasons: **Theme 1: Social Support and Accountability** - Keeping users accountable and motivated. - Fostering a sense of responsibility within the team. **Theme 2: Fun and Enjoyment**

			Theme 2: Building Relationships and Meeting People - The implementation was viewed as a way to form new relationships through engaging in activities. - Liked the prospect of meeting people who share an interest in exercise. **Theme 3: Encouragement and Bonding** - The implementation was seen as fostering bonds among people. - Appreciation for the cooperation it promotes among athletes. - The social chat room was acknowledged for encouraging group performance and motivating the group as a whole.	- Enjoyment when participating with friends. - Combining challenge with flexibility in walk times. **Theme 3: Teamwork and Healthy Competition** - Encouraging healthy competition as a team activity. **Theme 4: Gamification and Motivation** - Motivating participants through gamification. - Increasing efforts through challenges with others. **Theme 5: Enhanced Social Interactions** - Improved social interactions by inviting friends to participate.
12	Simulation	Less preference	Arabic participants show *less preference* for **IMPL-1 (Simulation as Battery Charging)** for the following reasons: **Theme 1: Ineffectiveness and a Lack of Relevance** - The display of a charging battery did not impact active time. - Simulation symbols were perceived as boring. - Some participants found the feature useless or unnecessary. - Confusion regarding the battery's purpose and its relation to the user. - A preference for the initial survey interface, which was considered better and easier to read. **Theme 2: Concerns About Realism and Feasibility** - Doubts about the realistic simulation of the battery for users. - Concerns about the feasibility of the new idea.	Non-Arabic participants show *less preference* for **IMPL-2 (Simulation as Educational Tips/Images (Current and Target Body-Shape Images))** for the following reasons: **Theme 1: Body Image and Self-Esteem Concerns** - Dislike for the 3D representation of a person. - Concerns about body shaming and potential disappointment among users. - Worry that this feature could negatively impact self-esteem. **Theme 2: Preference for a Holistic Approach to Wellness** - Belief that the app should take a more holistic approach to health instead of focusing on physical appearance. - Perception that this feature might encourage users to prioritize their appearance over health and fitness goals. **Theme 3: Concerns for Vulnerable Groups** - Concerns that this feature could be harmful to individuals with eating disorders and other vulnerabilities.

		More preference	Arabic participants show *more preference* for **IMPL-2 (Simulation as Educational Tips/Images (Current and Target Body-Shape Images))** for the following reasons: **Theme 1: Visualizing Target Body Shape for Motivation** - Liked setting the target body shape for reminders and motivation. - Found it helpful for continuing towards their goal by visualizing what they want to achieve. **Theme 2: Personalized and Logical Motivation** - Considered the feature useful, especially for women, as a form of motivation. - Appreciated the logical connection between personal data and motivation. **Theme 3: Increased Awareness and Accountability** - Acknowledged that the implementation enhances awareness of current performance and target goals. - Seen as a tool for increasing awareness about their exercise program and holding themselves accountable.	Non-Arabic participants show *more preference* for **IMPL-1 (Simulation as Battery Charging)** for the following reasons: **Theme 1: Positive Visual Metaphor** - The battery metaphor was engaging and made the experience enjoyable and visually appealing. - Positive feelings from the colorful indicator, especially when nearing a full charge. **Theme 2: Visual Aid and Monitoring** - Valuable as a visual aid for tracking progress. - Useful display for monitoring daily steps. **Theme 3: Motivation and Awareness** - Boosting self-confidence. - Increasing awareness of physical health. - Encouragement to achieve better results with an intuitive and visually appealing design.

6.5.3 Phase 3: Recommendations for Selecting Implementations in Persuasive System Design Across Stages of Behavior Change among Arabic and Non-Arabic Populations

Regardless of the conventional approach of designing for a wide user population, there has been a strong emphasis on tailoring experiences for system users [35], [144], [210], [207]. Our findings indicate that the current stage of change for individuals plays a crucial role and can guide the effective tailoring of persuasive systems to ultimately encourage users to adopt healthy behaviors. Our research findings indicate that the effectiveness of various implementations of persuasive strategies varies

depending on the stage of change individuals are in (refer to Table 22, Table 23, and Table 26). Table 26 summarizes the comparative analysis of the relationship between the stage of change, ARCS motivational constructs, and persuasive strategy implementations for Arabic and non-Arabic participants. I outlined how each implementation influences behavior change in Sections 6.4.3.1 and 6.4.3.2. In this section, I explored how these findings can inform the design of persuasive applications tailored to individuals among Arabic and non-Arabic populations at different stages of behavior change by employing suitable strategy implementations. The recommended implementation choices for the twelve strategies included in our study (*self-monitoring, personalization, suggestion, goal-setting, reminders, rewards, praise, reduction, competition, tunneling, cooperation, simulation*) for persuasive system design at each stage of change (*precontemplation, contemplation, preparation, action, maintenance*) are illustrated in Table 27, based on our findings among Arabic and non-Arabic populations.

Table 26: Comparative Analysis of the Relationship Between Stage of Change, ARCS Motivational Constructs and Persuasive Strategies' Implementations for Arabic and Non-Arabic participants.

				Arabic				Non-Arabic			
#	Persuasive Strategies	Stage of Change	Strategies' Implementations	ATT	CON	REL	SAT	ATT	CON	REL	SAT
1	Self-monitoring	Precontemplation	IMPL-1	L	-	-	L	L	-	-	L
			IMPL-2	M	M	M	M	M	M	M	M
		Contemplation	IMPL-1	-	L-S	L	-	**L**	-	**L-S**	-
			IMPL-2	**M**	M-S	**M**	M	M	**M**	**M-S**	M
		Preparation	IMPL-1	L	M	L-S	-	L	M-S	**L**	**L-S**
			IMPL-2	**M**	**L**	**M-S**	M	M	L-S	**M**	M-S
		Action	IMPL-1	-	L	L-S	L-S	-	L-S	-	L-S
			IMPL-2	M	**M**	M-S	M-S	M	M-S	M	M-S
		Maintenance	IMPL-1	-	L	**L-S**	-	-	**L**	-	**L**
			IMPL-2	**M**	**M**	M-S	M	M	M	M	M
2	Personalization	Precontemplation	IMPL-1	L	M	M	M	M	M	-	M
			IMPL-2	M	-	L	L	L	-	M	-

		Contemplation	IMPL-1	M	M	L	-	**L-S**	**L-S**	-	**M-S**
			IMPL-2	-	L	**M**	-	M-S	M-S	M	L-S
		Preparation	IMPL-1	M	M	**M**	M	**M-S**	M	**M**	L
			IMPL-2	-	-	-	L	L-S	-	-	**M**
		Action	IMPL-1	M	-	**M**	M	-	M	-	M
			IMPL-2	-	M	L	L	M	-	M	-
		Maintenance	IMPL-1	**M**	M-S	**M**	-	M	-	-	M
			IMPL-2	L	L-S	L	-	-	M	M	-
3	Suggestion	Precontemplation	IMPL-1	L	-	L	-	**M**	L	-	-
			IMPL-2	M	M	M	M	L	M	M	M
		Contemplation	IMPL-1	-	L	L	-	**L-S**	**L-S**	L-S	**L-S**
			IMPL-2	**M**	M	M	M	M-S	M-S	M-S	**M-S**
		Preparation	IMPL-1	-	L	L	L	L	-	M	M
			IMPL-2	M	**M**	**M**	M	M	M	L	L
		Action	IMPL-1	-	-	**L**	-	M	L	-	M
			IMPL-2	M	M	**M**	M	-	M	M	-
		Maintenance	IMPL-1	L	L	L	-	-	**L**	L-S	-
			IMPL-2	M	M	**M**	M	M	M	M-S	M
4	Goal-setting	Precontemplation	IMPL-1	M	M	L	L	M	L	M	L
			IMPL-2	L	-	**M**	M	-	M	-	M
		Contemplation	IMPL-1	M-S	-	M	M-S	**M**	M	M	M
			IMPL-2	**L-S**	M	L	L-S	L	L	-	-
		Preparation	IMPL-1	L	L-S	**M**	L	L	M-S	**M**	**L-S**
			IMPL-2	**M**	M-S	**L**	M	M	L-S	**L**	M-S
		Action	IMPL-1	-	-	**M**	L-S	-	M	-	M
			IMPL-2	M	**M**	L	M-S	M	-	**M**	-
		Maintenance	IMPL-1	**M**	-	**M-S**	M	L	-	M	L

			IMPL-2	-	**M**	**L-S**	**L**	**M**	M	-	M
5	Reminders	Precontemplation	IMPL-1	M	**M-S**	M	L	**L**	-	M	-
			IMPL-2	L	**L-S**	-	M	M	M	L	M
		Contemplation	IMPL-1	**L**	M-S	**M**	M	L-S	L-S	L-S	**L-S**
			IMPL-2	M	L-S	-	-	M-S	M-S	M-S	**M-S**
		Preparation	IMPL-1	M	-	**M**	L	-	**L**	**M**	**M-S**
			IMPL-2	-	**M**	-	**M**	M	**M**	-	L-S
		Action	IMPL-1	M	L	M	L	**L**	L	M	L
			IMPL-2	-	M	-	M	M	M	-	M
		Maintenance	IMPL-1	-	M	L	M	M	L	-	L
			IMPL-2	**M**	L	**M**	-	L	M	M	**M**
6	Rewards	Precontemplation	IMPL-1	-	**L-S**	L-S	L-S	L	-	L-S	-
			IMPL-2	M	M-S	M-S	M-S	M	M	M-S	M
		Contemplation	IMPL-1	L-S	L-S	-	L	L	-	-	L-S
			IMPL-2	M-S	M-S	-	M	**M**	M	M	**M-S**
		Preparation	IMPL-1	-	-	M	L	L	-	**M**	L-S
			IMPL-2	M	-	**L**	M	M	**M**	L	**M-S**
		Action	IMPL-1	-	-	L	L	-	L-S	**L**	-
			IMPL-2	M	M	**M**	**M**	M	M-S	**M**	M
		Maintenance	IMPL-1	L	L	L	-	-	**L**	-	L
			IMPL-2	**M**	M	**M**	M	M	M	M	M
7	Praise	Precontemplation	IMPL-1	-	L	L-S	L-S	L	M	M-S	M
			IMPL-2	M	M	M-S	M-S	**M**	-	L-S	L
		Contemplation	IMPL-1	-	L	M	M-S	M	M	M	L
			IMPL-2	M	M	L	L-S	**L**	-	-	**M**
		Preparation	IMPL-1	**M**	M	-	-	**M**	-	**M-S**	**M**

			IMPL-2	L	**L**	**M**	M	**L**	**M**	**L-S**	L
		Action	IMPL-1	L-S	M	M	-	M	-	M	L
			IMPL-2	M-S	L	L	M	-	M	L	M
		Maintenance	IMPL-1	L	M	L	**M**	M	M	M	M
			IMPL-2	M	-	M	-	-	**L**	-	L
8	Reduction	Precontemplation	IMPL-1	M	-	M	-	**M**	M-S	-	L
			IMPL-2	-	-	L	M	L	L-S	M	M
		Contemplation	IMPL-1	M	-	M	-	**M**	L	L	-
			IMPL-2	L	-	-	M	L	M	M	-
		Preparation	IMPL-1	**M**	L	**L**	M	-	E	L	-
			IMPL-2	-	M	M	-	M	E	**M**	**M**
		Action	IMPL-1	M	**L**	**M**	L	-	L	**M**	-
			IMPL-2	-	M	-	M	-	M	L	-
		Maintenance	IMPL-1	M	**M**	**L**	-	-	**L**	M	**L**
			IMPL-2	-	-	M	M	M	**M**	-	M
9	Competition	Precontemplation	IMPL-1	M	M	M-S	L-S	M	M	M-S	M
			IMPL-2	-	-	L-S	M-S	-	-	L-S	-
		Contemplation	IMPL-1	**M**	**M**	M	M-S	**M**	L	L-S	M
			IMPL-2	L	L	-	L-S	-	**M**	**M-S**	-
		Preparation	IMPL-1	M	M	M	**M**	M	**M**	M-S	M-S
			IMPL-2	L	L	-	-	-	-	L-S	L-S
		Action	IMPL-1	**M**	**M**	**M**	M	M	M	-	M
			IMPL-2	-	-	L	-	-	L	**M**	-
		Maintenance	IMPL-1	**M-S**	L	**M-S**	M	M-S	M	M	M-S
			IMPL-2	L-S	M	**L-S**	L	L-S	-	-	L-S
10	Tunneling	Precontemplation	IMPL-1	-	L	-	L	L	-	L	-

			IMPL-2	M	**M**	M	M	M	M	M	M
		Contemplation	IMPL-1	L	L	L	-	-	**L-S**	-	**L-S**
			IMPL-2	M	M	M	-	**M**	M-S	M	**M-S**
		Preparation	IMPL-1	-	L-S	L	**M-S**	L-S	-	-	L
			IMPL-2	M	**M-S**	M	L-S	M-S	-	M	M
		Action	IMPL-1	-	L	-	L	-	**L**	**L**	-
			IMPL-2	M	**M**	M	M	M	M	M	M
		Maintenance	IMPL-1	-	-	E	L	-	L	L	-
			IMPL-2	M	M	**E**	M	-	M	M	M
11	Cooperation	Precontemplation	IMPL-1	M	M	M	M-S	-	L-S	-	L
			IMPL-2	L	L	-	L-S	M	M-S	M	M
		Contemplation	IMPL-1	-	M	M	M	-	L	L	L
			IMPL-2	M	-	-	-	M	**M**	M	M
		Preparation	IMPL-1	**M**	M	**E**	-	-	**L**	**L**	L-S
			IMPL-2	-	-	E	-	M	**M**	**M**	M-S
		Action	IMPL-1	**M**	-	**M**	L	L-S	-	-	L
			IMPL-2	-	M	-	M	M-S	-	M	**M**
		Maintenance	IMPL-1	M-S	M	**L-S**	M-S	-	L	-	L
			IMPL-2	L-S	-	**M-S**	L-S	M	M	-	M
12	Simulation	Precontemplation	IMPL-1	-	M	-	M	L	M	L	M
			IMPL-2	M	L	-	L	M	-	M	-
		Contemplation	IMPL-1	-	-	M	L	L	M	**M-S**	M-S
			IMPL-2	**M**	M	L	M	M	**L**	L-S	L-S
		Preparation	IMPL-1	-	M	M	M	M-S	M-S	M	M
			IMPL-2	**M**	-	L	**L**	L-S	L-S	-	-
		Action	IMPL-1	-	L	L	L	**M**	M	-	L
			IMPL-2	**M**	M	**M**	M	L	-	M	M

		Maintenance	IMPL-1	-	L	L	L	L	L-S	-	L-S
			IMPL-2	M	M	**M**	M	M	M-S	**M**	M-S

ATT = Attention, CON = Confidence, REL = Relevance, SAT = Satisfaction

M = More Persuasiveness, L = Less Persuasiveness, M-S= More but Closely Similar Persuasiveness "0 < difference ≤ 0.04", L-S= Less but Closely Similar Persuasiveness "0 < difference ≤ 0.04", Equal = Identical Persuasiveness "difference = 0", '—' = Non-Significant Coefficient. Highlighted coefficients are significantly different across the two implementations for people at that stage of change. Bolded coefficients represent a significance level of p<.001, while un-bolded coefficients represent a significance level of p<.05.

6.5.3.1 PRECONTEMPLATION STAGE

For instance, individuals in the **precontemplation stage** often lack awareness of the negative consequences of their behavior [234] [275]. Therefore, persuasive strategies aimed at raising awareness about individuals' behaviors are appropriate at the **precontemplation stage**. Research indicates that self-monitoring enhances self-awareness and enhances individuals' consciousness regarding their behaviors concerning health and wellness [201]. Hence, the self-monitoring strategy utilizes individuals' inclination towards self-awareness by allowing them to monitor their behaviors and progress [123]. Studies have shown that self-monitoring fosters self-awareness and enhances individuals' consciousness regarding their health behaviors [210] [208]. Consequently, any implementation of this strategy is anticipated to enhance self-awareness or attention. However, our findings indicate that not every implementation of the strategy is related to Attention across different stages of change. This insight can guide designers intending to incorporate self-monitoring into their persuasive systems towards selecting the appropriate implementation to raise users' attention or consciousness regarding their risky behaviors. This correlates with our findings, which demonstrate the effectiveness of the self-monitoring strategy in capturing users' attention, as illustrated below (see Table 26 and Table 27).

6.5.3.1.1 Self-monitoring Strategy

Regarding the self-monitoring strategy, for Arabic participants in the **precontemplation stage,** both IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)** of the self-monitoring strategy are similarly effective in terms of capturing Attention and enhancing Satisfaction,

though there is a slightly higher preference for IMPL-2. However, only IMPL-2 of the self-monitoring strategy is associated with Confidence and Relevance. Additionally, our research reveals that for non-Arabic participants, IMPL-2 of the self-monitoring strategy demonstrates a significant association not only with Attention but also with Confidence and Relevance. Furthermore, it is similarly effective in terms of increasing Satisfaction, though there is a slightly higher preference for IMPL-2. This suggests that employing graphs/charts and progress bars to depict behavior change progress, as seen in IMPL-2 of the self-monitoring strategy, effectively raises users' consciousness regarding their health behaviors among Arabic and non-Arabic populations. It achieves this by stimulating their curiosity and exposing unhealthy behavioral patterns.

Our findings also correspond to the "consciousness raising" process of change, which involves increasing awareness to transition from the **precontemplation** stage to the next level, namely the **contemplation stage** [234]. Hence, I recommend that designers prioritize IMPL-2 of the self-monitoring strategy in persuasive systems aimed at non-Arabic individuals in the **precontemplation stage** to motivate them. Furthermore, I suggest that designers combine IMPL-1 and IMPL-2 when integrating the self-monitoring strategy targeting Arabic individuals in the **precontemplation stage** to provide a comprehensible approach to increase their awareness and engagement. Furthermore, our findings reveal that several strategy implementations are associated with increasing users' awareness and attention, as demonstrated in the following.

6.5.3.1.2 Personalization Strategy

In the personalization strategy, among Arabic participants, IMPL-2 (**Personalized Goal Recommendations**) of the personalization strategy is significantly linked with stimulating Attention. However, for non-Arabic participants, both IMPL-1 (**Personalized Motivational Content**) and IMPL-2 of the personalization strategy are similarly effective in capturing Attention, with a slight preference for IMPL-1. Therefore, designers of persuasive systems should consider integrating IMPL-2 of the personalization strategy when targeting Arabic individuals in the **precontemplation stage**. For non-Arabic individuals in this stage, designers should consider utilizing either IMPL-1 or IMPL-2 of the personalization strategy or combining both implementations.

6.5.3.1.3 Suggestion Strategy

Moreover, our study reveals that the motivational impact of different implementations of the suggestion strategy differs across various stages of change for both Arabic and non-Arabic participants. This implies that designers seeking to integrate suggestions into their applications should choose implementations that match the requirements of their target users, thus effectively motivating them and attaining desired outcomes. According to our findings, IMPL-1 (**Textual Suggestion Notifications**) of the suggestion strategy is significantly associated with Attention among non-Arabic participants. However, for Arabic participants, both IMPL-2 (**Visual Suggestion Notifications**) and IMPL-1 of the suggestion strategy are similarly effective in capturing Attention, with a slight preference for IMPL-2. This finding is consistent with the common lack of awareness among individuals in the **precontemplation stage** regarding their unhealthy behaviors and their associated consequences [234], [276]. Therefore, an implementation like IMPL-1, which offers timely textual pop-up tips, can effectively raise awareness about user behaviors without requiring human intervention, making it most suitable for non-Arabic individuals in this stage. On the other hand, IMPL-2, which provides timely visual suggestions and tips, is the most appropriate for Arabic individuals in the **precontemplation stage.** Studies indicate that timely suggestions are effective in interventions aimed at behavior change [95]. Hence, to improve awareness among individuals in the **precontemplation stage** regarding their risky health behaviors (e.g., prolonged sitting) and to maintain their attention, designers of persuasive systems should utilize the suggestion strategy, implemented as textual pop-up tips or suggestions (IMPL-1) for non-Arabic users while implemented as visual tips or suggestions (IMPL-2) for Arabic users.

6.5.3.1.4 Goal-setting Strategy

Regarding the goal-setting strategy, IMPL-1 (**Default/System-based Goals**) is significantly associated with stimulating Attention and boosting Confidence for the Arabic population. Furthermore, IMPL-1 of the goal-setting strategy is significantly associated with capturing Attention and increasing Relevance among the non-Arabic population. Therefore, designers of persuasive systems should incorporate IMPL-1 of the goal-setting strategy to boost attention and confidence among Arabic individuals in the **precontemplation stage**. Similarly, for non-Arabic individuals in this stage, employing IMPL-1 of the goal-setting strategy can enhance both attention and system relevance.

6.5.3.1.5 Reminder Strategy

Studies have demonstrated that when users employ a system that reminds them to perform their desired behavior, they will be more motivated to achieve their goals [123]. However, users have individual preferences regarding how they prefer to receive reminders. Among Arabic participants, IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) of the reminder strategy is significantly linked with stimulating Attention. However, for non-Arabic participants, both IMPL-1 and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) of the reminder strategy are similarly effective in capturing Attention, though there is a slight preference for IMPL-2. Additionally, only IMPL-2 is associated with boosting Confidence. According to our findings, Arabic individuals in the **precontemplation stage** regarded IMPL-1 (utilizing push notifications) as the most effective method of reminding if the system aims to increase their awareness (attention) of the target healthy behavior. This preference is understandable, as those in this stage have yet to commit to changing their unhealthy habits, making a less intrusive reminder approach (e.g., push notifications) more likely to improve their awareness among the Arabic population. Conversely, non-Arabic individuals in the **precontemplation stage** showed a similar preference for both push reminders (IMPL-1), which increase users' attention and remind them to stay engaged with the system, and scheduled/customized pop-up reminders (IMPL-2), which deliver notifications at customized and preferred times rather than randomly. Accordingly, I recommend that designers of persuasive systems consider employing push reminders (IMPL-1) when designing for Arabic individuals in the **precontemplation stage**. Additionally, they should consider combining both push reminders (IMPL-1) and scheduled/customized pop-up reminders (IMPL-2) when targeting non-Arabic individuals in this stage.

6.5.3.1.6 Reward Strategy

The reward strategy is widely employed in persuasive systems due to its capacity to incentivize users [210]. However, our findings indicate that the way rewards are implemented can impact the motivational appeal for users at different stages of change. For instance, IMPL-2 (**Collecting Virtual Reward Badges**) of the reward strategy is the only implementation associated with Attention among Arabic participants. However, for non-Arabic participants, both IMPL-1 (**Collecting of Virtual**

Reward Points) and IMPL-2 of the reward strategy are similarly effective in capturing Attention, with a slight preference for IMPL-2. Accordingly, I recommend designers to employ badge-based rewards (IMPL-2), which are the only significant implementation capable of raising awareness (Attention) for Arabic individuals in the **precontemplation stage**. However, for non-Arabic participants, both point-based and badge-based rewards (IMPL-1 and IMPL-2) are perceived as similarly effective for stimulating and maintaining Attention. Only IMPL-2, however, is capable of boosting Confidence and increasing Satisfaction for non-Arabic individuals in this stage. Thus, I recommend that designers consider combining both implementations (point-based and badge-based) of the reward strategy when designing for non-Arabic individuals in the **precontemplation stage.**

6.5.3.1.7 Praise Strategy

Concerning the praise strategy, our findings indicate that among Arabic participants, only IMPL-2 (**Audio and Visual Praise**) is associated with capturing Attention. Meanwhile, among non-Arabic participants, IMPL-2 is significantly more associated with Attention compared to IMPL-1 (**Textual Praise**). Thus, according to our findings, designers of persuasive systems should consider integrating IMPL-2 of the praise strategy when targeting Arabic individuals in the **precontemplation stage** to further increase their attention. Additionally, for non-Arabic individuals in this stage, designers should consider utilizing IMPL-1 of the praise strategy to enhance users' attention and motivation.

6.5.3.1.8 Reduction Strategy

In the reduction strategy, among Arabic participants, only IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) is associated with stimulating Attention. However, for non-Arabic participants, both IMPL-1 and IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) are similarly effective in capturing Attention, though there is a slight preference for IMPL-1. Thus, according to our findings, designers should consider employing IMPL-1 of the reduction strategy, which stands out as significantly associated with attracting Attention among Arabic individuals in the **precontemplation stage.** Additionally, designers can consider employing either IMPL-1 or IMPL-2 of the reduction strategy to increase Attention among non-Arabic individuals in this stage.

6.5.3.1.9 Competition Strategy

The competition strategy operates under the assumption that individuals are motivated to engage in their target desired behavior when they compete with others [93]. Moreover, competition has been shown to reinforce and incentivize behaviors, make them enjoyable and manageable, and aid individuals in maintaining focus and commitment [210]. Nevertheless, our findings indicate that these advantages can only be completely utilized if the persuasive strategy is tailored to individuals by employing an appropriate implementation that aligns with their current stage of change. Our findings indicate that different implementations of the competition strategy produce varying motivational outcomes for individuals at different stages of change. For instance, IMPL-1 (**Competition as a Leaderboard**) of the competition strategy emerges as the sole implementation associated with capturing Attention and boosting Confidence for both Arabic and non-Arabic participants. Additionally, only IMPL-1 of the competition strategy is linked with increasing Satisfaction among non-Arabic participants. Therefore, designers of persuasive systems should incorporate the leaderboard aspect (IMPL-1) of the competition strategy to increase attention and confidence among Arabic individuals and to boost attention, confidence, and satisfaction among non-Arabic individuals in the **precontemplation stage**.

6.5.3.1.10 Tunneling Strategy

Regarding the tunneling strategy, for Arabic participants, only IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) is associated with attracting Attention and increasing Relevance. Nevertheless, among non-Arabic participants, both IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 of the tunneling strategy are similarly effective in stimulating Attention, though there is a slight preference for IMPL-2. Consequently, according to our findings, designers of persuasive systems should consider employing IMPL-2 of the tunneling strategy when targeting Arabic individuals in the **precontemplation stage** to increase their attention and system relevance. Additionally, for non-Arabic individuals in this stage, designers should consider combining both textual instructions (IMPL-1) and map visualization for walking routes (IMPL-2) of the tunneling strategy to effectively capture users' attention and engagement, thereby increasing their PA level.

6.5.3.1.11 Cooperation Strategy

Regarding the cooperation strategy, for Arabic participants, both IMPL-1 (**Message Exchange via Social Cooperation Networks**) and IMPL-2 (**Cooperation as Teamwork**) are associated with grabbing Attention. Conversely, only IMPL-2 of the cooperation strategy is associated with capturing Attention and strengthening Relevance among non-Arabic participants. Subsequently, based on our findings, designers of persuasive systems can employ either message exchange via social networks (IMPL-1) or teamwork and group challenges (IMPL-2) of the cooperation strategy when designing for Arabic individuals in the **precontemplation stage** to increase their attention. Furthermore, for non-Arabic individuals in this stage, designers should consider applying teamwork and group challenges (IMPL-2) of the cooperation strategy to stimulate users' attention and increase system relevance.

6.5.3.1.12 Simulation Strategy

In the simulation strategy, among Arabic participants, only IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) is associated with arousing Attention. On the other hand, for non-Arabic participants, both IMPL-1 (**Simulation as Battery Charging**) and IMPL-2 are similarly effective in stimulating Attention, though there is a slightly higher preference for IMPL-2. Accordingly, I recommend that designers of persuasive systems consider utilizing IMPL-2 of the simulation strategy for Arabic individuals in the **precontemplation stage**. Moreover, when targeting non-Arabic individuals in this stage, designers have the option to select either IMPL-1 or IMPL-2 of the simulation strategy to enhance users' attention.

6.5.3.2 CONTEMPLATION STAGE

Individuals in the **Contemplation stage** are conscious of both the advantages and drawbacks of their behavior, leading to feelings of ambivalence toward change [235]. Shifting this state of decisional balance requires a focus on emphasizing the benefits of altering risky health behaviors. "Self-reevaluation" (or self-reflection) serves as a crucial process in this regard, involving a cognitive and affective reassessment of one's self-image capable of driving **contemplators** towards readiness for action (**preparation stage**) [234]. Self-reflection can be facilitated by monitoring past behaviors (e.g., through daily journaling or activity logging) and exploring gathered data using visualizations [55], both of which align with the self-monitoring strategy.

6.5.3.2.1 Self-monitoring Strategy

To motivate users in the **contemplation stage**, designers should choose IMPL-2 of the self-monitoring strategy, which utilizes visual representations such as graphs, charts, and progress bars to illustrate progress in behavior change. Our findings suggest that IMPL-2 **(Numerical and Visual Feedback)** is the only effective implementation for stimulating and maintaining Attention and increasing Satisfaction among Arabic participants while also boosting Confidence and increasing Satisfaction among non-Arabic participants the **contemplation stage**. Furthermore, for Arabic participants, IMPL-2 is significantly associated with Relevance, whereas both IMPL-1 (**Textual and Numerical Feedback such as textual representation**) and IMPL-2 are similarly effective in boosting Confidence. Conversely, among non-Arabic participants, IMPL-2 of the self-monitoring strategy is significantly associated with increasing Attention in this stage. These findings are consistent with research suggesting that self-reevaluation or self-reflection, facilitated by tracking past behaviors through data visualization, can motivate **contemplators** toward readiness for **action** [234]. Therefore, to motivate both Arabic and non-Arabic individuals in the **contemplation stage**, designers should consider employing IMPL-2 of the self-monitoring strategy to raise their consciousness. IMPL-2 has been shown to increase motivational effects in terms of Attention stimulation and sustainability and Confidence boosting.

Accordingly, in addition to promoting self-awareness, self-monitoring has been shown to enhance self-efficacy [289]. Self-efficacy refers to individuals' confidence or belief in their ability to adopt a behavior necessary to achieve a goal or perform a task successfully [289]. Our findings demonstrate that at least one implementation of the self-monitoring strategy is related to confidence across various stages of behavior change.

Additionally, prompts or cues (reminders) have been proven effective in inducing a reflective state of mind [79]. Providing information on adopting healthier lifestyle changes is also essential within the self-reevaluation process [44] [174]. This can be accomplished through personalized recommendations/content, system instructions/tips, reminder notifications, goal recommendations, PA plans, walking routes, suggestion, reminders, goal-setting, reduction, or tunneling strategies. Therefore, applying self-monitoring, personalization, suggestions, reminders, goal-setting, reduction

or tunneling are suitable for fostering behavior change in those **contemplating change**. Therefore, to motivate **contemplators**, designers should consider employing self-monitoring and reminders, along with either personalization, suggestions, goal-setting, reduction, or tunneling. However, designers need to also consider employing the appropriate implementations for each persuasive strategy while considering cultural differences and preferences among Arabic and non-Arabic individuals. Consequently, our findings reveal that several strategy implementations are associated with increasing users' confidence and self-efficacy in the **contemplation stage,** as illustrated in the following.

6.5.3.2.2 Personalization Strategy

According to our findings, among Arabic participants, only IMPL-1 (**Personalized Motivational Content**) of the personalization strategy is associated with increasing Attention, while both IMPL-1 and IMPL-2 (**Personalized Goal Recommendations**) are similarly effective in boosting Confidence, though there is a slight preference for IMPL-1. Additionally, for non-Arabic participants, both IMPL-1 and IMPL-2 of the personalization strategy are equally effective in boosting Confidence, while IMPL-2 is the only implementation associated with enhancing Relevance. Therefore, designers of persuasive systems should consider employing IMPL-1 of the personalization strategy in the **contemplation stage** for Arabic individuals to stimulate their attention and increase their confidence. Furthermore, designers should consider employing IMPL-2 of the personalization strategy for non-Arabic individuals to reinforce confidence and system relevance in this stage.

6.5.3.2.3 Suggestion Strategy

In terms of the suggestion strategy, our findings reveal that for Arabic participants, IMPL-2 (**Visual Suggestion Notifications**) is the only implementation associated with capturing Attention and increasing Satisfaction. Additionally, it is significantly associated with boosting Confidence and Relevance. On the other hand, among non-Arabic participants, both IMPL-1 (**Textual Suggestion Notifications**) and IMPL-2 of the suggestion strategy are similarly effective across the four motivational constructs (Attention, Confidence, Relevance, and Satisfaction), with a slight preference for IMPL-2. Therefore, according to our findings, designers aiming to enhance confidence in persuasive systems should consider employing IMPL-2 of the suggestion strategy in the **contemplation stage** for Arabic individuals. Furthermore, designers should consider combining both

textual and visual suggestions (IMPL-1 and IMPL-2) of the suggestion strategy for non-Arabic individuals to motivate them in this stage.

6.5.3.2.4 Goal-setting Strategy

Concerning the goal-setting strategy, only IMPL-2 (**Customized/User-Driven Goals**) is associated with boosting Confidence for Arabic individuals in the **contemplation stage**. However, among non-Arabic individuals, IMPL-1 (**Default/System-based Goals**) is the only implementation associated with increasing Relevance and Satisfaction. Additionally, both IMPL-1 and IMPL-2 are similarly associated with capturing Attention and boosting Confidence due to the lack of significant differences; however, there is a slight preference for IMPL-1. Thus, I recommend that designers of persuasive systems incorporate IMPL-2 of the goal-setting strategy to boost confidence among Arabic individuals in the **contemplation stage**. Furthermore, for non-Arabic individuals in this stage, I recommend that designers employ IMPL-1 of the goal-setting strategy to enhance confidence, relevance, and satisfaction.

6.5.3.2.5 Reminder Strategy

Regarding the reminder strategy, among Arabic participants, IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) of the reminder strategy are similarly effective in increasing Confidence, with a slight preference for IMPL-1. However, only IMPL-1 is associated with increasing Relevance and Satisfaction. Conversely, for non-Arabic participants, both IMPL-1 and IMPL-2 of the reminder strategy are similarly effective across all four motivational constructs (Attention, Confidence, Relevance, Satisfaction), with a slight preference for IMPL-2. Based on our findings, I recommend that designers of persuasive systems consider employing push reminders (IMPL-1) when designing for Arabic individuals in the **contemplation stage to** increase their confidence, relevance, and satisfaction. Moreover, I recommended that designers consider integrating both push reminders (IMPL-1) and scheduled/customized pop-up reminders (IMPL-2) when targeting non-Arabic individuals in the **contemplation stage**.

6.5.3.2.6 Reward Strategy

In the context of the reward strategy, among Arabic participants, IMPL-1 (**Collecting of Virtual Reward Points**) and IMPL-2 (**Collecting Virtual Reward Badges**) are similarly effective in capturing Attention and increasing Confidence, with a slight preference for IMPL-2. However, IMPL-2 is significantly associated with increasing Satisfaction. Furthermore, for non-Arabic participants, only IMPL-2 of the reward strategy is associated with boosting Confidence and increasing Relevance in the **contemplation stage.** Consequently, I recommend that designers of persuasive systems utilize badge-based rewards (IMPL-2) to increase attention, confidence and satisfaction among Arabic individuals and to boost confidence and relevance among non-Arabic individuals in the **contemplation stage**.

6.5.3.2.7 Praise Strategy

Concerning the praise strategy, our findings indicate that among Arabic participants, only IMPL-2 (**Audio and Visual Praise**) is associated with capturing Attention, while both IMPL-1 (**Textual Praise**) and IMPL-2 are similarly associated with increasing Confidence due to the lack of significant differences, though there is a slight preference for IMPL-2. However, among non-Arabic participants, only IMPL-1 is associated with boosting Confidence and Relevance in the **contemplation stage**. Therefore, according to our findings, designers of persuasive systems should consider employing IMPL-2 of the praise strategy when designing for Arabic individuals in the **contemplation stage** to increase their attention and confidence. Furthermore, for non-Arabic individuals in this stage, designers should consider employing IMPL-1 of the praise strategy to enhance confidence and relevance.

6.5.3.2.8 Reduction Strategy

In the context of the reduction strategy, among Arabic participants, neither IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) nor IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) are associated with the Confidence motivational construct in the **contemplation stage.** However, both IMPL-1 and IMPL-2 are similarly effective in attracting Attention, though there is a slightly higher preference for IMPL-1. Additionally, only IMPL-1 is associated with increasing Relevance. On the other hand, among non-Arabic participants, both IMPL-1 and IMPL-2 of the reduction strategy are similarly associated with boosting Confidence, with a slight

preference for IMPL-2. Furthermore, IMPL-2 is significantly associated with increasing relevance. Thus, designers should consider employing IMPL-1 of the reduction strategy among Arabic individuals in the **contemplation stage** to increase attention and system relevance. Furthermore, I recommend that designers consider applying IMPL-2 of the reduction strategy to increase confidence and relevance among non-Arabic individuals in this stage.

6.5.3.2.9 Competition Strategy

Concerning the competition strategy, among Arabic participants, IMPL-1 (**Competition as a Leaderboard**) emerges as the sole implementation associated with increasing Relevance, while both IMPL-1 and IMPL-2 (**Displaying a Progress Bar for Each Competitor**) are similarly associated with capturing Attention and boosting Confidence in the **contemplation stage,** though there is a slight preference for IMPL-1. On the other hand, among non-Arabic participants, only IMPL-1 is linked with stimulating Attention and increasing Satisfaction, while both IMPL-1 and IMPL-2 of the competition strategy are associated with enhancing Confidence. Therefore, designers of persuasive systems should incorporate the leaderboard aspect (IMPL-1) of the competition strategy to increase attention, confidence, and relevance among Arabic individuals and to increase attention, confidence, and satisfaction among non-Arabic individuals in the **contemplation stage**.

6.5.3.2.10 Tunneling Strategy

Concerning the tunneling strategy, for Arabic participants, both IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) are similarly associated with increasing Attention, Confidence, and Relevance due to a lack of significant differences; however, there is a slight preference for IMPL-2. Conversely, among non-Arabic participants, IMPL-2 is the only implementation associated with increasing Attention and Relevance, while both IMPL-1 and IMPL-2 of the tunneling strategy are related to boosting Confidence. Consequently, according to our findings, designers of persuasive systems should consider combining both textual instructions (IMPL-1) and map visualization for walking routes (IMPL-2) of the tunneling strategy when targeting Arabic individuals in the **contemplation stage**. Additionally, for non-Arabic individuals in this stage, designers should consider employing map visualization for

walking routes (IMPL-2) of the tunneling strategy to effectively stimulate users' attention, boost confidence, and increase system relevance.

6.5.3.2.11 Cooperation Strategy

Regarding the cooperation strategy, for Arabic participants, only IMPL-1 (**Message Exchange via Social Cooperation Networks**) is associated with boosting Confidence, strengthening Relevance, and increasing Satisfaction in the **contemplation stage.** However, among non-Arabic participants, only IMPL-2 (**Cooperation as Teamwork**) of the cooperation strategy is associated with capturing Attention, while both IMPL-1 and IMPL-2 are similarly associated with enhancing Confidence, though there is a slightly higher preference for IMPL-2. Therefore, based on our findings, designers of persuasive systems should employ message exchange via social networks (IMPL-1) of the cooperation strategy when designing for Arabic individuals in the **contemplation stage** to increase confidence, relevance, and satisfaction. Furthermore, for non-Arabic individuals in this stage, designers should consider employing teamwork and group challenges (IMPL-2) of the cooperation strategy to arouse users' attention and boost confidence.

6.5.3.2.12 Simulation Strategy

In the simulation strategy, among Arabic participants, only IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) is associated with arousing Attention and boosting Confidence. Nevertheless, for non-Arabic participants, both IMPL-1 (**Simulation as Battery Charging**) and IMPL-2 are similarly effective in stimulating Attention and enhancing Confidence. Accordingly, I recommend that designers of persuasive systems consider employing IMPL-2 of the simulation strategy for Arabic individuals in the **contemplation stage**. Moreover, when targeting non-Arabic individuals in this stage, designers have the option to select either IMPL-1 or IMPL-2 of the simulation strategy to enhance users' attention and confidence.

6.5.3.3 PREPARATION STAGE

Furthermore, individuals in the **Preparation stage** are ready to take gradual steps toward behavior change, motivated by the conviction that modifying their behavior can result in a healthier lifestyle [275]. Transitioning from the **Preparation stage** to the **Action stage** requires "self-liberation," which

involves a commitment to behavior change based on the belief that healthy behaviors are attainable [275]. This aligns with the Confidence construct of the ARCS model of motivation. Therefore, a persuasive strategy that boosts users' confidence in their ability to achieve the desired behavior will be effective for those in the **Preparation stage**. Consequently, our findings reveal that several strategy implementations are associated with increasing users' confidence and self-liberation in the **preparation stage,** as demonstrated in the following.

6.5.3.3.1 Self-monitoring Strategy

For instance, in the self-monitoring strategy, among Arabic participants, IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**) are similarly associated with boosting Confidence in the **preparation stage**, though there is a slight preference for IMPL-1. However, among non-Arabic participants in this stage, both IMPL-1 and IMPL-2 are similarly associated with boosting Confidence and increasing Satisfaction. Therefore, I recommend that designers of persuasive technology strike a balance by incorporating both textual and visual data tracking (IMPL-1 and IMPL-2) of the self-monitoring strategy among Arabic and non-Arabic individuals in the **preparation stage**.

6.5.3.3.2 Personalization Strategy

According to our findings, among Arabic participants, only IMPL-1 (**Personalized Motivational Content**) of the personalization strategy is associated with capturing Attention, enhancing Confidence, and increasing Relevance. Similarly, IMPL-1 is significantly associated with increasing Satisfaction among Arabic participants in the **preparation stage**. Additionally, for non-Arabic participants, only IMPL-1 is associated with boosting Confidence and system Relevance. Hence, designers of persuasive systems should consider employing IMPL-1 of the personalization strategy in the **preparation stage** among Arabic individuals to increase attention, confidence, and relevance and among non-Arabic individuals to reinforce confidence and system relevance in this stage.

6.5.3.3.3 Suggestion Strategy

In terms of the suggestion strategy, our findings reveal that for Arabic participants, IMPL-2 (**Visual Suggestion Notifications**) is the only implementation associated with capturing Attention, while both IMPL-1 (**Textual Suggestion Notifications**) and IMPL-2 of the suggestion strategy are similarly

effective across the remaining three motivational constructs (Confidence, Relevance, and Satisfaction), though there is a slight preference for IMPL-2. Conversely, among non-Arabic participants, IMPL-2 is significantly associated with attracting Attention and is the only implementation associated with boosting Confidence in the **preparation stage.** Thus, according to our findings, designers aiming to improve confidence and self-liberation for the users of persuasive systems should consider employing IMPL-2 of the suggestion strategy in the **preparation stage** among both Arabic and non-Arabic individuals.

6.5.3.3.4 Goal-setting Strategy

Concerning the goal-setting strategy, both IMPL-1 (**Default/System-based Goals**) and IMPL-2 (**Customized/User-Driven Goals**) are similarly associated with capturing Attention and boosting Confidence among both Arabic and non-Arabic participants in the **preparation stage.** Consequently, I recommend that designers of persuasive systems incorporate both IMPL-1 and IMPL-2 of the goal-setting strategy to increase Attention and boost confidence among individuals from both cultural backgrounds (Arabic and non-Arabic) in the **preparation stage**.

6.5.3.3.5 Reminder Strategy

In terms of the reminder strategy, among Arabic participants, only IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) is associated with enhancing Confidence, and it is significantly linked to increasing Satisfaction in the **preparation stage**. Conversely, for non-Arabic participants, only IMPL-2 of the reminder strategy is associated with grabbing Attention, while both IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 are similarly effective in improving Confidence, though there is a slightly higher preference for IMPL-2. Based on our findings, I recommend that designers of persuasive systems consider employing scheduled/customized pop-up reminders (IMPL-2) when designing for both Arabic and non-Arabic individuals in the **preparation stage.**

6.5.3.3.6 Reward Strategy

In the context of reward strategy, among Arabic participants, neither IMPL-1 (**Collecting of Virtual Reward Points**) nor IMPL-2 (**Collecting Virtual Reward Badges**) are associated with the Confidence motivational construct in the **preparation stage.** However, only IMPL-2 is associated

with increasing Attention. On the other hand, for non-Arabic participants, only IMPL-2 of the reward strategy is linked to boosting Confidence. Consequently, I recommend designers of persuasive systems to apply badge-based rewards (IMPL-2) among both Arabic and non-Arabic individuals in the **preparation stage.**

6.5.3.3.7 Praise Strategy

Concerning the praise strategy, our findings indicate that among Arabic participants, both IMPL-1 (**Textual Praise**) and IMPL-2 (**Audio and Visual Praise**) are similarly associated with increasing Attention and boosting Confidence due to a lack of significant differences; however, there is a slight preference for IMPL-1. Conversely, among non-Arabic participants, only IMPL-2 is associated with boosting Confidence in the **preparation stage.** Therefore, based on our findings, designers of persuasive systems should consider combining both IMPL-1 and IMPL-2 of the praise strategy when designing for Arabic individuals in the **preparation stage** to increase their attention and confidence. Furthermore, for non-Arabic individuals in this stage, designers should consider employing **audio and visual praise** (IMPL-2) of the praise strategy to boost confidence.

6.5.3.3.8 Reduction Strategy

In the context of the reduction strategy, among Arabic participants, both IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) and IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) are similarly associated with the Confidence and Relevance motivational constructs in the **preparation stage,** though there is a slightly higher preference for IMPL-2. Furthermore, among non-Arabic participants, both IMPL-1 and IMPL-2 of the reduction strategy are equally associated with boosting Confidence, while only IMPL-2 is associated with capturing Attention and increasing Satisfaction. Hence, according to our findings, designers should consider employing IMPL-2 of the reduction strategy among Arabic individuals in the **preparation stage** to increase confidence and system relevance and among non-Arabic individuals to enhance attention, confidence and satisfaction in this stage.

6.5.3.3.9 Competition Strategy

Regarding the competition strategy, among Arabic participants, both IMPL-1 (**Competition as a Leaderboard**) and IMPL-2 (**Displaying a Progress Bar for Each Competitor**) are similarly

associated with capturing Attention and boosting Confidence in the **preparation stage,** though there is a slight preference for IMPL-1. Additionally, only IMPL-1 is linked with increasing Relevance and Satisfaction. Furthermore, among non-Arabic participants, only IMPL-1 is associated with stimulating Attention and boosting Confidence. Thus, I recommend designers of persuasive systems to employ the leaderboard aspect (IMPL-1) of the competition strategy among Arabic individuals to enhance attention, confidence, relevance, and satisfaction and among non-Arabic individuals to improve attention and confidence in the **preparation stage**.

6.5.3.3.10 Tunneling Strategy

In the tunneling strategy, for Arabic participants, only IMPL-1 (**Tunneling as Textual/Written Instructions**) is associated with stimulating Attention, while both IMPL-1 and IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) are similarly associated with boosting Confidence in the **preparation stage,** with a slight preference for IMPL-2. Conversely, among non-Arabic participants, neither IMPL-1 nor IMPL-2 are associated with the Confidence motivational construct, while both IMPL-1 and IMPL-2 are similarly associated with attracting Attention, with a slight preference for IMPL-2. Furthermore, only IMPL-2 is linked to increasing Relevance. Hence, according to our findings, designers of persuasive systems should consider employing map visualization for walking routes (IMPL-2) of the tunneling strategy when targeting Arabic individuals in the **preparation stage** to enhance attention and confidence and among non-Arabic individuals to effectively enhance attention, confidence, and relevance.

6.5.3.3.11 Cooperation Strategy

Concerning the cooperation strategy, for Arabic participants, only IMPL-1 (**Message Exchange via Social Cooperation Networks**) is associated with stimulating Attention and boosting Confidence, while both IMPL-1 and IMPL-2 (**Cooperation as Teamwork**) are equally associated with increasing Relevance in the **preparation stage**. Conversely, among non-Arabic participants, IMPL-2 is the only implementation associated with increasing Attention, and it is significantly associated with boosting Confidence. Therefore, based on our findings, designers of persuasive systems should consider integrating message exchange via social networks (IMPL-1) of the cooperation strategy when targeting Arabic individuals in the **preparation stage** to enhance attention, confidence, and relevance.

Furthermore, for non-Arabic individuals in this stage, designers should consider employing teamwork and group challenges (IMPL-2) of the cooperation strategy to effectively arouse users' attention and boost confidence.

6.5.3.3.12 Simulation Strategy

In the simulation strategy, among Arabic participants, only IMPL-1 (**Simulation as Battery Charging**) is associated with boosting Confidence, and it is significantly linked to increasing Satisfaction in the **preparation stage**. Furthermore, for non-Arabic participants, both IMPL-1 and IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) are similarly effective at arousing Attention and enhancing Confidence, with a slight preference for IMPL-1; however, only IMPL-1 is associated with increasing Relevance and Satisfaction. Therefore, designers of persuasive systems should consider employing IMPL-1 of the simulation strategy for Arabic individuals in the **preparation stage** to enhance confidence and satisfaction and among non-Arabic individuals to enhance attention and confidence and to strengthen relevance and satisfaction.

6.5.3.4 ACTION STAGE

Individuals in the **Action stage** of behavior change demonstrate abstention from risky health behaviors, such as prolonged time spent sitting or a lack of PA, either by altering unhealthy behaviors or adopting new healthy habits [275]. To facilitate this transition and support individuals in maintaining their behavior change (i.e., reaching **the maintenance stage**), three processes of change have been proposed [174]: stimulus control, counterconditioning, and helping relationships. Employing self-monitoring, reminder, reward, and praise strategies can facilitate stimulus control, while suggestion, goal-setting, reduction, and tunneling strategies can promote counterconditioning by offering healthy alternatives or tips (e.g., standing, or walking tips like warmup exercises and stretching) for users to adopt in place of risky behaviors (e.g., SB). Establishing personalized recommendations and simulated educational tips can fulfill the need for helping relationships, which correlates with the personalization and simulation strategies. Personalizing tips, advice, and simulated educational tips not only supports helping relationships but also facilitates counterconditioning by offering learning opportunities to substitute risky behaviors. Accordingly, our findings reveal that

several strategy implementations are associated with enhancing users' attentions and confidence. Furthermore, other implementations collectively have a significant influence on attention, relevance, confidence, and satisfaction for individuals in the **action stage,** as illustrated in the following.

6.5.3.4.1 Self-monitoring Strategy

In the self-monitoring strategy, among Arabic participants, only IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**) is associated with capturing Attention, while both IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 are similarly associated with boosting Confidence, Relevance, and Satisfaction, though there is a slightly higher preference for IMPL-2. However, among non-Arabic participants, only IMPL-2 of the self-monitoring strategy is linked to stimulating Attention and increasing Relevance, while both IMPL-1 and IMPL-2 are similarly associated with boosting Confidence and increasing Satisfaction in the **action stage,** with a slight preference for IMPL-2. Therefore, based on our findings, I recommend that designers of persuasive technology employ visual data tracking (IMPL-2) of the self-monitoring strategy among Arabic and non-Arabic individuals in the **action stage**.

6.5.3.4.2 Personalization Strategy

In the personalization strategy, among Arabic participants, only IMPL-2 (**Personalized Goal Recommendations**) is associated with boosting Confidence, while both IMPL-1 (**Personalized Motivational Content**) and IMPL-2 are similarly associated with increasing Relevance and Satisfaction; however, there is a slight preference for IMPL-1. On the other hand, among non-Arabic participants, only IMPL-1 is associated with enhancing Confidence and increasing Satisfaction in the **action stage**. Therefore, according to our findings, designers of persuasive systems should consider employing IMPL-2 of the personalization strategy in the **action stage** among Arabic individuals to increase confidence, relevance, and satisfaction. Conversely, among non-Arabic individuals in this stage, designers should consider integrating IMPL-1 of the personalization strategy to emphasize confidence and satisfaction.

6.5.3.4.3 Suggestion Strategy

For individuals in the **action stage** who are actively taking steps to modify or adopt healthier behaviors [276], stimulus control through cues or prompts has been shown to be crucial [234], [276]. Therefore,

IMPL-2, which provides timely visual suggestions and tips, is more effective among Arabic and non-Arabic individuals in the **action stage** compared to IMPL-1, which offers timely textual pop-up tips. Thus, in the suggestion strategy, our findings reveal that for Arabic participants, IMPL-2 (**Visual Suggestion Notifications**) is the only implementation associated with capturing Attention, boosting Confidence, and increasing Satisfaction in the **action stage**. Furthermore, IMPL-2 is significantly associated with increasing Relevance. Conversely, among non-Arabic participants, IMPL-2 of the suggestion strategy is significantly associated with boosting Confidence, and it is the only implementation associated with increasing Relevance. Hence, based on our findings, designers of persuasive systems should consider employing IMPL-2 of the suggestion strategy in the **action stage** among Arabic individuals to improve attention, confidence, relevance, and satisfaction and among non-Arabic individuals to enhance confidence and relevance.

6.5.3.4.4 Goal-setting Strategy

In the context of the goal-setting strategy, among Arabic participants, only IMPL-2 (**Customized/User-Driven Goals**) is associated with arousing Attention and motivating Confidence in the **action stage**. On the other hand, among non-Arabic participants, only IMPL-1 (**Default/System-based Goals**) of the goal-setting strategy is effectively associated with improving Confidence and increasing Satisfaction. Subsequently, I recommend that designers of persuasive systems utilize IMPL-2 of the goal-setting strategy when targeting Arabic individuals in the **action stage** to increase attention and confidence. Furthermore, employing IMPL-1 is advised when targeting non-Arabic individuals to enhance confidence and satisfaction.

6.5.3.4.5 Reminder Strategy

In terms of the reminder strategy, among Arabic participants, only IMPL-1(**Automatic/System-based Reminders (Push Reminders)**) is associated with capturing Attention and improving Relevance in the **action stage**. Conversely, among non-Arabic participants, both IMPL-1 and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) of the reminder strategy are similarly associated with stimulating Attention, boosting Confidence, and increasing Satisfaction, though there is a slightly higher preference for IMPL-2. Therefore, based on our findings, designers of persuasive systems should consider employing push reminders (IMPL-1) among Arabic participants to increase

attention and system relevance. However, designers should consider employing both push reminders (IMPL-1) and scheduled/customized pop-up reminders (IMPL-2) when designing for non-Arabic individuals in the **action stage** to improve attention, confidence, and satisfaction. This aligns with expectations, as individuals in the **action stage** have committed to changing their risky or unhealthy behavior (e.g., prolonged sitting) and require reminders that readily attract their attention and reinforce their commitment to adopting healthy behaviors (e.g., walking), even among busy schedules.

6.5.3.4.6 Reward Strategy

Regarding the reward strategy, among Arabic participants, only IMPL-2 (**Collecting Virtual Reward Badges**) is linked to stimulating Attention and strengthening Confidence, while both IMPL-1 (**Collecting of Virtual Reward Points**) and IMPL-2 are similarly associated with improving Relevance and Satisfaction, though there is a slight preference for IMPL-2. Similarly, among non-Arabic participants, only IMPL-2 is associated with capturing Attention and increasing Satisfaction, and it is significantly associated with enhancing Relevance. Therefore, based on our findings, I recommend designers of persuasive systems to employ badge-based rewards (IMPL-2) among Arabic individuals in the **action stage** to enhance attention and confidence and among non-Arabic individuals to improve attention, relevance, and satisfaction.

6.5.3.4.7 Praise Strategy

In terms of the praise strategy, our findings indicate that among Arabic participants, both IMPL-1 (**Textual Praise**) and IMPL-2 (**Audio and Visual Praise**) are similarly associated with boosting Confidence and increasing Relevance, though there is a slightly higher preference for IMPL-1. However, among non-Arabic participants, only IMPL-2 is associated with boosting Confidence in the **action stage.** Therefore, based on our findings, designers of persuasive systems should consider choosing either IMPL-1 or IMPL-2 of the praise strategy when designing for Arabic individuals in the **action stage** to increase confidence and relevance. Furthermore, for non-Arabic individuals in this stage, designers should consider employing audio and visual praise (IMPL-2) of the praise strategy to boost confidence.

6.5.3.4.8 Reduction Strategy

In the context of the reduction strategy, among Arabic participants, only IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) is linked to stimulating Attention and enhancing Relevance in the **action stage**. However, among non-Arabic participants, both IMPL-1 and IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) of the reduction strategy are similarly associated with boosting Confidence, though there is a slightly higher preference for IMPL-2. Therefore, based on our findings, designers should consider employing IMPL-1 of the reduction strategy among Arabic individuals in the **action stage** to improve attention and relevance. Furthermore, designers should consider employing IMPL-2 of the reduction strategy among non-Arabic individuals to enhance confidence in this stage.

6.5.3.4.9 Competition Strategy

Regarding the competition strategy, among Arabic participants, only IMPL-1 (**Competition as a Leaderboard**) is associated with arousing Attention, strengthening Confidence, and enhancing Satisfaction in the **action stage**. Similarly, among non-Arabic participants, only IMPL-1 of the competition strategy is linked to attracting Attention and increasing Satisfaction. Additionally, both IMPL-1 and IMPL-2 (**Displaying a Progress Bar for Each Competitor**) are similarly associated with boosting Confidence, though there is a slight preference for IMPL-1. Accordingly, designers of persuasive systems should consider employing the leaderboard aspect (IMPL-1) of the competition strategy among Arabic individuals to enhance attention, confidence, and satisfaction in the **action stage**. Additionally, I recommend that designers consider combining both the leaderboard aspect (IMPL-1) and progress bars (IMPL-2) of the competition strategy for non-Arabic individuals, with the aim to enhance attention, confidence, and satisfaction.

6.5.3.4.10 Tunneling Strategy

In the tunneling strategy, for Arabic participants, only IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) is associated with capturing Attention and increasing Relevance, while both IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 are similarly associated with boosting Confidence and increasing Satisfaction; however, there is a slightly higher preference for IMPL-2. Furthermore, among non-Arabic participants, only IMPL-2 is linked to arousing Attention and increasing Satisfaction, while both IMPL-1 and IMPL-2 are similarly associated with enhancing

Confidence and Relevance; however, there is a slightly higher preference for IMPL-2. Hence, I recommend that designers of persuasive systems consider employing map visualization for walking routes (IMPL-2) of the tunneling strategy when targeting both Arabic and non-Arabic individuals in the **action stage** to enhance attention, confidence, relevance, and satisfaction.

6.5.3.4.11 Cooperation Strategy

In the cooperation strategy, for Arabic participants, only IMPL-2 (**Cooperation as Teamwork**) is associated with boosting Confidence, and it is significantly associated with increasing Satisfaction in the **action stage**. Furthermore, among non-Arabic participants, IMPL-2 is the only implementation associated with enhancing Relevance and it is significantly linked to increasing Satisfaction, while both IMPL-1 (**Message Exchange via Social Cooperation Networks**) and IMPL-2 are similarly associated with capturing Attention. Therefore, based on our findings, designers of persuasive systems should consider employing teamwork and group challenges (IMPL-2) of the cooperation strategy when targeting Arabic individuals in the **action stage.** Moreover, for non-Arabic individuals in this stage, designers of persuasive systems should consider integrating both IMPL-1 and IMPL-2 of the cooperation strategy to comprehensively enhance attention, relevance, and satisfaction.

6.5.3.4.12 Simulation Strategy

In the simulation strategy, among Arabic participants, only IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) is associated with stimulating Attention, while both IMPL-1 (**Simulation as Battery Charging**) and IMPL-2 are similarly associated with boosting Confidence, enhancing Relevance, and increasing Satisfaction, though there is a slight preference for IMPL-2. Conversely, among non-Arabic participants, only IMPL-1 is linked to strengthening Confidence, while both IMPL-1 and IMPL-2 are similarly effective at arousing Attention; however, there is a slightly higher preference for IMPL-1. Hence, I recommend that designers of persuasive systems consider employing IMPL-2 of the simulation strategy for Arabic individuals in the **action stage** to enhance attention, confidence, relevance, and satisfaction. Furthermore, I recommend designers to apply IMPL-1 among non-Arabic individuals in this stage to improve attention and confidence.

6.5.3.5 MAINTENANCE STAGE

Individuals in the **Maintenance stage** have successfully adopted and need to preserve their healthy behaviors. While a "fading out" phase has been proposed to gradually reduce interventions as users sustain behavior changes over time [174], negative outcomes may occur when personal counseling is discontinued for individuals in the **maintenance stage** [235]. This is not unexpected, as users may have become reliant on behavior change interventions, driven by various persuasive strategies, for their motivation as they progressed through different stages [218]. Our findings indicate that various strategy implementations are linked to improving users' attention, confidence, and satisfaction. Moreover, other implementations have a significant influence on one or more of the four motivational constructs—attention, confidence, relevance, and satisfaction—for individuals in the **maintenance stage,** as demonstrated in the following.

6.5.3.5.1 Self-monitoring Strategy

In the self-monitoring strategy, among Arabic participants, only IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**) is associated with capturing Attention and increasing Satisfaction. Furthermore, it is significantly associated with boosting Confidence in the **maintenance stage**. Conversely, among non-Arabic participants, only IMPL-2 of the self-monitoring strategy is linked to stimulating Attention and increasing Relevance, while both IMPL-1 (**Textual and Numerical Feedback such as textual representation**) and IMPL-2 are similarly associated with enhancing Confidence and increasing Satisfaction, though there is a slightly higher preference for IMPL-2. Therefore, based on our findings, designers of persuasive technology should consider utilizing visual data tracking (IMPL-2) of the self-monitoring strategy among Arabic individuals to preserve attention, confidence, and satisfaction and among non-Arabic individuals to maintain attention, confidence, and satisfaction and enhance system relevance in the **maintenance stage**.

6.5.3.5.2 Personalization Strategy

In the personalization strategy, among Arabic participants, IMPL-1 (**Personalized Motivational Content**) is significantly associated with increasing Relevance, while both IMPL-1 and IMPL-2 (**Personalized Goal Recommendations**) are similarly associated with capturing Attention and boosting Confidence; however, there is a slight preference for IMPL-1. On the other hand, among non-

Arabic participants, only IMPL-1 of the personalization strategy is associated with stimulating Attention and increasing Satisfaction, while IMPL-2 is the only implementation associated with enhancing Confidence and Relevance in the **maintenance stage**. Thus, based on our findings, I recommend designers of persuasive systems to consider employing personalized motivational content (IMPL-1) of the personalization strategy in the **maintenance stage** among Arabic individuals to maintain attention, confidence, and relevance. Furthermore, among non-Arabic individuals in this stage, designers have the option to either integrate personalized motivational content (IMPL-1) to preserve attention and satisfaction or personalized goal recommendations (IMPL-2) to enhance confidence and relevance or both strategies simultaneously.

6.5.3.5.3 Suggestion Strategy

Individuals in the **Maintenance stage** have already embraced healthy behaviors and require ongoing support to preserve these changes. Thus, offering timely visual suggestions and tips (IMPL-2) about healthy PA options can preserve users' awareness (attention), confidence, satisfaction, and system relevance. This aligns with our findings, as IMPL-2 presents healthy tips and options in a visual format, allowing users to easily explore and properly learn suggested healthy practices. In contrast, IMPL-1 of the suggestion strategy relies on plain textual suggestions and tips, which may not be as engaging or intuitive for users. Accordingly, in the suggestion strategy, our findings reveal that for Arabic participants, IMPL-2 (**Visual Suggestion Notifications**) is the only implementation associated with increasing Satisfaction in the **maintenance stage**, while both IMPL-1 (**Textual Suggestion Notifications**) and IMPL-2 are similarly associated with stimulating Attention, reinforcing Confidence, and enhancing Relevance, though IMPL-2 is slightly preferred. Furthermore, among non-Arabic participants, IMPL-2 of the suggestion strategy is the sole implementation associated with capturing Attention and improving Satisfaction, while both IMPL-1 and IMPL-2 are similarly associated with boosting Confidence and increasing Relevance, with a slight preference for IMPL-2. Consequently, according to our findings, I recommend that designers of persuasive systems consider applying visual suggestions and tips (IMPL-2) of the suggestion strategy in the **maintenance stage** for Arabic and non-Arabic individuals.

6.5.3.5.4 Goal-setting Strategy

In the **maintenance stage**, individuals possess the knowledge, strength, and confidence to set suitable step count goals, often surpassing the default recommended step counts provided by the system. This is unsurprising, given that individuals in this stage have already committed to adopting a healthier lifestyle for an extended period (e.g., more than 6 months). Accordingly, in the goal-setting strategy, among Arabic participants, only IMPL-2 (**Customized/User-Driven Goals**) is associated with boosting Confidence in the **maintenance stage**. Furthermore, among non-Arabic participants, only IMPL-2 of the goal-setting strategy is effectively associated with improving Confidence, and it is significantly associated with arousing Attention and increasing Satisfaction. Therefore, designers of persuasive systems should consider employing IMPL-2 of the goal-setting strategy among Arabic individuals in the **maintenance stage** to increase confidence and among non-Arabic individuals to stimulate attention, enhance confidence, and increase satisfaction.

6.5.3.5.5 Reminder Strategy

In terms of the reminder strategy, among Arabic participants, only IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**) is associated with stimulating Attention, while both IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 are similarly associated with increasing Relevance in the **maintenance stage,** with a slight preference for IMPL-2. Additionally, among non-Arabic participants, only IMPL-2 of the reminder strategy is linked to enhancing Relevance, and it is significantly associated with increasing Satisfaction. However, both IMPL-1 and IMPL-2 of the reminder strategy are similarly associated with boosting Confidence, with a slight preference for IMPL-2. Therefore, based on our findings, designers of persuasive systems should consider employing scheduled/customized pop-up reminders (IMPL-2) in the **maintenance stage** among Arabic participants to maintain attention and system relevance and among non-Arabic individuals to preserve confidence, relevance, and satisfaction.

6.5.3.5.6 Reward Strategy

Concerning the reward strategy, among Arabic participants, only IMPL-2 (**Collecting Virtual Reward Badges**) is associated with increasing Satisfaction, while it is significantly associated with enhancing Relevance. Furthermore, both IMPL-1 (**Collecting of Virtual Reward Points**) and IMPL-2 are similarly associated with arousing Attention and boosting Confidence, with a slight preference

for IMPL-2. Conversely, among non-Arabic participants, only IMPL-2 of the reward strategy is associated with capturing Attention and improving Relevance. Therefore, based on our findings, designers of persuasive systems should consider applying badge-based rewards (IMPL-2) among Arabic individuals in the **maintenance stage** to specifically enhance relevance and satisfaction and among non-Arabic individuals to improve attention and system relevance.

6.5.3.5.7 Praise Strategy

In the praise strategy, our findings indicate that among Arabic participants, only IMPL-1 (**Textual Praise**) is associated boosting Confidence and increasing Satisfaction, while IMPL-2 (**Audio and Visual Praise**) is significantly associated with capturing Attention in the **maintenance stage**. However, among non-Arabic participants, only IMPL-2 is linked to stimulating Attention and increasing Relevance. Therefore, I recommend designers of persuasive systems to consider combining IMPL-1 and IMPL-2 of the praise strategy when designing for Arabic individuals in the **maintenance stage** to comprehensively maintain attention, confidence, and satisfaction. Furthermore, for non-Arabic individuals in this stage, I recommend designers to consider utilizing textual praise (IMPL-1) of the praise strategy to improve attention and relevance.

6.5.3.5.8 Reduction Strategy

In terms of the reduction strategy, among Arabic participants, only IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) is associated with arousing Attention and reinforcing Confidence in the **maintenance stage**. However, IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) is significantly associated with enhancing Relevance, and it is the only implementation associated with increasing Satisfaction. On the other hand, among non-Arabic participants, only IMPL-2 of the reduction strategy is associated with stimulating Attention, while it is significantly associated with boosting Confidence. Thus, based on our findings designers of persuasive systems have the option of whether to employ IMPL-1 or IMPL-2 of the reduction strategy among Arabic individuals in the **maintenance stage.** However, I recommend that designers consider integrating both IMPL-1 and IMPL-2 of the reduction strategy for Arabic individuals to preserve attention, confidence, relevance, and satisfaction. Furthermore, designers should consider employing

IMPL-2 of the reduction strategy among non-Arabic individuals to maintain attention and confidence in this stage.

6.5.3.5.9 Competition Strategy

Regarding the competition strategy, among Arabic participants, both IMPL-1 (**Competition as a Leaderboard**) and IMPL-2 (**Displaying a Progress Bar for Each Competitor**) are similarly associated with arousing Attention, boosting Confidence, increasing Relevance, and enhancing Satisfaction due to a lack of significant differences. Conversely, among non-Arabic participants, only IMPL-1 of the competition strategy is linked to strengthening Confidence and improving Relevance in the **maintenance stage**. Therefore, according to our findings, designers of persuasive systems have the flexibility to employ either the leaderboard (IMPL-1) or progress bar (IMPL-2) of the competition strategy among Arabic individuals. Furthermore, I recommend designers to employ the leaderboard (IMPL-1) of the competition strategy among non-Arabic individuals to maintain confidence and relevance in the **maintenance stage**.

6.5.3.5.10 Tunneling Strategy

In the tunneling strategy, for Arabic participants, only IMPL-2 (**Tunneling as Map Visualization for Walking Routes**) is associated with arousing Attention and boosting Confidence, while both IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 are equally associated with enhancing Relevance in the **maintenance stage**. Furthermore, among non-Arabic participants, IMPL-2 of the tunneling strategy is the only implementation associated with increasing Satisfaction, while both IMPL-1 and IMPL-2 are similarly associated with boosting Confidence and enhancing Relevance, with a slight preference for IMPL-2. Consequently, based on our findings, I recommend that designers of persuasive systems consider employing map visualization for walking routes (IMPL-2) of the tunneling strategy when targeting Arabic individuals to maintain attention, confidence and system relevance and for non-Arabic individuals to preserve confidence, relevance, and satisfaction in the **maintenance stage.**

6.5.3.5.11 Cooperation Strategy

In the cooperation strategy, for Arabic participants, only IMPL-1 (**Message Exchange via Social Cooperation Networks**) is associated with boosting Confidence, while both IMPL-1 and IMPL-2

(**Cooperation as Teamwork**) are similarly associated with attracting Attention and increasing Satisfaction, with a slight preference for IMPL-1. Conversely, among non-Arabic participants, IMPL-2 of the cooperation strategy is the only implementation associated with capturing Attention, while both IMPL-1 and IMPL-2 are similarly associated with boosting Confidence and increasing Satisfaction, with a slight preference for IMPL-2. Hence, based on our findings, I recommend that designers of persuasive systems consider employing message exchange via social networks (IMPL-1) when targeting Arabic individuals to maintain attention, confidence and satisfaction. Furthermore, I recommend that designers apply teamwork and group challenges (IMPL-2) of the cooperation strategy when targeting non-Arabic individuals to help maintain attention, confidence and satisfaction in the **maintenance stage.**

6.5.3.5.12 Simulation Strategy

In the simulation strategy, among Arabic participants, only IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**) is associated with capturing Attention, while it is significantly associated with boosting Confidence. Furthermore, both IMPL-1 (**Simulation as Battery Charging**) and IMPL-2 are similarly associated with enhancing Relevance, and increasing Satisfaction, with a slight preference for IMPL-2. Additionally, among non-Arabic participants, only IMPL-2 is linked to strengthening Relevance, while both IMPL-1 and IMPL-2 are similarly associated with stimulating Attention, motivating Confidence, and improving Satisfaction, with IMPL-2 slightly preferred. Based on our findings, I recommend that designers of persuasive systems consider employing IMPL-2 of the simulation strategy for both Arabic and non-Arabic individuals in the **maintenance stage**. This approach can help maintain attention and confidence while also providing means of system relevance and user satisfaction. This finding is expected, as users in the maintenance stage are likely to be highly motivated to observe the cause-and-effect relationship between their PA performance and progress over an extended period (e.g., more than 6 months). Displaying animated body-shape transformations before and after their achievements allows them to celebrate their progress, fostering confidence and a sense of satisfaction.

Table 27: Recommended Implementation Choices for Persuasive System Design Across Stages of Behavior Change Among Arabic and Non-Arabic Populations.

Recommended Implementation Choices for Persuasive System Design Among SoC				
#	**Persuasive Strategies**	**Stages of Change**	**Arabic**	**Non-Arabic**
1	Self-monitoring	Precontemplation	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**	Employing IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**
		Contemplation	Employing IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**	Employing IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**
		Preparation	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Textual and Numerical Feedback, such as textual representation**) and IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**
		Action	Employing IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**	Employing IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**
		Maintenance	Employing IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**	Employing IMPL-2 **(Numerical and Visual Feedback, such as pie charts, graphs, and progress bars)**
2	Personalization	Precontemplation	Employing IMPL-2 (**Personalized Goal Recommendations**)	Selecting either IMPL-1 or IMPL-2: IMPL-1 (**Personalized Motivational Content**) or IMPL-2 (**Personalized Goal Recommendations**)

		Contemplation	Employing IMPL-1 (**Personalized Motivational Content**)	Employing IMPL-2 (**Personalized Goal Recommendations**)
		Preparation	Employing IMPL-1 (**Personalized Motivational Content**)	Employing IMPL-1 (**Personalized Motivational Content**)
		Action	Employing IMPL-2 (**Personalized Goal Recommendations**)	Employing IMPL-1 (**Personalized Motivational Content**)
		Maintenance	Employing IMPL-1 (**Personalized Motivational Content**)	Selecting either IMPL-1 or IMPL-2 or both: IMPL-1 (**Personalized Motivational Content**) or IMPL-2 (**Personalized Goal Recommendations**) or both
3	Suggestion	Precontemplation	Employing IMPL-2 (**Visual Suggestion Notifications**)	Employing IMPL-1 (**Textual Suggestion Notifications**)
		Contemplation	Employing IMPL-2 (**Visual Suggestion Notifications**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Textual Suggestion Notifications**) and IMPL-2 (**Visual Suggestion Notifications**)
		Preparation	Employing IMPL-2 (**Visual Suggestion Notifications**)	Employing IMPL-2 (**Visual Suggestion Notifications**)
		Action	Employing IMPL-2 (**Visual Suggestion Notifications**)	Employing IMPL-2 (**Visual Suggestion Notifications**)
		Maintenance	Employing IMPL-2 (**Visual Suggestion Notifications**)	Employing IMPL-2 (**Visual Suggestion Notifications**)

4	Goal-setting	Precontemplation	Employing IMPL-1 (**Default/System-based Goals**)	Employing IMPL-1 (**Default/System-based Goals**)
		Contemplation	Employing IMPL-2 (**Customized/User-Driven Goals**)	Employing IMPL-1 (**Default/System-based Goals**)
		Preparation	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Default/System-based Goals**) and IMPL-2 (**Customized/User-Driven Goals**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Default/System-based Goals**) and IMPL-2 (**Customized/User-Driven Goals**)
		Action	Employing IMPL-2 (**Customized/User-Driven Goals**)	Employing IMPL-1 (**Default/System-based Goals**)
		Maintenance	Employing IMPL-2 (**Customized/User-Driven Goals**)	Employing IMPL-2 (**Customized/User-Driven Goals**)
5	Reminders	Precontemplation	Employing IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**)
		Contemplation	Employing IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**)
		Preparation	Employing IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**)	Employing IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**)

		Action	Employing IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Automatic/System-based Reminders (Push Reminders)**) and IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**)
		Maintenance	Employing IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**)	Employing IMPL-2 (**Customized/User-Driven Reminders (Pop-up Reminders)**)
6	Rewards	Precontemplation	Employing IMPL-2 (**Collecting Virtual Reward Badges**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Collecting of Virtual Reward Points**) and IMPL-2 (**Collecting Virtual Reward Badges**)
		Contemplation	Employing IMPL-2 (**Collecting Virtual Reward Badges**)	Employing IMPL-2 (**Collecting Virtual Reward Badges**)
		Preparation	Employing IMPL-2 (**Collecting Virtual Reward Badges**)	Employing IMPL-2 (**Collecting Virtual Reward Badges**)
		Action	Employing IMPL-2 (**Collecting Virtual Reward Badges**)	Employing IMPL-2 (**Collecting Virtual Reward Badges**)
		Maintenance	Employing IMPL-2 (**Collecting Virtual Reward Badges**)	Employing IMPL-2 (**Collecting Virtual Reward Badges**)
7	Praise	Precontemplation	Employing IMPL-2 (**Audio and Visual Praise**)	Employing IMPL-1 (**Textual Praise**)
		Contemplation	Employing IMPL-2 (**Audio and Visual Praise**)	Employing IMPL-1 (**Textual Praise**)

		Preparation	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Textual Praise**) and IMPL-2 (**Audio and Visual Praise**)	Employing IMPL-2 (**Audio and Visual Praise**)
		Action	Selecting either IMPL-1 or IMPL-2: IMPL-1 (**Textual Praise**) or IMPL-2 (**Audio and Visual Praise**)	Employing IMPL-2 (**Audio and Visual Praise**)
		Maintenance	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Textual Praise**) and IMPL-2 (**Audio and Visual Praise**)	Employing IMPL-1 (**Textual Praise**)
8	Reduction	Precontemplation	Employing IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**)	Selecting either IMPL-1 or IMPL-2: IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) or IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**)
		Contemplation	Employing IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**)	Employing IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**)
		Preparation	Employing IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**)	Employing IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**)
		Action	Employing IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**)	Employing IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**)
		Maintenance	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**) and IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**)	Employing IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**)

9	Competition	Precontemplation	Employing IMPL-1 (**Competition as a Leaderboard**)	Employing IMPL-1 (**Competition as a Leaderboard**)
		Contemplation	Employing IMPL-1 (**Competition as a Leaderboard**)	Employing IMPL-1 (**Competition as a Leaderboard**)
		Preparation	Employing IMPL-1 (**Competition as a Leaderboard**)	Employing IMPL-1 (**Competition as a Leaderboard**)
		Action	Employing IMPL-1 (**Competition as a Leaderboard**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Competition as a Leaderboard**) and IMPL-2 (**Displaying a Progress Bar for Each Competitor**)
		Maintenance	Selecting either IMPL-1 or IMPL-2: IMPL-1 (**Competition as a Leaderboard**) or IMPL-2 (**Displaying a Progress Bar for Each Competitor**)	Employing IMPL-1 (**Competition as a Leaderboard**)
10	Tunneling	Precontemplation	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)
		Contemplation	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Tunneling as Textual/Written Instructions**) and IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)
		Preparation	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)

		Action	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)
		Maintenance	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)	Employing IMPL-2 (**Tunneling as Map Visualization for Walking Routes**)
11	Cooperation	Precontemplation	Selecting either IMPL-1 or IMPL-2: IMPL-1 (**Message Exchange via Social Cooperation Networks**) or IMPL-2 (**Cooperation as Teamwork**)	Employing IMPL-2 (**Cooperation as Teamwork**)
		Contemplation	Employing IMPL-1 (**Message Exchange via Social Cooperation Networks**)	Employing IMPL-2 (**Cooperation as Teamwork**)
		Preparation	Employing IMPL-1 (**Message Exchange via Social Cooperation Networks**)	Employing IMPL-2 (**Cooperation as Teamwork**)
		Action	Employing IMPL-2 (**Cooperation as Teamwork**)	Combining both IMPL-1 and IMPL-2: IMPL-1 (**Message Exchange via Social Cooperation Networks**) and IMPL-2 (**Cooperation as Teamwork**)
		Maintenance	Employing IMPL-1 (**Message Exchange via Social Cooperation Networks**)	Employing IMPL-2 (**Cooperation as Teamwork**)
12	Simulation	Precontemplation	Employing IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**)	Selecting either IMPL-1 or IMPL-2: IMPL-1 (**Simulation as Battery Charging**) or IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**)
		Contemplation	Employing IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images)**)	Selecting either IMPL-1 or IMPL-2: IMPL-1 (**Simulation as Battery Charging**) or IMPL-2 (**Simulation as**

				Educational Tips/Images (Current and Target Body-Shape Images))
		Preparation	Employing IMPL-1 (**Simulation as Battery Charging)**	Employing IMPL-1 (**Simulation as Battery Charging)**
		Action	Employing IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images))**	Employing IMPL-1 (**Simulation as Battery Charging)**
		Maintenance	Employing IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images))**	Employing IMPL-2 (**Simulation as Educational Tips/Images (Current and Target Body-Shape Images))**

6.5.4 Phase 4: Recommendations and Design Guidelines for Arabic and Non-Arabic Populations

This section provides an in-depth exploration and discussion of recommendations and app design guidelines from both Arabic and non-Arabic populations. The results emphasize unique preferences, underscoring the crucial significance of tailoring interventions to meet cultural and context-specific requirements. **Error! Reference source not found.** and **Error! Reference source not found.** present design guidelines for persuasive PA apps, informed by the comments and feedback of Arabic and non-Arabic participants. Furthermore, this study empirically investigated and compared the perceived persuasiveness of various implementations of each persuasive strategy. Our findings uncovered valuable insights that can guide design decisions. The results demonstrated that the effectiveness of different implementations of the same persuasive strategy varies among individuals from both Arabic and non-Arabic populations. I provided design guidelines based on investigating and addressing the preferences, perspectives, and recommendations provided by both Arabic and non-Arabic participants, as illustrated in the following.

6.5.4.1 Self-monitoring Strategy

For instance, when implementing the *self-monitoring* strategy in the form of graphs or charts, as demonstrated in IMPL-2 (**Numerical and Visual Feedback, such as pie charts, graphs, and progress bars**), it was perceived as more persuasive than IMPL-1 (**Textual and Numerical Feedback**) by both Arabic and non-Arabic participants. This preference stemmed from the effective use of visual tracking and feedback in IMPL-2, offering clear progress information. Real-time visual aids such as bars and charts were found to be helpful in tracking progress, and participants appreciated the overall visual appeal, readability, and engagement of this implementation. The colorful and well-structured design drew users in and enhanced their understanding. Additionally, participants expressed gratitude for the quicker access to information through graphical representations, aligning with existing research that indicates visuals are generally perceived as more persuasive, beneficial, and trustworthy than text [115] [274]. Consequently, **designers of persuasive applications should prioritize the use of visuals, such as graphs or charts, to display users' progress and performance**. The following are some comments from Arabic and non-Arabic participants:

"*From my perspective, I find that apps with **graphical representations** are **better and quicker** for accessing the required information.*" [Ar.P - 23] (IMPL-2), "*The formatting is **better** than the previous one and **very engaging**. Also **colorful**.*" [En.P - 133] (IMPL-2).

6.5.4.2 Personalization Strategy

Furthermore, the implementation of the *personalization* strategy, represented by IMPL-1 (**Personalized Motivational Content**), was more preferred by Arabic participants, while IMPL-2 (**Personalized Goal Recommendations**) was favored by non-Arabic participants. Arabic participants appreciated the appeal of motivational words and messages in the personalized motivational content, which instilled a sense of belonging and boosted self-confidence, ultimately enhancing PA performance and promoting an active lifestyle. Moreover, Arabic participants emphasized the importance of providing positive and encouraging feedback, accompanied by engaging icons, while avoiding discouraging feedback. On the other hand, non-Arabic participants valued the system's goal-oriented approach comprised of manageable steps to achieve targets. They found personalized goal recommendations useful for personal motivation and guidance, likening it to having a personal trainer. However, some non-Arabic participants recommended incorporating motivation-boosting features while setting reasonable limits on PA goals to prevent adverse outcomes. They also emphasized the

necessity of offering positive and motivational recommendations, supported by clear justifications and explanations, to ensure users better comprehend the suggested changes or goals. Combining both implementations (IMPL-1 and IMPL-2) of the personalization strategy, including personalized motivational content and personalized goal recommendations, would yield greater benefits in terms of users' PA engagement and motivation. Therefore, **I recommend that designers tailor the personalization strategy in the PA domain for Arabic users by focusing on personalized motivational content and avoiding the use of negative feedback to prevent discouragement. Conversely, I suggest that designers employ the personalization strategy in the PA domain for non-Arabic participants, integrating both implementations as personalized motivational content and personalized goal recommendations. Additionally, it is crucial to set goal limits and offer clear justifications and explanations for the recommended PA goals.** The following are comments provided by Arabic and non-Arabic participants:

"It would be more enjoyable ***if fun icons appear when the daily requirements are met****."* [Ar.P - 96] (IMPL-1), "*It should offer* ***congratulations and comfort*** *instead of* ***urging users to reach that goal***" [Ar.P - 262] (IMPL-1), "*I feel that this would help aid in* ***motivation****, however, there would* ***need to be a limit to ensure negative results do not emerge from increasing the goal****."* [En.P - 325] (IMPL-2), "***Needs justification of the suggestion****."* [En.P - 335] (IMPL-2).

6.5.4.3 Suggestion Strategy

Moreover, the implementation of the *suggestion* strategy, represented by IMPL-2 (**Visual Suggestion Notifications**), was significantly more persuasive than IMPL-1 (**Textual Suggestion Notifications**). In essence, individuals from both populations (Arabic and non-Arabic) preferred the inclusion of images and visual instructions, finding them motivating, helpful, and clear. On the other hand, textual suggestions and tip notifications offered timely recommendations, which are known to be effective in behavior change interventions, while avoiding the risk of becoming repetitive and annoying over time. Therefore, **I recommend that designers of PA persuasive applications provide users with visually appealing, clear, and regularly updated suggestions, along with adaptive textual tips that are unobtrusive**. The following comments were provided by Arabic and non-Arabic participants:

"***Tips*** *are beneficial when* ***they are regularly updated*** *and* ***directly applicable to my activities***." [Ar.P - 136] (IMPL-1), "*These types of tips would be useful* ***but the amount of pop ups need to be limited***." [En.P - 11] (IMPL-2).

6.5.4.4 Goal-setting Strategy

In the context of the *goal-setting* strategy, as presented in IMPL-2 (**Customized/User-Driven Goals**), both Arabic and non-Arabic participants demonstrated a strong preference for customizing their PA goals rather than accepting the automatic ones assigned by the system as in IMPL-1 (**Default/System-based Goals**). They appreciated the ability to set personalized goals that matched their abilities, preferences, circumstances, and health conditions. They highly valued the adaptability of the customized implementation, enabling them to start at their individual fitness levels and make adjustments to achieve their specific goals. However, participants recommended offering initial goal suggestions provided by the system, which could then be customized by users. They also suggested that the system provide informative health-based goal-setting guidelines for awareness and educational purposes. Consequently, it would be more beneficial to consider combining both implementations of default and customized goals (IMPL-1 and IMPL-2) within the goal-setting strategy while ensuring the inclusion of essential information to guide users in establishing their target goals. Therefore, **I recommend that designers integrate both automatic system-based goals and customized user-driven goals while also ensuring the provision of informative goal-setting guidelines tailored to users' age, gender, activity level, and health conditions**. Below are comments offered by Arabic and non-Arabic participants:

"*I like that I can set the goal* ***according to my circumstances***." [Ar.P - 60] (IMPL-2), "***Customized goal*** *is great as it would help the older aged user based on* ***their health conditions***." [Ar.P - 543] (IMPL-2), "***Everyone starts at different stages****...Being able to change this setting would help me* ***stay on track and meet the goals*** *that I want to meet.*" [En.P - 331] (IMPL-2), "*A person needs to* ***know the appropriate number of steps for their health*** *and needs* ***based on age, gender, and their physical activities***." [Ar.P - 21] (IMPL-2), "*The ability to set my step goal is good,* ***but it should have more information about goals*** *that would be helpful for me to set.*" [En.P - 24] (IMPL-2), "*I think a* ***combination of suggested and personalized goals*** *would be best.*" [En.P - 314] (IMPL-2).

6.5.4.5 Reminder Strategy

Moreover, the implementation of the *reminder* strategy, represented by IMPL-1 (**Automatic/System-based Reminders - Push Reminders)**, was more preferred by Arabic participants, while IMPL-2 (**Customized/User-Driven Reminders - Pop-up Reminders)** was favored by non-Arabic participants. Arabic participants found monitoring and frequent nudges in the form of push reminders to be helpful for user engagement and motivation in overcoming laziness. On the other hand, non-Arabic participants found customized pop-up reminders, which were based on users' schedules and availability, to be more relevant and organized, especially for those with busy and monotonous routines. However, both Arabic and non-Arabic populations recommended integrating both implementations of automatic push and customized pop-up reminders. They emphasized the importance of optimizing and balancing reminder notifications to avoid feeling pushy and to allow users to customize reminder times for a more personalized experience and greater flexibility according to their needs, preferences, and availability. Therefore, **I recommend that designers combine the use of automatic push reminders along with customized pop-up reminders while ensuring a balance in providing reminders to avoid intrusiveness and annoyance. This approach can increase users' engagement and motivation**. The following are comments provided by Arabic and non-Arabic participants:

"*I hope there is* ***time to set the reminder***." [Ar.P - 503] (IMPL-1), "*Nice feature,* ***as long as it can be configured***." [En.P - 303] (IMPL-1), "*Reminders are helpful* ***but I just hope they're not too frequent***." [En.P - 336] (IMPL-1), "***Great*** *feature, can be even* ***better if had both hourly reminders plus customized times***." [En.P - 311] (IMPL-2).

6.5.4.6 Reward Strategy

Regarding the *reward* strategy, our results indicated that both Arabic and non-Arabic participants found badges in IMPL-2 (**Collecting Virtual Reward Badges**) to be more persuasive than points in IMPL-1 (**Collecting Virtual Reward Points**). Moreover, participants from both populations expressed an interest in exchanging accumulated badges or points for tangible items such as money, app store credits, gift cards, discount offers, or goods. While tangible rewards have the potential to enhance user engagement [168], designers should exercise caution to avoid diverting the actual benefits of adopting desired behaviors towards external incentives [53] [213]. However, some Arabic participants recommended combining points and badges for a more motivating rewards system.

Therefore, **I recommend that designers tailor the reward strategy in persuasive PA apps for Arabic users by combining points and badges to increase motivation and engagement. Furthermore, I recommend that designers tailor the reward strategy for non-Arabic users by employing badges as the preferred reward implementation over points**. The following comments were provided by Arabic and non-Arabic participants:

"*Badges will be an **excellent motivator** for many people as they represent **measurable and achievable goals and challenges***." [Ar.P - 30] (IMPL-2), "***Both features are nice**, whether through points or badges, and **I think they can be integrated to make it even better***." [Ar.P - 31] (IMPL-2), "*If virtual rewards were **converted into tangible rewards** when achieving more virtual badges, it would motivate people even more.*" [Ar.P - 117] (IMPL-2), "*Virtual **badges rewards** really **bring me a sense of accomplishment** and an endeavor to accomplish more goals and possibly set and **accomplish even tougher goals***." [En.P - 306] (IMPL-2), "***Perhaps something more tangible like a gift card would be better***." [En.P - 316] (IMPL-2).

6.5.4.7 Praise Strategy

Regarding the *praise* strategy, IMPL-2 (**Audio and Visual Praise**) was preferred by Arabic participants, while IMPL-1 (**Textual Praise**) was favored by non-Arabic participants. Arabic participants found audio and visual praise to bring positive feedback and celebratory effects, such as clapping sounds and fireworks, that enhanced their experience and enjoyment. On the other hand, non-Arabic participants preferred textual praise because they felt motivated and appreciated through friendly compliments. They found that language-based encouragement enhanced their determination and activity during sports. However, integrating both textual and audio-visual praise might have a greater benefit in motivating a wider range of audiences, especially if employed with frequently refreshed and updated messages. It is essential to maintain control over sound volume and duration customization by users (e.g., high, low, on, off) to avoid drawing unwanted attention or causing annoyance in public or during important times (e.g., meetings, lectures, appointments). Therefore, **I recommend that designers tailor the praise strategy for non-Arabic users to employ textual praise while ensuring a balanced and moderated approach to effectively motivate and encourage users. Furthermore, I recommend that designers tailor audio and visual praise for Arabic users. I also suggest that designers integrate both textual and audio-visual praise to appeal to an even wider audience (e.g., Arabic and non-Arabic populations) while providing users with the**

flexibility to customize the sound volume and duration. Below are comments provided by Arabic and non-Arabic participants:

"*Offering praise is a **positive** choice. Moreover, the inclusion of **clapping sounds**, **fireworks**, and **visually appealing effects** feels like a celebration of my efforts.*" [Ar.P - 234] (IMPL-2), "***Feels** like a **real compliment** from a friend.*" [En.P - 285] (IMPL-1), "*The **language encouragement** can **call the heart more** unyielding voice, so that **I be more active in sports**.*" [En.P - 367] (IMPL-1), "*I suggest **refreshing the phrases and changing them** every time*." [Ar.P - 43] (IMPL-1), "*I think it is **nice** to get some praise, **in moderation**.*" [En.P - 314] (IMPL-1), "***As long as I have some control over the volume and length of the sounds**, I'd be okay with it.*" [En.P - 49] (IMPL-2).

6.5.4.8 Reduction Strategy

Furthermore, the implementation of the *reduction* strategy, represented by IMPL-1 (**Reduction as a List of Different Predefined Options for Nearby Activities**), was preferred by Arabic participants, while IMPL-2 (**Reduction as a Set of Predefined PA Plans/Goals**) was favored by non-Arabic participants. Arabic participants found the list of predefined options for nearby activities to be a solution to the dilemma of choosing walking locations, making it more convenient. This implementation was seen as a tool to break free from monotonous routines and promote a more active lifestyle. However, some Arabic participants recommended including a walking list (IMPL-1) alongside the weekly plan (IMPL-2) with nearby walking locations. Furthermore, they suggested that the system should regularly update the walking locations by generating new ones while allowing users to contribute by adding new walking places. On the other hand, non-Arabic participants appreciated the flexibility of creating a weekly plan with different locations and having control over their location choices, which saved them time and energy. However, non-Arabic participants emphasized the importance of simplifying the interface and streamlining options for a more straightforward user experience. Furthermore, some of the non-Arabic participants recommended combining both implementations (IMPL-1 and IMPL-2) of the reduction strategy. Therefore, **I recommend that designers employ the reduction strategy in the PA promotion domain by combining both implementations: providing a predefined walking list of nearby activities along with predefined PA plans. This approach should include the capability to generate new walking locations and**

allow users to customize and add new walking places while ensuring clarity and a user-friendly interface. Below are comments obtained from Arabic and non-Arabic participants:

"***Good**, and it's even better to **have a walking list alongside the weekly plan**, with the **addition of nearby walking locations** at the same time*." [Ar.P - 29] (IMPL-1), "***Good** if **new** places are **continuously added***." [Ar.P - 16] (IMPL-1), "*A **beautiful idea** that would be even **better if users could add additional walking places that may not be present in the program**, and the program distributes them to others*." [Ar.P - 30] (IMPL-1), "*This just seems a little more convoluted to me and too much - **simplify it and take out some of the options***." [En.P - 68] (IMPL-2), "*This is also **good** to have, **I think a combination of this and the last one** is the way to go.*" [En.P - 335] (IMPL-2).

6.5.4.9 Competition Strategy

In the context of the *competition* strategy, as seen in IMPL-1 (**Competition as a Leaderboard**), both Arabic and non-Arabic participants displayed a strong preference for the leaderboard presentation formats over the visual bars of IMPL-2 (**Displaying a Progress Bar for Each Competitor**). They valued the visual appeal of badges and trophies and drew motivation from their leaderboard rankings in their quest to reach the top. Additionally, they found the awareness of the gap between themselves and other competitors to be an additional source of motivation. Celebrating achievements was a highly enjoyable experience for them. However, it is crucial to approach the competition strategy with care by making it optional rather than mandatory to prevent demotivation. Users should have the freedom to choose whether they want to participate in competitions and whether to make their achievements public with strangers or keep them within their circle of family and friends. Therefore, **I recommend that designers provide users with the flexibility to decide on their level of involvement in competitions and to select their preferred competition circle, which may include family members, close friends, or other users of the system**. The following comments were provided by Arabic and non-Arabic participants:

"*I **prefer** this to be **an optional feature** rather than mandatory.*" [Ar.P - 468] (IMPL-1), "*Considering social competition is **a great idea**. I'm curious **whether it's based on my friends' list or includes strange random people***." [Ar.P - 512] (IMPL-1), "*The **ability to connect with friends or family** using the same app can be **a big help in competition and motivation***." [Ar.P - 114] (IMPL-2), "***Competing with friends and family** might*

encourage the use of the app more." [En.P - 321] (IMPL-1), "*You can also **add friends**, right?*" [En.P - 358] (IMPL-2).

6.5.4.10 Tunneling Strategy

Regarding the *tunneling* strategy, as demonstrated in IMPL-2 (**Tunneling as Map Visualization for Walking Routes**), both Arabic and non-Arabic participants exhibited a strong preference for map visualization of walking routes over textual instructions as seen in IMPL-1 (**Tunneling as Textual/Written Instructions**). They appreciated the integration of map technology and valued the ability to view the route through a map rather than relying on a written description. The visual aspect of the map implementation was visually appealing and provided clear directions with an easier-to-follow layout. In contrast, they found textual instructions for walking routes to be boring, complex, and lacking in clarity. To enhance the use of map implementation, participants suggested that users should have the ability to initiate walking routes and determine their own locations autonomously. Additionally, the app should ensure the suitability and safety of walking paths. Therefore, when employing the tunneling strategy for walking routes, it is crucial to do so with care to avoid intruding on users' privacy and to guarantee the safety and appropriateness of the suggested walking routes while still allowing users to choose their own routes. **Consequently, I recommend that designers employ map tunneling for walking routes and directions rather than textual instructions and ensure the safety and suitability of the walking routes. Furthermore, designers need to consider users' choices and preferences in determining their own walking routes alongside the suggested ones from the persuasive system**. Below are comments provided by Arabic and non-Arabic participants:

"***Great** with the **integration of maps technology**.*" [Ar.P - 38] (IMPL-2), "*It **looks great** give **visually attract**, and also **direction with map**.*" [En.P - 38] (IMPL-2), "*I **prefer** to **determine** my **own locations**.*" [Ar.P - 4] (IMPL-2), "***It will be truly useful** if walking paths are **carefully entered**, ensuring that there are **suitable routes for walking**.*" [Ar.P - 45] (IMPL-2).

6.5.4.11 Cooperation Strategy

Regarding the *cooperation* strategy, IMPL-1 (**Message Exchange via Social Cooperation Networks**), was preferred by Arabic participants, while IMPL-2 (**Cooperation as Teamwork**) was favored by non-Arabic participants. Arabic participants found that collaborating with other users could

lead to forming new relationships through engaging in PAs. Furthermore, the social chat room was acknowledged as encouraging group performance and motivating the entire group. On the other hand, non-Arabic participants enjoyed cooperating with friends in PA challenges as it helped keep them accountable and motivated. They found collaborating with friends to be safer than collaborating with strangers. Therefore, **I recommend that designers tailor the cooperation strategy for Arabic users to involve collaborating with other users (either friends or strangers) by inviting them to join the group before starting to interact with each other via message exchange or chat rooms. This should be done with caution to ensure user privacy and safety. Additionally, I recommend that designers tailor the cooperation challenge as teamwork with friends for non-Arabic users, allowing flexibility in choosing the time for group challenges**. The following are comments provided by Arabic and non-Arabic participants:

"*It's possible to* ***help form new relationships*** *through* ***engaging in activities***." [Ar.P - 6] (IMPL-1), "***Social chatting*** *room* ***encourages group performance****. It helps in group* ***motivation***." [Ar.P - 360] (IMPL-1), "***Good****, but I prefer* ***inviting the person to join the group before starting chatting****, with* ***a daily walking goal for the group***." [Ar.P - 29] (IMPL-1), "*This is a* ***really good*** *way to keep the users* ***accountable and motivated***." [En.P - 302] (IMPL-2), "*I think* ***a challenge would be fun and cooperative*** *while allowing* ***flexibility in walk times***." [En.P - 314] (IMPL-2).

6.5.4.12 Simulation Strategy

In the context of the *simulation* strategy, IMPL-2 (**Simulation as Educational Tips/Images - Current and Target Body-Shape Images**) was more favored by Arabic participants, while IMPL-1 (**Simulation as Battery Charging**) was preferred by non-Arabic participants. Arabic participants found that visualizing the target body shape served as an effective reminder and source of motivation, aiding their progress towards their fitness goals. They also recognized its value in increasing awareness about their exercise program and maintaining accountability. However, some participants recommended giving users the option to choose whether to display these body shape images. On the other hand, non-Arabic participants enjoyed the use of a colorful battery indicator as a metaphor, finding it engaging and visually appealing for tracking progress and boosting self-confidence. Nonetheless, they suggested employing a different visualization for the simulation strategy to distinguish it from standard phone battery icons, such as progress bars or pie charts. Therefore, **I**

recommend that designers tailor the simulation strategy for Arabic users by displaying it as an animated human figure representing their current and target body shape. This can simulate the cause-and-effect relationship of adopting PA behavior changes, with the option to toggle the display of the body shape images by adding a hide/show button. Additionally, I suggest that designers customize the simulation strategy for non-Arabic users by using visual progress bars, pie charts, or other suitable indicators to simulate the cause and effect of their PA on the real world to be displayed on the persuasive system's screen. Below are comments provided by Arabic and non-Arabic participants:

"*It's **great** to **set the shape of the target body** for **reminders** and **motivation***." [Ar.P - 3] (IMPL-2), "*I **like** it because it helps you to **continue with your goal** by **showing** you what you **want to achieve***." [Ar.P - 166] (IMPL-2), "I'd prefer a **simple card without images** here." [Ar.P - 32] (IMPL-2), "*This progression makes me **feel like I'm filling my battery as fast as I can**, and this makes it **fun***." [En.P - 45] (IMPL-1), "*It **boosts self-confidence***." [En.P - 40] (IMPL-1), "*The **icons are too close** to **my phone battery icon** and **should be something different***." [En.P - 535] (IMPL-1), "***I would rather prefer a pie chart or a progress bar***." [En.P - 336] (IMPL-1).

In conclusion, this study utilized a large sample size representing diverse populations, ensuring the stability of our findings. Nonetheless, future research should explore whether changes in sample size and the personal and cultural characteristics of Arabic and non-Arabic participants may have minimal or no impact on study outcomes.

Table 28: Recommendations and Design Guidelines for Persuasive Physical Activity Apps, Informed by Arabic Participants' Comments and Feedback.

Persuasive Strategies	Implementations	Insights and Design Guidelines	Additional Required Strategies and Features
Self-monitoring	IMPL-1	**Theme 1: Educational Features** - Provide detailed exercise instructions to guide users in learning how to perform physical exercises. → Rehearsal **Theme 2: Comprehensive Activity Planning** - Offer a complete weekly activity schedule. **Theme 3: Motivational Messaging**	- Rehearsal - Praise - Personalization - Social Role - Liking - Reminders

		- Inspire users with congratulatory messages. → Praise **Theme 4: Safety and Health Considerations** - Include personalized safety info and consider heart rate monitoring. → Personalization **Theme 5: User Engagement and Interaction** - Make the app interactive with encouragement, coaching, tracking, and rewards. → Social Role and Praise **Theme 6: Visual and Interface Design** - Improve the interface with vibrant colors for a more appealing look. → Liking **Theme 7: Health Notifications and Daily Reminders** - Send daily reminders and caring health alerts to promote a healthy lifestyle. → Reminder	
	IMPL-2	**Theme 1: Comprehensive Fitness App** - Offer a wide range of exercises for different goals. → Goal-setting - Include a calorie calculator for nutritional management. - Provide quick access to effective exercises. - Send daily exercise reminders to help users stay on track. → Reminder **Theme 2: App Features and Integration** - Integrate popular fitness wearables like the Apple Watch. - Improve widgets, notifications, reminders, and appearance for a better user experience. → Reminders and Liking - Let users choose how they track progress. - Show precise numerical progress data. - Enable viewing of long-term progress charts over months and years.	- Goal-setting - Reminders - Liking
Personalization	IMPL-1	**Theme 1: Frequency of Results**	- Self-monitoring - Customization

		- Offer weekly or monthly result updates for user preferences. → Self-monitoring **Theme 2: User Interaction and Feedback** - Let users update and track goals in the app for control and customization. → Goal-setting, Customization, and Self-monitoring. - Use fun icons for motivation when goals are met. → Rewards - Provide positive and encouraging feedback, avoiding discouragement. → Praise **Theme 3: Integration of Features** - Combine features from various fitness apps into one comprehensive solution. - Offer a variety of tools and functions to cater to diverse needs and preferences.	- Goal-setting - Self-monitoring - Rewards - Praise
	IMPL-2	**Theme 1: Frequency of Results** - Let users choose the results update frequency (daily, weekly, or monthly) based on their preference. → Self-monitoring **Theme 2: Goal Tracking and Updates** - Implement goal tracking for users. → Self-monitoring - Provide weekly progress updates on goals. → Goal-setting - Explain adjustments and show algorithms for goal changes. → Verifiability **Theme 3: Variety of Activities and Music** - Expand activity tracking options beyond walking. - Allow users to create custom playlists for their workouts. → Customization and Adding a Playlist of Music **Theme 4: Motivational Features** - Integrate motivational elements, such as inspirational voices and explanations from well-known sports personalities. → Social Role, Expertise, and Add Audio Motivational Quotations - Offer adaptive and supportive feedback, especially for beginners. → Praise	- Self-monitoring - Goal-setting - Self-monitoring - Verifiability - Customization - Adding a Playlist of Music - Social Role and Expertise - Add Audio Motivational Quotations - Verifiability - Praise - Add Motivational and Inspirational Quotations

		Theme 5: Enhancing the User Experience - Provide fitness recommendations based on user goals and progress. - Include inspirational quotes and motivational content in the app. → Add Motivational and Inspirational Quotations	
Suggestion	IMPL-1	**Theme 1: The Need for Reminders and Encouragement** - Suggest enhancing reminders with colorful and motivating messages while providing more specific information. → Reminders and Liking - Allow users to enable/disable reminders as they prefer. → Customization **Theme 2: Importance of Educational Content** - Recommend adding reasons for warming up before exercising. → Verifiability - Provide educational content on warming up, exercise techniques, and health tips. → Expertise - Offer a library of instructional videos and display visual instructions for correct exercise techniques. → Rehearsal - Suggest providing regularly updated and directly applicable tips. → Expertise **Theme 3: Emphasizing Proper Diet** - Integrate dietary guidance and nutrition information. - Include meal planning and dietary guidelines within the app. → Add Diet-related App Features	- Reminders - Liking - Customization - Verifiability - Rehearsal - Expertise - Add Diet-related App Features
	IMPL-2	**Theme 1: Enhanced Exercise Features** - Add a "follow" button for guided exercise programs. → Rehearsal - Include easy exercises for user convenience. - Improve app design for seamless transitions from messages to exercises. → Reduction **Theme 2: Rotation of Tips and Tricks** - Keep tips, tricks, and warm-up and cool-down content fresh. → Expertise - Prevent intrusive pop-ups for tips.	- Rehearsal - Reduction - Expertise

Goal-setting	IMPL-1	**Theme 1: Flexible Goal Setting** - Let users set custom fitness goals, with minimum and maximum limits. → Customization - Allow adjustments based on age, weight, and health. → Customization and Personalization - Offer optional guidance for goal setting. → Customization - Enable goal changes as health or circumstances evolve. **Theme 2: Inclusion of Expert Advice** - Include expert guidance, possibly from reliable sources like the WHO. → Authority and Third-Party Endorsements - Enhance the workout experience with virtual expert support. → Social Role and Expertise **Theme 3: Time Management and Challenges** - Add a time management feature for scheduling workouts based on the user's average activity times. → Personalization and Reminders - Introduce challenges to motivate users. → Competition	- Customization - Personalization - Social Role - Expertise - Authority - Third-Party Endorsements - Reminders - Social Competition
	IMPL-2	**Theme 1: User-Centered Goal Setting** - Offer initial goal suggestions that are customizable by users. → Suggestion and Customization - Combine automatic and manual goal adjustment for user control. → Customization **Theme 2: Goal Customization and Flexibility** - Allow users to set and adjust goals as needed. → Customization - Consider gradual, weekly percentage increases in targets. → Suggestion **Theme 3: Providing Health-Based Recommendations** - Provide health-based step recommendations considering age, gender, and activity level. → Personalization - Include a reference chart for recommended steps.	- Suggestion - Customization - Personalization

		- Start with a baseline of 8,000 steps for a healthier lifestyle.	
Reminders	IMPL-1	**Theme 1: Automated and Personalized Reminders** - Use automated reminders based on the user's exercise history. → Personalization **Theme 2: Minimal and Non-Intrusive Reminders** - Let users set a single, non-intrusive reminder. - Optimize notifications to avoid feeling pushy. **Theme 3: Creative Design and Customization** - Improve app design with vibrant colors and engaging visuals. → Liking - Allow users to customize reminder times for a personalized experience. → Customization	- Personalization - Liking - Customization
	IMPL-2	**Theme 1: Integrating with Calendar and Scheduling** - Link the app to the user's calendar to suggest exercise times. → Personalization - Add a timetable feature for better exercise planning. **Theme 2: Easy Initial Reminder Setup** - Include an option in the app's initial settings for configuring exercise reminders during onboarding. → Customization	- Personalization - Customization
Rewards	IMPL-1	**Theme 1: Point System and Rewards** - Explore point-based rewards from various businesses. - Implement a point system with tangible benefits like app store credits. **Theme 2: Linking to Discounts and Rewards** - Partner with businesses for point redemption on healthy meals and sports gear. - Clearly communicate how and where users can use their points for benefits.	
	IMPL-2	**Theme 1: Integration of Features**	- Social Recognition

		- Combine points and badges for a more motivating rewards system. **Theme 2: Social Integration and Competition** - Enable the sharing of achievements on social media. → Social Recognition - Create local or global competitions. → Social Competition - Implement comparisons with friends or peers. → Social Comparison and Normative Influence **Theme 3: Tangible Rewards and Rankings** - Offer tangible rewards for high points. - Include a ranking system for user comparison. → Social Recognition	- Social Competition - Social Comparison - Normative Influence
Praise	IMPL-1	**Theme 1: Varied and Refreshing Messaging** - Users want diverse and changing messages to keep the app engaging and avoid monotony.	
	IMPL-2	**Theme 1: Motivational Features** - Consider adding motivational music or songs. → Add a Playlist of Motivational Music and Songs - Utilize speech recognition systems like Siri for motivation. → Add Speech Production and Recognition Features **Theme 2: Authenticity and Sincerity** - Strive for sincerity and authenticity in the app's messaging. -	- Add a Playlist of Motivational Music and Songs - Add Speech Production and Recognition Features
Reduction	IMPL-1	**Theme 1: Continuous Updates and Variety** - Continuously add new walking locations to keep the app fresh. → Expertise **Theme 2: Integration with Weekly Plans** - Include a walking list alongside the weekly plan, with nearby walking locations. **Theme 3: User-Generated Content and Sharing** - Allow users to contribute additional walking places. - Share user-contributed locations with others.	- Expertise - Tunneling

		Theme 4: Consideration of Notifications - Consider using sound notifications for users who may not check the app while exercising. → Tunneling	
	IMPL-2	**Theme 1: Flexibility in Walking Plans** - Participants prefer multiple choices over pre-set walking plans. - Recommending to add a walking suggestion for each day rather than a fixed plan for variation. → Suggestion **Theme 2: User-Controlled Location Selection** - Allow users to select locations without system specifications. → Customization **Theme 3: Integration of Features** - Recommend integrating the feature with a previous one. **Theme 4: Safety and Weather Considerations** - Suggest considering safety and weather when suggesting exercise locations, particularly around the user's area. → Suggestion and Personalization	- Suggestion - Customization - Personalization
Social Competition	IMPL-1	**Theme 1: Preference for Competition with Friends and Family** - Participants prefer competition with known individuals. - Suggest making competition panels specific to friends and close connections. - Emphasize the importance of including friends and family in competitive features. - Support incorporating walking groups for competition. → Social Cooperation - Recommend enabling communication among members in competitive features. - Enthusiastically endorse family competition. **Theme 2: Flexibility and Inclusivity in Fitness App Competition** - Some participants preferred self-competition. - Highlight the need for an opt-in option for competition, as mandatory competition could	- Social Cooperation - Customization

		discourage non-competitive individuals. → Customization - Expressed concerns about feeling less competent in social competition and questioned the basis of participant selection.	
	IMPL-2	**Theme 1: Visual Presentation for Motivation** - Suggest presenting motivation graphically for better impact. → Liking **Theme 2: Social Connection for Competition and Motivation** - Highlight the importance of connecting with friends or family through the app for competition and motivation. **Theme 3: Separation of Progress and Competition Results** - Keep progress and competition results separate when viewing them in the app.	- Liking
Tunneling	IMPL-1	**Theme 1: Visual Mapping and Clarification** - Suggest the use of visual maps or informative signs on walking paths for clarity. - Recommend an interactive approach with visual aids instead of text. - Prefer using map applications like Google Maps to display routes visually. **Theme 2: Voice Notifications for Guidance** - Advocate for the use of voice notifications for better guidance. - Desire spoken directions for navigation. **Theme 3: Minimizing Reading Time** - Suggest reducing the time spent reading instructions. **Theme 4: Simplified Information** - Prefer receiving only information about the distance covered, not detailed directions.	

	IMPL-2	**Theme 1: User Autonomy in Location Determination** - Participants prefer having the autonomy to determine their own locations. → Customization **Theme 2: Emphasis on Quality Walking Paths** - Suggest that the app should carefully curate walking paths to ensure suitable routes for walking. **Theme 3: Interest in Exploring the Local Area** - Express an interest in learning about the local area, viewing maps, and possibly connecting with other users. → Social Support **Theme 4: Steps Tracking and Reporting** - Recommend the inclusion of a feature that provides a report on the number of steps taken during a walk. → Self-monitoring	- Customization - Social Support - Self-monitoring
Social Cooperation	IMPL-1	**Theme 1: Group Activities and Daily Walking Goals** - Suggest inviting people to a daily walking group with individual summaries and optional group walks at specified locations. → Goal-setting and Self-monitoring **Theme 2: Customized Invitations Based on Exercise Type** - Offer customized invitations based on exercise type. → Customization **Theme 3: Notification-Based Social Cooperation** - Use notification-based social cooperation with the option to join teams via notifications.	- Goal-setting - Self-monitoring - Customization
	IMPL-2	**Theme 1: Voluntary Participation** - Allow users the choice to participate voluntarily. → Customization	- Customization
Simulation	IMPL-1	**Theme 1: Emphasis on Motivation** - Suggest incorporating motivating walking goals into the app. → Goal-setting	- Goal-setting - Customization - Liking

		Theme 2: Customization and User-Controlled Settings - Recommend including customization options in the app settings that can be changed later. → Customization **Theme 3: Aesthetics and Visual Design** - Encourage the use of icons and graphics to enhance the app's visual design. → Liking **Theme 4: Contextual Use of Battery Images** - Advise against using battery images unless related to topics like sleep, food, or self-care.	
	IMPL-2	**Theme 1: Alternative Metrics for Assessing Health** - Provide alternative metrics for assessing health, such as body mass, body fat, and water content, instead of the current method. → Self-monitoring - **Theme 2: Tracking Water Consumption** - Add a feature to calculate and track daily water consumption. → Self-monitoring and Add Water Consumption Feature **Theme 3: Display Preferences and Motivation** - Prefer a simpler display without images and suggested incorporating motivating quotes daily. → Liking and Praise	- Self-monitoring - Add Water Consumption Feature - Liking - Praise

Table 29: Recommendations and Design Guidelines for Persuasive Physical Activity Apps, Informed by Non-Arabic Participants' Comments and Feedback.

Persuasive Strategies	Implementations	Insights and Design Guidelines	Additional Required Strategies and Features
Self-monitoring	IMPL-1	**Theme 1: Simplification and User-Friendly Design** - Allow users to set their own goals → Goal-setting and Customization - Simplify the layout for a more user-friendly experience. → Liking - Use intuitive representations instead of numerical figures to reduce cognitive load.	- Goal-setting - Customization - Liking - Suggestion

		- Provide distance in km in the progress table, not just steps. **Theme 2: Effective Visualization and Graphical Presentation** - Implement graphs for more effective visualization instead of tables. → Liking - Utilize graphical elements for step count and progress representation. → Liking **Theme 3: Incorporating Additional Data and Features** - Include sedentary time in data metrics. - Offer suggestions for daily calorie burning goals based on daily PA analysis. → Suggestion **Theme 4: Motivation and Goal Alignment** - Integrate features for fitness monitoring and personalized goal setting. → Goal-setting - Add a comparison feature for progress tracking. - Develop features to help users understand exercise intensity and stay motivated. **Theme 5: Contextual Information and Meaningful Feedback** - Enhance the app interface to provide contextual information. - Ensure feedback is presented in a meaningful way for users.	
	IMPL-2	**Theme 1: Request for a Free Version** - Implement a free version of the app for users who prefer not to pay. **Theme 2: Preference for Graphics and Visual Appeal** - Enhance the design with more graphics and creative elements for a visually appealing interface. → Liking **Theme 3: Clarity on Progress Bars and Data Representation** - Provide clarity on how progress bars and goals are determined. - Include specific counts alongside percentages for detailed progress representation. - Show actual numbers alongside percentages for better user understanding.	- Liking - Social Competition - Social Cooperation - Expertise - Social Role

		Theme 4: Social and Competitive Features - Allow users to add friends, especially those nearby, for social connections. → Social Cooperation - Implement features for friendly competition among users. → Social Competition **Theme 5: Suggestion for Enhanced Exercise Intensity Guidelines** - Consider incorporating exercise intensity guidelines from health experts for comprehensive fitness insights. → Expertise and Social Role	
Personalization	IMPL-1	**Theme 1: Negative Impact of Insincere Motivational Messages** - Avoid negative messaging. → Avoid Punishment and Negative Reinforcement - Minimize patronizing features, such as pre-scripted motivational quotes. Maintain clear data presentation for tracking progress. → Self-monitoring **Theme 2: Desire for Personalized Feedback** - Implement personalized weekly reviews by professionals for motivation. → Social Role, Expertise and Personalization - Include a step-tracking feature that calculates and suggests the number of remaining steps needed to reach goals. → Self-monitoring, Suggestion, and Reminders	- Avoid Punishment and Negative Reinforcement - Self-monitoring - Social Role - Expertise - Suggestion - Reminders
	IMPL-2	**Theme 1: Desire for Reminders and Personalized Goals** - Add reminder and personalized goal-setting features. → Reminders and Goal-setting - Include positive recommendations like, "At least I worked out today." → Praise and Positive Reinforcement **Theme 2: Preference for Visual Over Numeric Representation** - Include graphical representations alongside numeric data for users who prefer visuals. → Self-monitoring and Liking **Theme 3: Concerns About Overly Ambitious Goals** - Implement motivation-boosting features but set reasonable limits to avoid negative outcomes. → Add Safety Tips and Elements	- Reminders - Goal-setting - Praise - Positive Reinforcement - Self-monitoring - Liking - Add Safety Tips and Elements - Verifiability

		- Gradually introduce new goals to prevent discouragement while ensuring they are achievable and aligned with users' capabilities. **Theme 4: Preference for Flexibility and Multimodal Activity Tracking** - Expand the app's focus to include various forms of cardio exercise, such as swimming, to accommodate different preferences and activities. **Theme 5: Data Presentation and Justified Suggestions** - Provide users with the option to view and analyze their own statistics and data. → Self-monitoring - Offer clear justifications and explanations for suggested changes or goals to provide users with a clearer understanding. → Verifiability	
Suggestion	IMPL-1	**Theme 1: Appreciation for Personalized and Inclusive Suggestions** - Allow users to specify disabilities or injuries in their profiles for personalized suggestions. → Personalization **Theme 2: Interest in Varied and Novel Tips** - Provide interesting and fresh tips to engage users. **Theme 3: Preferences for In-App Display Over Pop-Up Notifications** - Display content within the app instead of using pop-up notifications. - Ensure notifications are context-aware to avoid annoyance. **Theme 4: Suggested Improvements for Enhancing Engagement** - Use more encouraging language like "You could try..." instead of "do not." - Include links to 5-minute stretching warm-up videos for user convenience. → Rehearsal - Consider adding animation to pop-up text to capture interest. → Rehearsal - Offer video options or links for those who prefer visual guidance. → Rehearsal	- Rehearsal - Personalization
	IMPL-2	**Theme 1: Limitation on Pop-Up Notifications**	- Self-monitoring

		- Restrict the frequency of pop-up notifications to prevent user frustration. - Limit pop-up notifications to important or time-sensitive information, like low heart rate during exercise. → Self-monitoring - Provide an option to disable pop-ups for users who prefer minimal interruptions. **Theme 2: Preference for Video Instructions** - Prioritize video instructions for exercises as they are more motivating and effective. → Rehearsal - Consider using videos for exercise demonstrations instead of static images. → Rehearsal **Theme 3: Randomized and Varied Exercise Examples** - Display a limited set of exercise examples and introduce randomness for variety. - Show 2/3 examples initially and change them each time the same tip appears for a cleaner user experience. → Liking **Theme 4: Interactive Features and Countdowns** - Include countdowns to make exercises more motivating. - Utilize animated simulations for exercise demonstrations. → Rehearsal - Offer suggestions on the recommended number of warm-up repetitions.	- Liking - Rehearsal
Goal-setting	IMPL-1	**Theme 1: Customization of Goals** - Implement personalized goal setting based on user stamina and ability. → Personalization - Provide recommended and customizable goals to accommodate varying fitness levels. → Personalization and Customization - Allow users to adjust recommended goals to their preference. → Customization **Theme 2: Skepticism and Trust in Goal Recommendations** - Avoid emphasizing the source of goal recommendations if it affects user trust. → Trustworthiness and Authority - Consider incorporating medical information or doctor recommendations for enhanced trust. → Social Role and Expertise **Theme 3: Need for Gradual Goal Progression**	- Customization - Personalization - Trustworthiness - Authority - Social Role - Expertise - Verifiability - Rewards

		- Gradually increase goals as users become more active. → Personalization - Offer achievable and purposeful daily step goals. → Verifiability **Theme 4: Goal Adjustments Based on Health Conditions** - Recognize that standard guidelines may not suit everyone, particularly those with chronic illnesses. - Tailor fitness goals to individual health conditions and needs. → Personalization **Theme 5: Motivation Through Rewards and Smaller Goals** - Introduce rewards for goal achievements to boost motivation. → Reward - Emphasize daily, achievable goals to keep users engaged and motivated.	
	IMPL-2	**Theme 1: Customized Goal Setting** - Enhance the goal-setting feature with more informative guidelines. → Customization and Verifiability - Include additional metrics like calorie burn and distance alongside step goals. → Self-monitoring - Encourage users to increase their goals if they consistently exceed them. → Customization and Personalization **Theme 2: Combining Personalized Suggestions with Customization** - Offer a combination of suggested and personalized goals. → Customization and Personalization - Provide flexibility for users to adjust suggested goals to suit their needs. → Customization **Theme 3: Access to Ideal Goals and Guideline Information** - Offer guidelines and information to help users make informed goal-setting decisions. → Customization and Verifiability - Display ideal goals alongside user-defined goals for reference. → Personalization **Theme 4: Automation and Reminders** - Explore automated tracking systems for step counts. → Self-monitoring	- Customization - Verifiability - Self-monitoring - Personalization - Reminders - Add Water Consumption Feature - Social Competition - Social Support

		- Implement reminders for hydration to enhance user wellness. → Reminders and Add Water Consumption Feature **Theme 5: Personalized Fitness Goals and Competitive Engagement** - Combine science-suggested goals with user-defined ones for a balanced approach. → Personalization and Customization - Introduce competitive features like daily sports competitions within the app. → Social Competition **Theme 6: Gradual Goal Adjustments** - Allow users to set their own goals and consider the option for others to set goals collaboratively. → Social Support - Expand goal-setting beyond just step counts to cater to diverse preferences and activities.	
Reminders	IMPL-1	**Theme 1: Customization and Configurability** - Ensure that features are configurable to match user preferences. → Customization - Replace default auto-reminders with customizable options for greater flexibility. → Customization **Theme 2: Timing and Context of Notifications** - Consider setting notification windows during less busy time ranges to reduce annoyance. → Personalization - Improve notification relevance by detecting user activity patterns and sending notifications accordingly. → Personalization - Contextualize notifications to align with users' regular schedules and activities. → Personalization **Theme 3: Positivity and Motivation** - Enhance reminders with creative elements such as funny notes or inspirational quotes for sustained interest. → Add Humorous and Inspirational/Motivational Messages and Quotations - Utilize positive affirmations to motivate and encourage users. → Praise and Positive Reinforcement - Avoid guilt-trip notifications, as they may have a negative impact. → Avoid Punishment and Negative Reinforcement - Provide explanations of the consequences of choices to drive effective motivation. → Verifiability and Expertise	- Customization - Personalization - Add Humorous and Inspirational/Motivational Messages and Quotations. - Praise - Positive Reinforcement - Avoid Punishment and Negative Reinforcement - Verifiability - Expertise

		Theme 4: Frequency and Avoidance of Annoyance - Address potential notification fatigue by balancing helpful reminders with user preferences. - Ensure that reminders are not overly frequent to prevent annoyance and ignoring notifications.	
	IMPL-2	**Theme 1: Contextual and Automated Reminders** - Replace default reminders with automated reminders based on users' recent activity levels. → Self-monitoring and Personalization - Automate reminders to sense when prolonged sitting occurs rather than requiring manual adjustments. → Personalization **Theme 2: Customized and Flexible Reminder Scheduling** - Enhance reminder options with both hourly reminders and customizable scheduling to accommodate users' daily routines. → Customization and Personalization - Allow users to set reminder times based on their specific needs and preferences. → Customization **Theme 3: Suggestion-Based Reminders** - Shift from specifying activities at particular times to providing suggestions for activities to be done during the day. → Suggestion **Theme 4: Motivational Content with Reminders** - Incorporate motivational quotes or content along with reminders to enhance user engagement and motivation. → Add Inspirational/Motivational Messages and Quotations	- Self-monitoring - Personalization - Customization - Suggestion - Add Inspirational/Motivational Messages and Quotations
Rewards	IMPL-1	**Theme 1: Skepticism and Arbitrary Nature of Points** - Acknowledge skepticism around point systems and their perceived arbitrariness. - Highlight the importance of a strong social element to make points more motivating. → Social Competition **Theme 2: Points as Incentives and Rewards** - Emphasize the value of redeemable points for incentives or rewards. - Provide information in advance about the types of rewards and their worth.	- Social Competition - Customization

		- Suggest possible rewards tied to specific point levels to enhance motivation. - Consider offering customizable content or real-world rewards as motivators. **Theme 3: Social and Competitive Element** - Leverage the social aspect of the app by encouraging user participation and interaction. → Social Competition - Implement features like leaderboards and in-app competitions to tap into users' competitive sides. → Social Competition **Theme 4: Reward Customization** - Offer customizable content within the app, such as backgrounds and message options, as redeemable rewards. → Customization - Provide opportunities for users to use points for real-world rewards to enhance motivation and engagement.	
	IMPL-2	**Theme 1: Badges as a Form of Recognition** - Consider displaying badges within the user community for added engagement. → Social Recognition and Social Comparison - Emphasize the community aspect by allowing badges to be displayed in user profiles. → Social Recognition and Social Learning - Consider more frequent badge opportunities, such as daily or weekly, for increased motivation. **Theme 2: Value and Utility of Badges** - Explore options for more tangible rewards like gift cards to enhance the value of badges. - Consider offering coupons for online shopping as a motivating feature. **Theme 3: Frequency and Availability of Badges** - Offer badges that can be used to access fun features like avatars. - Ensure that badges are earned at a satisfying frequency, including the possibility of daily rewards. - Provide visibility of available badges and their limits to users. **Theme 4: Competitive Aspect of Badges**	- Social Recognition - Social Comparison - Social Learning - Social Competition

		- Consider adding competitive features to the app, such as user-to-user competition, to enhance the appeal of earning badges. → Social Competition	
Praise	IMPL-1	**Theme 1: Personalized and Interactive Feedback** - Consider incorporating visually appealing elements like images or celebrity endorsements to engage users. → Liking - Enhance interactivity in feedback to make it more engaging and effective. → Positive Reinforcement **Theme 2: Positive Reinforcement and Motivation** - Use emojis and inspirational quotes to provide positive reinforcement. → Liking and Add Motivational and Inspirational Quotations - Balance praise in moderation to motivate and encourage users effectively.	- Liking - Add Motivational and Inspirational Quotations
	IMPL-2	**Theme 1: Customization and Control** - Provide users with control options for adjusting the volume and duration of sounds. → Customization - Consider allowing sound and image customization to offer a personalized experience. → Customization - Explore the possibility of customizing gifs and memes with user names for added engagement. → Personalization **Theme 2: Novelty and Excitement** - Make the motivational sounds as novel and exciting as possible to create a rewarding experience. → Reward and Gamification **Theme 3: User Preferences and Social Media Resonance** - Recognize that the effectiveness of auditory motivation may vary among users and consider making it an optional feature. → Customization - Consider incorporating social media features similar to Facebook to align with the participant's preference. → Add Social Media Support Elements **Theme 4: Design Considerations** - Draw inspiration from audio and visual praises from successful apps like Duolingo to make progress celebration more engaging. → Liking and Gamification - Continuously improve the design for a more visually appealing experience. → Liking	- Customization - Personalization - Rewards - Gamification - Add Social Media Support Elements - Liking

Reduction	IMPL-1	**Theme 1: Personalization and Control** - Allow users to opt in or customize location-based recommendations rather than having them appear unasked for. → Customization - Offer dynamic options for location recommendations beyond the ones based solely on user history. → Personalization and Customization - Provide the flexibility for users to select their preferred activity choices or explore other attractions in their area. → Suggestion and Customization **Theme 2: Evaluation and Performance Tracking** - Enable the storage of activity history to help users evaluate their overall performance and progress. → Self-monitoring - Support users in planning their sports routes more effectively. → Suggestion and Customization **Theme 3: Exploration and Attraction** - Implement the idea of awarding badges for completing local routes to promote exploration and integrate it with daily fitness goals. → Rewards, Gamification, and Goal-setting - Explore the feasibility and benefits of implementing such features in rural areas like Nova Scotia.	- Customization - Personalization - Suggestion - Self-monitoring - Rewards - Gamification - Goal-setting
	IMPL-2	**Theme 1: User-Friendly Notifications and Simplicity** - Ensure notifications are not intrusive and that they align with user preferences. → Customization - Simplify the interface and streamline options for a more straightforward user experience. → Liking - Consider combining the best elements of different notification approaches to create an optimal user experience.	- Customization - Liking
Social Competition	IMPL-1	**Theme 1: Enhancing User Motivation and Engagement** - Consider offering tangible rewards to increase the appeal of the app. → Rewards - Explore partnerships with businesses for real-world rewards or incentives like free Starbucks products for users. → Rewards - Provide the option for users to compare their performance against aggregate statistics. → Self-monitoring - Promote healthy competition among users while emphasizing the importance of listening to their bodies and not overextending themselves. → Reminders and Suggestion	- Rewards - Self-monitoring - Reminders - Suggestion -

	IMPL-2	**Theme 1: Visualizing Competition and Involving Friends** - Visual representations of competition can be valuable, especially if users know the others involved. → Liking Integration with social media friends can enhance the app's appeal. → Social Support - Consider including badges alongside visualizations for added visual appeal. → Rewards and Liking - To prevent direct comparisons, consider not displaying the exact step goal numbers of users. - Enable the option for users to add and compete with their friends within the app. → Customization	- Liking - Social Support - Rewards - Customization
Tunneling	IMPL-1	**Theme 1: Navigation Preferences** - Allow users to choose between Google Maps directions and ensure they are not intrusive. → Liking and Customization - Consider providing audible directions for better on-the-go usability. → Customization and Add Audio Instructions and Guidance **Theme 2: Accessibility and User Diversity** - Make step-by-step navigation optional. → Customization - Optimize for users with visual impairments. - Explore usability on different devices and in rural areas. **Theme 3: Usability and Contextual Relevance** - Offer an on/off toggle for the navigation feature. → Customization - Simplify on-screen text for a more visually appealing approach. → Liking - Implement GPS voiceover for real-time guidance. **Theme 4: User Interface and Design** - Enhance the app's dynamic and vibrant design. → Liking	- Liking - Customization - Add Audio Instructions and Guidance
	IMPL-2	**Theme 1: User Preferences for Visual Maps** - Users like visual maps, but they should be user-initiated. → Customization **Theme 2: Comparison with Maps in Other Apps** - Participants prefer maps like those in Runkeeper.	- Customization - Add Audio Instructions and Guidance - Personalization

		Theme 3: Accessibility Considerations - Ensure visual maps are accessible and explore sound versions for the hearing impaired. → Add Audio Instructions and Guidance **Theme 4: Safety and Responsible Use** - Encourage reviewing maps at home, not while walking, for increased safety. → Suggestion **Theme 5: Flexibility in Mapping Options** - Offer both visual and text map options to cater to user preferences. → Customization and Personalization **Theme 6: Visual vs. Audio Guidance for Active Users** - Include audio-guided directions for a more convenient and distraction-free experience during walking and running. → Add Audio Instructions and Guidance **Theme 7: Text and Image Switching for Navigation Flexibility** - Provide the option for users to switch between text and images for navigation, allowing text for familiar routes and images for unfamiliar locations. → Customization	
Social Cooperation	IMPL-1	**Theme 1: Social Interaction and Communication** - Focus on making the social features of the app as user-friendly and enjoyable as popular messaging apps like WhatsApp. → Liking and Surface Credibility - Allow users to join and create different fitness communities based on their interests and hobbies. → Customization - Facilitate connections among users with similar exercise preferences and interests. → Normative Influence and Personalization - Ensure that the app offers a variety of ways for users to engage in private conversations or group activities. → Add Social Support and Interaction Elements -	- Liking - Surface Credibility - Customization - Normative Influence - Personalization - Add Social Support and Interaction Elements
	IMPL-2	**Theme 1: Uncertainty About the Purpose and Utility of Points** - Clarify the purpose of points within the app to make their utility more evident and meaningful for users. → Rewards **Theme 2: Desire for Fun and Flexibility in Challenges**	- Rewards - Customization - Add Privacy and Safety Features

		- Design challenges to be enjoyable and cooperative while allowing flexibility in choosing when to participate. → Customization **Theme 3: Suggestion for Real-Life Rewards and an Improved Point System** - Implement a system that allows users to exchange points for real-life rewards to provide a safer and more appealing incentive than the previous implementation. → Rewards and Add Privacy and Safety Features - Explore the idea of allowing users to redeem virtual points for simple sports equipment as a rewarding option. → Rewards -	
Simulation	IMPL-1	**Theme 1: Ineffective Comparison with a Battery for Self-Measurement** - Replace the battery comparison with a more intuitive progress bar or pie chart. → Liking - Make self-measurement easier without relying on external references. - Improve clarity in tracking progress and energy levels within the app. → Self-monitoring **Theme 2: Concerns About Visual Icon Similarity** - Redesign icons to be distinct from phone battery icons. → Liking - Use unique and easily recognizable symbols for app functions. - Ensure visual clarity to avoid confusion with phone features.	- Liking - Self-monitoring
	IMPL-2	**Theme 1: Skepticism about the Effectiveness of Walking Alone** - Expand the app's scope to include a holistic approach to health while incorporating dietary information. → Add Diet-related App Features - Encourage users to progress from walking to jogging for a more significant impact. → Suggestion and Reminders **Theme 2: Emphasis on Context and Education** - Provide context and educational resources to help users maximize the app's benefits. → Verifiability - Approach weight-related features with caution and offer guidance on healthy weight management. → Expertise	- Add Diet-related App Feature - Suggestion - Reminders - Verifiability - Expertise - Personalization

		Theme 3: Desire for Personalized Weight Information - Include height-specific weight recommendations to help users understand their ideal weight. → Expertise - Provide personalized insights to assist users in maintaining their best weight. → Personalization	

6.6 Limitations

In our initial assessment, I conducted an evaluation of the persuasiveness of strategy implementations using self-reported data collected from an online user study. This explicit approach, involving users' self-assessments of the strategies and their implementations, predominantly relies on user perceptions. This methodology is a common practice in human-computer interaction (HCI) research and is an established method within the persuasive systems community for tailoring persuasive interventions. Prior research has demonstrated the efficacy of tailored applications based on self-report data in motivating actual behavior across diverse domains, including eCommerce, PA, dietary habits, and snacking [144], [146], [147], [205], [213].

It is imperative to acknowledge that user perceptions may not always align with concrete behavioral outcomes. Consequently, to validate the effectiveness of the design recommendations derived from this study, I intend to implement these strategies in a real-world persuasive system and assess their impact on user behavior.

Furthermore, although our study's application prototypes primarily focused on the domain of PA, the strategies I explored have broader applicability across various domains, particularly within the context of health-related behaviors. Therefore, our findings extend beyond the context of discouraging risky behaviors and hold potential relevance for promoting healthy behaviors such as mental health, smoking cessation, and maintaining a nutritious diet. Nonetheless, further research is necessary to establish the generalizability of our findings across different behavioral domains. Consequently, our results should be interpreted with caution and applied thoughtfully when addressing behaviors outside the scope of this study's domain, which primarily focuses on promoting PA.

6.7 Conclusion and Future Work

In this comprehensive research dissertation, I conducted an extensive study involving 1100 participants representing diverse backgrounds, including both Arabic and non-Arabic populations. Our primary objective centered around the investigation and comparison of the perceived persuasiveness and effectiveness of various implementations, specifically IMPL-1 and IMPL-2 for each persuasive strategy.

Our findings reveal noteworthy variation in the overall persuasiveness of the twelve persuasive strategies employed in our study. These strategies included self-monitoring, personalization, suggestion, goal-setting, reminders, rewards, praise, reduction, competition, tunneling, cooperation, and simulation. Importantly, this variation in perceived persuasiveness was observed between Arabic and non-Arabic populations.

This study significantly contributes to the field of PT research within HCI by shedding light on the subtle differences in perceived persuasiveness across distinct implementations of the same strategy, each driven by distinct motivating factors. Building on these insights, I proposed practical guidelines for tailoring persuasive systems. These guidelines involve the careful selection of strategy implementations to align with specific user groups while considering the participants' perspectives and recommendations. Furthermore, I provided qualitative perceptions by investigating and explaining the reasons behind participants' preferences for and dislikes of the implementations of each persuasive strategy.

Furthermore, our empirical investigation aimed to ascertain whether significant differences exist in the effectiveness of persuasive strategies based on their implementation within persuasive systems, both in Arabic and non-Arabic populations. To achieve this goal, I explored the relationships between diverse implementations of persuasive strategies and the motivational dimensions relevant to individuals at various stages of behavior change, namely precontemplation, contemplation, preparation, action, and maintenance. This examination was conducted in accordance with the four ARCS motivational constructs: Attention, Confidence, Relevance, and Satisfaction, through a large-scale study.

This work introduces novel contributions to HCI and PT by demonstrating that the effectiveness of distinct implementations of the same strategy varies among people, specifically among Arabic and non-Arabic participants, at different stages of behavior change. Furthermore, these implementations serve as motivators for different reasons and through varying mechanisms.

Our study establishes meaningful connections between the Stages of Change Theory, rooted in the TTM, and motivation theory, based on the ARCS model of motivation and the PSD model. These connections help identify motivational patterns among individuals at different stages of behavior change, thereby informing the selection of implementation choices when designing persuasive systems to enhance their effectiveness in motivating behavior change.

Additionally, I offered qualitative insights by linking the persuasiveness of strategy implementations to behavior change, drawing from comments provided by both Arabic and non-Arabic participants. These insights were precisely mapped to theoretical motivational dimensions, including Attention, Relevance, Confidence, and Satisfaction.

In future research endeavors, I plan to examine:

1. **Real-world Implementation:** Implement the design recommendations derived from this study in actual persuasive systems to assess their real-world effectiveness.
2. **Behavior Change Transitions**: Explore whether users exhibit preferences for specific implementations as they transition between different stages of behavior change.
3. **Less Favored Strategies:** Examine less favored strategies and their corresponding implementations to compare their impact on motivating target users.
4. **Additional Implementations**: Investigate additional implementations of each strategy and their effects on user motivation.
5. **Broader Application:** Extend the applicability of our findings to other behavioral domains such as smoking cessation, mental health, and healthy eating.
6. **Age, Gender, and Personality Traits**: Assess the persuasiveness of strategies and their implementations on individuals based on specific characteristics, such as age, gender, and personality traits.

7. **Cultural Variations:** Investigate a comparison between specific cultures within particular countries rather than studying broad populations.

7 CHAPTER 7: PERSUASIVE PHYSICAL ACTIVITY APP PROTOTYPES TAILORED TO ARABIC AND NON-ARABIC POPULATIONS

This chapter represents the fifth and final stage of the five main stages in this dissertation, which involves mapping persuasive strategies to app features. This chapter presents wireframe designs of the user interface for our mobile physical activity (PA) app, 'Walk4Wellness,' tailored for both Arabic and non-Arabic users. These wireframes have been developed based on insights from the user study and follow a structured approach for selecting design strategies and features, as illustrated in Chapter 6. This chapter introduces two versions of the app (Arabic and non-Arabic) and highlights similarities and differences in their features. Additionally, screenshots of app interface designs for each implementation (feature) are provided, accompanied by a detailed description of each.

7.1 Wireframes of User Interface Designs for the Mobile PA App for Arabic and Non-Arabic Users

In developing the future PA app, I followed a structured sequence of six phases to determine strategies, implementations, and features, all of which are in line with our primary objective of increasing or maintaining users' step counts and reducing sedentary behavior (SB), including prolonged sitting. Drawing insights from the perspectives and recommendations of both Arabic and non-Arabic participants, I progressed through these phases. First, I selected the top six persuasive strategies. Second, I chose the most preferred implementation, either implementation 1 (IMPL-1) or implementation 2 (IMPL-2), for each selected strategy. Third, I conducted an in-depth investigation to identify recommended features based on the valuable input from the participants. Fourth, I explored and investigated additional recommended strategies and features. Fifth, I made the pivotal final decision regarding the selection of strategies and features. Lastly, I transitioned to the phase of prototyping and designing user interfaces for the app, with careful consideration for both Arabic and non-Arabic user groups. Figure 76 shows the phases for selecting the persuasive strategies and features for the PA app design.

Based on our quantitative findings, I identified the top six persuasive strategies out of the twelve employed in our study and determined the most preferred implementation (either IMPL-1 or IMPL-2) for each strategy among both the Arabic and non-Arabic populations. Subsequently, two researchers and I investigated and selected the detailed recommended features for participants under each chosen

implementation. Following this investigation, the social competition strategy was included as the seventh persuasive strategy in our future PA application, 'Walk4Wellness.' After finalizing the selection of persuasive strategies, implementations, and the mapping process of the design guidelines and features with the two researchers, another researcher and I collaboratively worked on designing the prototypes illustrating the features of each persuasive strategy. This was achieved through iterative meetings, discussions, and the utilization of the Figma Interface Design tool [89].

Accordingly, I have developed two versions of our future PA app, 'Walk4Wellness,' tailored for Arabic and non-Arabic users (see **Error! Reference source not found.** and **Error! Reference source not found.**). Both versions include common strategies, such as self-monitoring, goal-setting, reminders, and competition; however, the reward strategy is implemented differently in each version. Additionally, specific strategies are designed for each user group: the Arabic version includes tunneling and simulation, while the non-Arabic version includes personalization and suggestion strategies. The details of each strategy's implementation are outlined in the following sections.

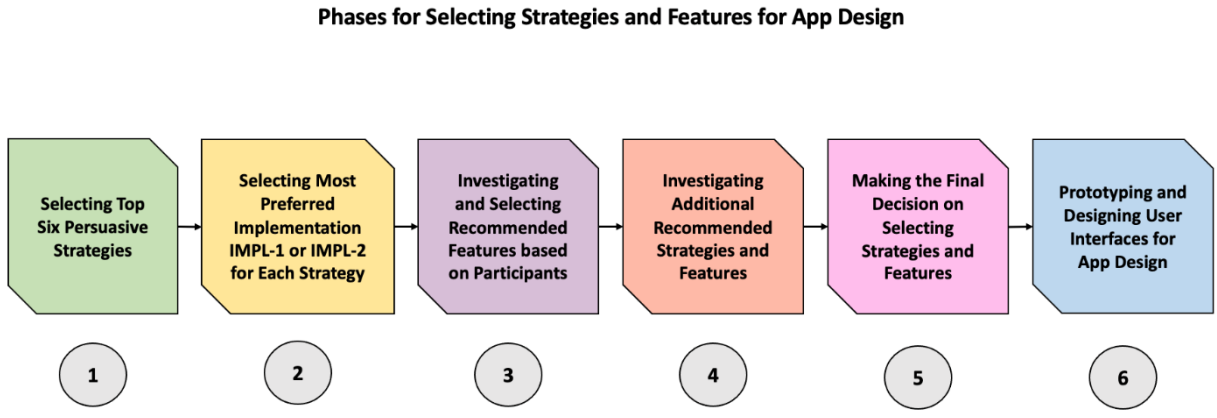


Figure 76: Phases for Selecting Strategies and Features for App Design.

7.1.1 Home Screen and Visual Data Tracking for Self-Monitoring Strategy across Arabic and Non-Arabic Users

This section demonstrates the implementation of the self-monitoring strategy within both versions of our future PA app, 'Walk4Wellness,' tailored to include visual and graphical data tracking and representation (IMPL-2) for both Arabic and non-Arabic populations. As a result, both versions of our PA app (Arabic and non-Arabic) share identical features and data visualizations for the self-monitoring strategy. Consequently, the Home Screen provides users with a comprehensive overview of their PA progress.

Upon entering the Home Screen, users are greeted with a personalized welcome message along with a gender-specific image [94], fostering a sense of value and belonging. Additionally, the target step count for the day is prominently displayed as a pie chart, further encouraging users to strive for achievement. Directly below the Home Screen, a step count progress bar visually illustrates the user's steps taken throughout the week, aiding in accountability and motivation towards daily step goals.

Insights into vertical movement are provided through the count of stairs climbed, while calories burnt from walking are quantified in kilocalories, leveraging integration with the Omni calculator [269]. Furthermore, users can track their total distance traveled on foot. Average walking and running speeds are valuable metrics displayed on the Home Screen, enabling users to monitor progress and set goals for improving speed and endurance. Active time spent engaging in walking and running activities is also highlighted, promoting regular PA. The Home Screen includes a tracker illustrating users' progress towards their weekly step count target as a percentage, introducing a gamification aspect to motivate consistent engagement in walking activities and goal achievement. All of the prototypes (user interfaces) were created using the Figma interface design tool [89].

To access the primary strategies of this application, users can click on the hamburger icon adjacent to the default image. This action triggers the appearance of a sidebar displaying the main strategies offered by our PA application, which include some similar and different strategies for the Arabic and non-Arabic versions of the app (see Figure 77). These common strategies include the ability to adjust the daily step goal, set reminders, and challenge others by initiating competitions in both Arabic and non-Arabic versions of the app. However, for the Arabic version of the app, there are two more strategies available in the menu: the tunneling and simulation strategies represented as the “Walking Route Viewer,” which allows users to view walking paths between two points on a real-time map, and

the “Weight Change Visualizer”, which displays a simulated and animated person showing the current and target body weight, respectively.

At the beginning of each day, all metrics within each progress bar start at zero. As users engage in walking activities throughout the day, each metric count increases accordingly. Overall, the combination of daily pie charts and weekly progress bars for tracking step counts on the Home Screen empowers users to stay motivated and accountable towards their health and wellness goals through regular PA. By visualizing their progress, users are encouraged to make positive decisions and prioritize their PA.

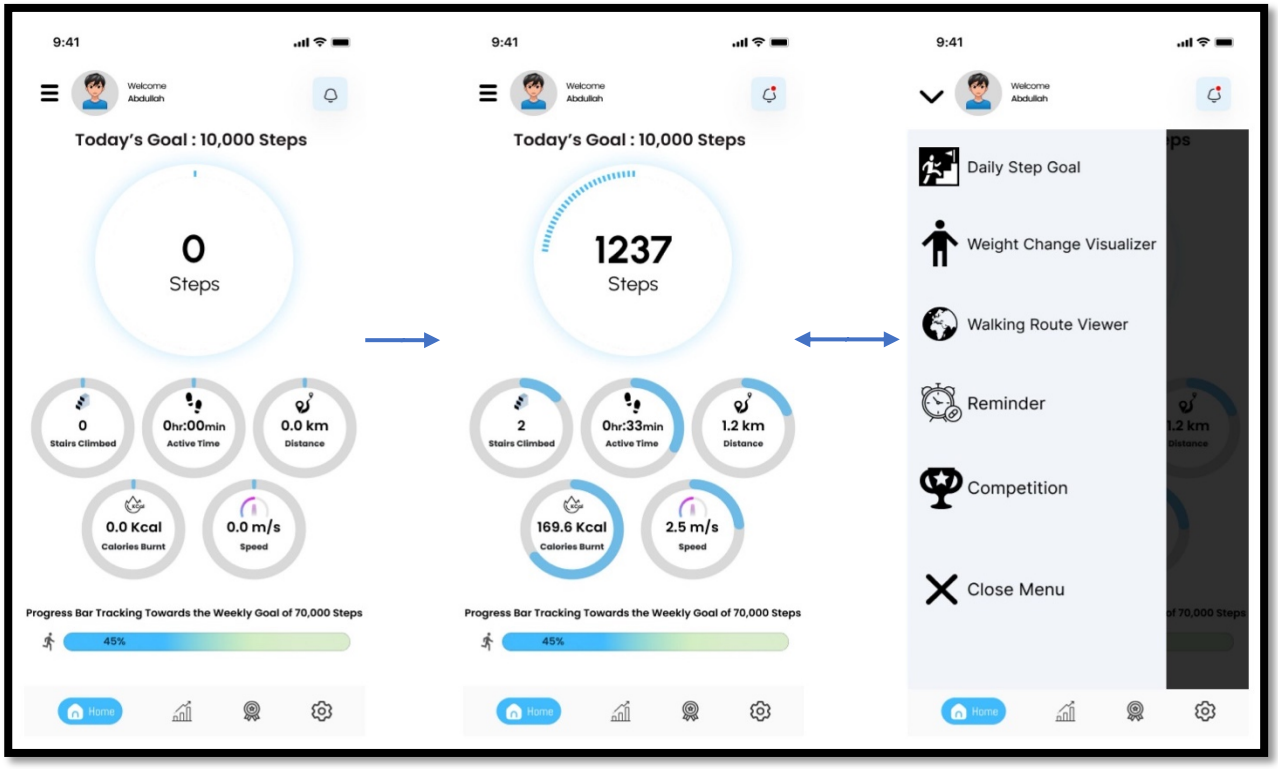


Figure 77: Self-Monitoring Strategy in the Arabic App.

7.1.2 Charts and Reports Screen for Self-Monitoring Strategy across Arabic and Non-Arabic Users

The charts and reports screen within the self-monitoring feature offers users a comprehensive overview of their performance history and progress, presenting statistical and graphical charts on a

weekly, monthly, and yearly basis. This feature remains consistent across both versions of the PA app (Arabic and non-Arabic) for self-monitoring.

Within the 'Statistics' section of our future PA app, 'Walk4Wellness,' users can track and monitor their progress and step count over time using visualization tools such as graphs. These reports are generated regularly on a weekly, monthly, and yearly basis. The visual representations serve two primary purposes: firstly, they allow users to observe their improvement over time, providing insights into their walking journey; and secondly, they serve as a source of motivation, encouraging users to strive towards their step count goals. Additionally, users can select any specific calendar date to view reports for that particular day.

By facilitating the monitoring of progress over time, the application aids users in gaining a detailed understanding of the gradual changes occurring in their walking efforts. Through graphical representations, users can discern patterns, trends, and variations in their step counts across different time periods. This analytical capability promotes a more engaged approach to achieving higher step count goals, enabling users to make informed decisions and adapt their goals accordingly.

Moreover, the consistent generation of reports on weekly, monthly, and yearly intervals emphasizes the application's commitment to sustaining motivation and dedication among users (see Figure 78). By providing frequent updates on progress and achievements, the application fosters a sense of accountability and drive, encouraging proactive participation in PA.

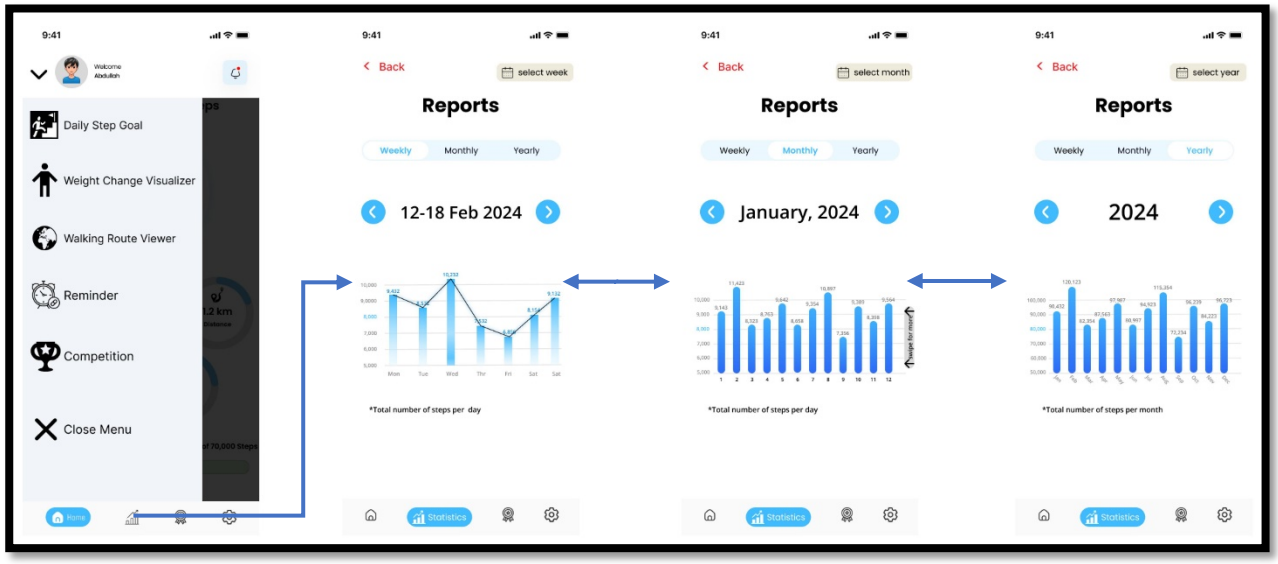


Figure 78:The Charts and Reports of the Self-Monitoring Strategy in the Arabic App.

7.1.3 Personalized Goal Recommendations within the Personalization Strategy for Non-Arabic Users

In the non-Arabic version of our future PA app, 'Walk4Wellness,' the personalization strategy offers users tailored goal recommendations (IMPL-2) by analyzing their weekly and daily step count progress, drawing insights from their performance history. These personalized recommendations are reinforced by numerical data integration, facilitating progress tracking and the establishment of realistic limits. To mitigate potential adverse effects such as overexertion or injury, personalized goal recommendations are calibrated, taking into account user-specific details such as age, gender, step count performance, and progress.

For instance, if a user typically maintains an average of 5,000 steps per day and is identified as a male aged between 18 and 59, with regular performance, a recommendation may be proposed to incrementally increase this count by 7,000 steps per day (refer to Figure 79). This gradual approach ensures that goals remain achievable and sustainable, minimizing the likelihood of overwhelming users and mitigating risks of injuries or health complications. Furthermore, each recommended change is accompanied by clear justifications and explanations, empowering users with deeper insights into the rationale behind these goal adjustments.

Additionally, users retain the ability to monitor their progress and step count over time through the self-monitoring strategy. This functionality enables users to validate the recommendations provided and proceed accordingly, fostering a sense of control and accountability in their pursuit of personalized PA goals.

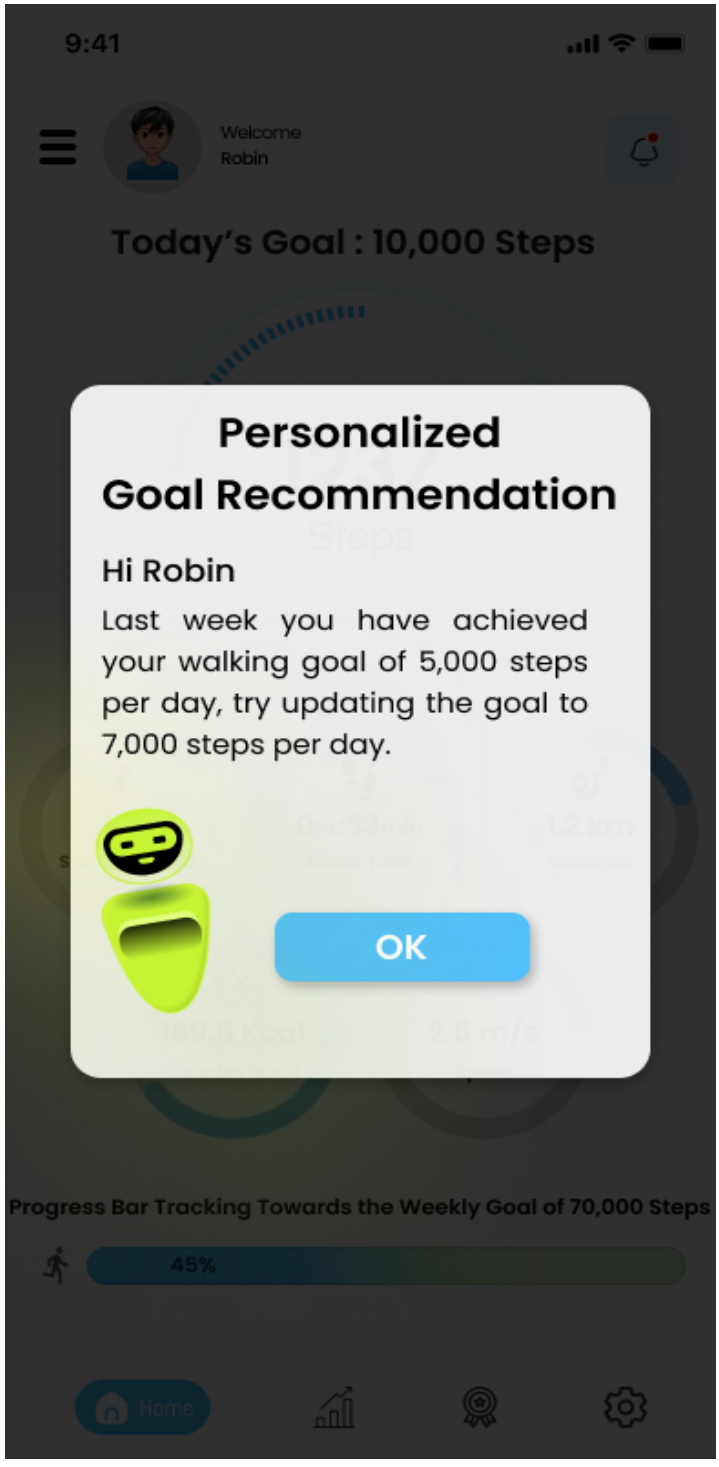


Figure 79: Personalization Strategy in the Non-Arabic App.

7.1.4 Animated Visual Walking Tips as Notifications within the Suggestion Strategy for Non-Arabic Users

This section elaborates on the implementation of the suggestion strategy in the non-Arabic version of our future PA app, 'Walk4Wellness,' tailoring it to deliver visual suggestion notifications (IMPL-2) specifically designed for the non-Arabic population.

In the non-Arabic iteration of our PA app, the suggestion strategy provides walking suggestions and tips, such as warm-up exercises, to enhance users' walking experience, improve their step count performance, and mitigate the risk of injury. These recommendations take the form of visual pop-up notifications, presenting short animated videos that offer engaging and informative content with step-by-step demonstrations of suggested exercises. The use of brief, high-quality videos adds an element of excitement, motivating users to actively participate in the warm-up routine. Furthermore, clear and detailed demonstrations of each exercise are provided through animated videos [299] to ensure users understand the proper form and technique.

To maintain a user-friendly experience and prevent excessive interruptions, the frequency of pop-up notifications is strategically limited. This approach respects users' time and attention while still delivering valuable content. Additionally, users are empowered to dismiss notifications by clicking on the “close” icon button provided in the interface, granting them control over their interaction with the suggestion strategy.

Furthermore, the display of the duration of each video at the bottom of the notification helps users assess the length of the video to ensure they are aware of the time commitment required and reduce concerns about lengthy animated content (see Figure 80).

These suggestion videos offer users a visual guide to executing exercises with the proper form and technique, facilitating accurate performance and maximizing the benefits of walking tips and warm-up routines. By integrating visual pop-up notifications with animated videos, the suggestion strategy delivers an immersive and comprehensive experience aimed at optimizing users' walking preparations and overall outcomes.

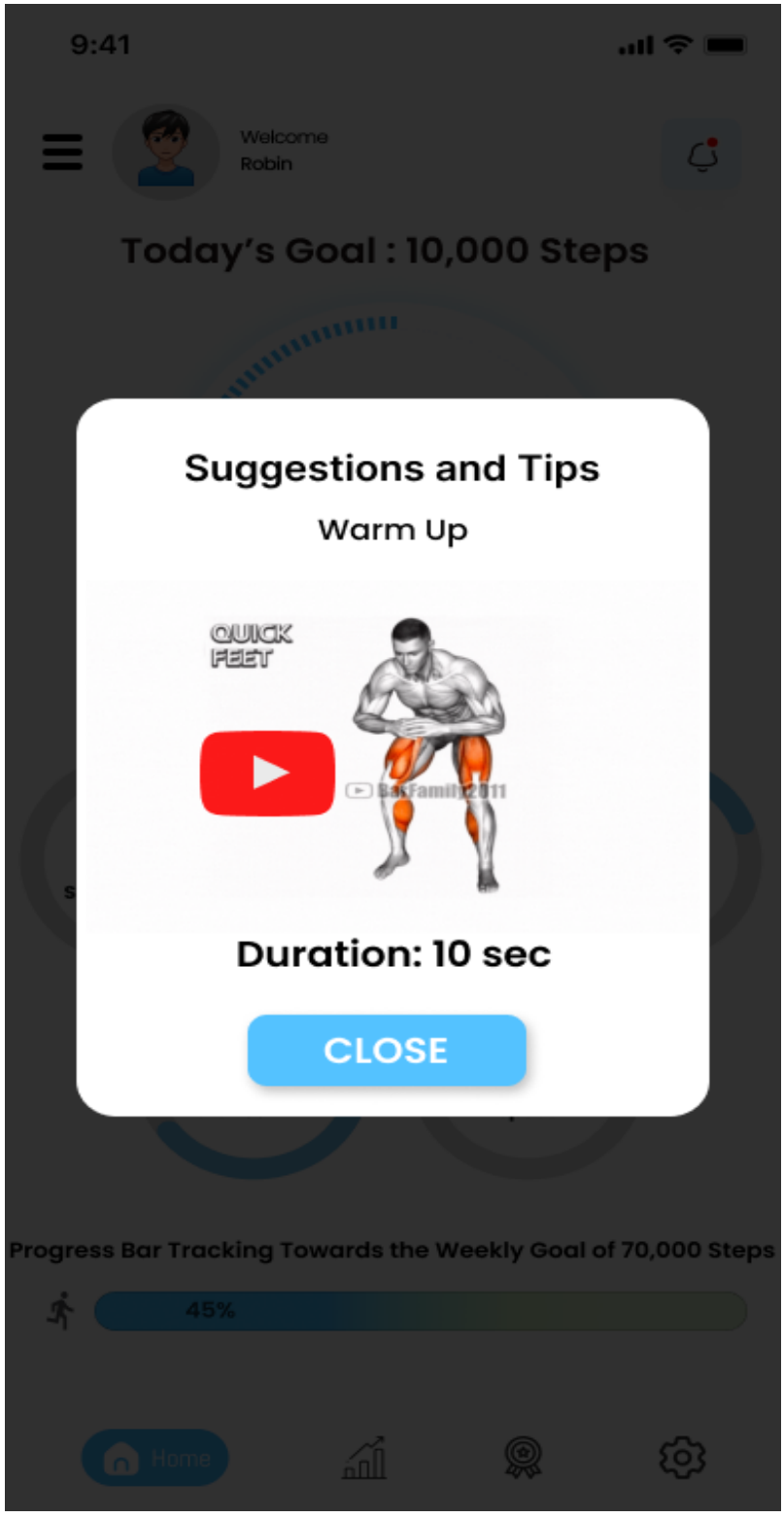


Figure 80: Visual Suggestions in the Non-Arabic App.

7.1.5 Automatic and Customized Target Step Counts within the Goal-setting Strategy for Arabic and Non-Arabic Users

This section demonstrates the utilization of the goal-setting strategy in both versions of our future PA app, 'Walk4Wellness,' tailoring it to incorporate default/system-based goals (IMPL-1) as well as customized/user-driven goals (IMPL-2) for both Arabic and non-Arabic populations. Thus, both iterations of our PA app (Arabic and non-Arabic) share identical features within the goal-setting strategy.

Within our PA app, the goal-setting strategy serves as a cornerstone feature, facilitating customized and motivational goal setting processes for users. It adopts a user-friendly approach aimed at promoting PA through step count targets. By default, users encounter the globally recognized benchmark of 10,000 steps per day, a goal widely acknowledged for its health benefits.

Beneath the default step count, three tables provide customized recommendations based on specific criteria: activity level [307] [62], age [241] [134], and gender [29], as shown in Figure 81. These recommendations are selected following comprehensive analysis and insights sourced from reputable health authorities.

Various activity levels, ranging from sedentary to highly active, are considered, with step counts gradually escalating based on users' activity levels. Additionally, age plays a pivotal role in determining the recommended step count, with users aged 18–59 encouraged to aim for a higher daily step count compared to those aged 60 and above.

Adjacent to the default step count, an "edit" button offers users the flexibility to customize their daily step target according to their preferences and capabilities. Upon selecting the "edit" button, users can adjust the default step count provided by the persuasive system. Whether they opt to increase, decrease, or maintain the default target, this customization empowers users to establish realistic and achievable goals tailored to their unique circumstances and PA levels. Alternatively, users can revert to the default step count value by selecting the "cancel" button to ensure a seamless and user-centric interaction experience.

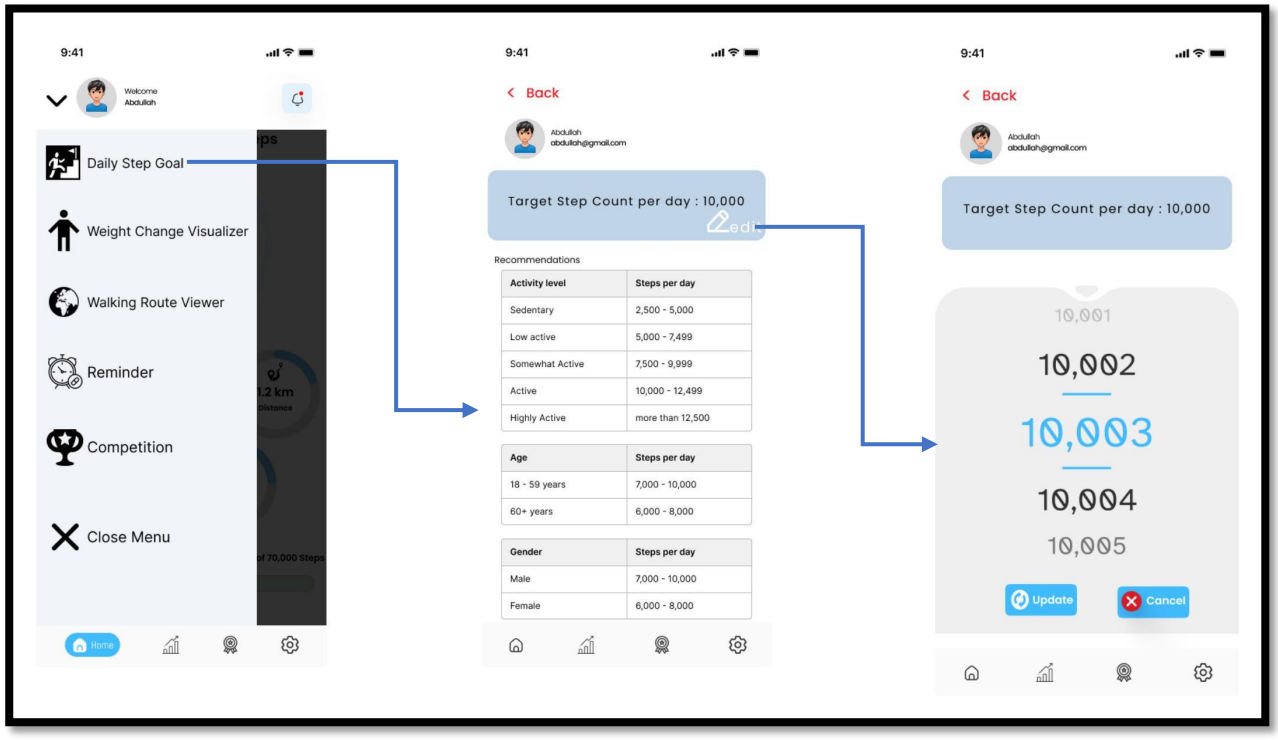


Figure 81: Goal-Setting Strategy in the Arabic App.

7.1.6 Automatic (Push) and Scheduled (Pop-up) Reminders within the Reminder Strategy for Arabic and Non-Arabic Users

This section illustrates the implementation of the reminder strategy in both versions of our future PA app, 'Walk4Wellness,' adapting it to include automatic/system-based reminders—push reminders (IMPL-1)—and customized/user-driven reminders—pop-up reminders (IMPL-2)—for both Arabic and non-Arabic populations. Hence, both iterations of our PA app (Arabic and non-Arabic) offer the same features within the reminder strategy.

In our PA app, users can schedule tasks for their daily walks in their calendar to ensure they allocate time specifically for walking among their other activities. The calendar distinguishes walks from other tasks using colors to make them easily identifiable. When users add an entry to their calendar, they select the task type, facilitating visibility of their scheduled walks. If users wish to identify the category under which their tasks fall, an optional button beside the category provides assistance. Clicking the 'Help' button reveals a popup explaining each category, aiding users in decision-making. Scheduling

time for other tasks ensures that no push/automatic notifications are sent during these intervals, preventing users from feeling overwhelmed by constant interruptions.

Thus, there are two primary types of notifications:

a. Push Notifications: Based on tracked walking progress, users receive push notification reminders at random intervals. For instance, if a user is falling short of their daily target, a notification might encourage them with a message like "Regular walks are beneficial for your health." These notifications foster inclusivity and motivate users to maintain a consistent walking routine and achieve their daily goals.

b. Scheduled Time Notifications (Pop-up): Users set daily reminders for walking sessions on their calendar schedule. These scheduled notifications serve as timely reminders of the user's walking schedule to ensure they never miss their designated walking time. Establishing this routine through reminders helps foster a habit of regular walking, contributing to user wellness.

Additionally, if a user is unable to go for a walk at the scheduled time, they can postpone it by clicking the "Remind Me Later" button, which prompts them to specify a new time to receive a scheduled notification reminder. This feature enables users to reschedule their walking sessions if they miss the original time due to other commitments, which encourages them to not skip their walks entirely (see Figure 82).

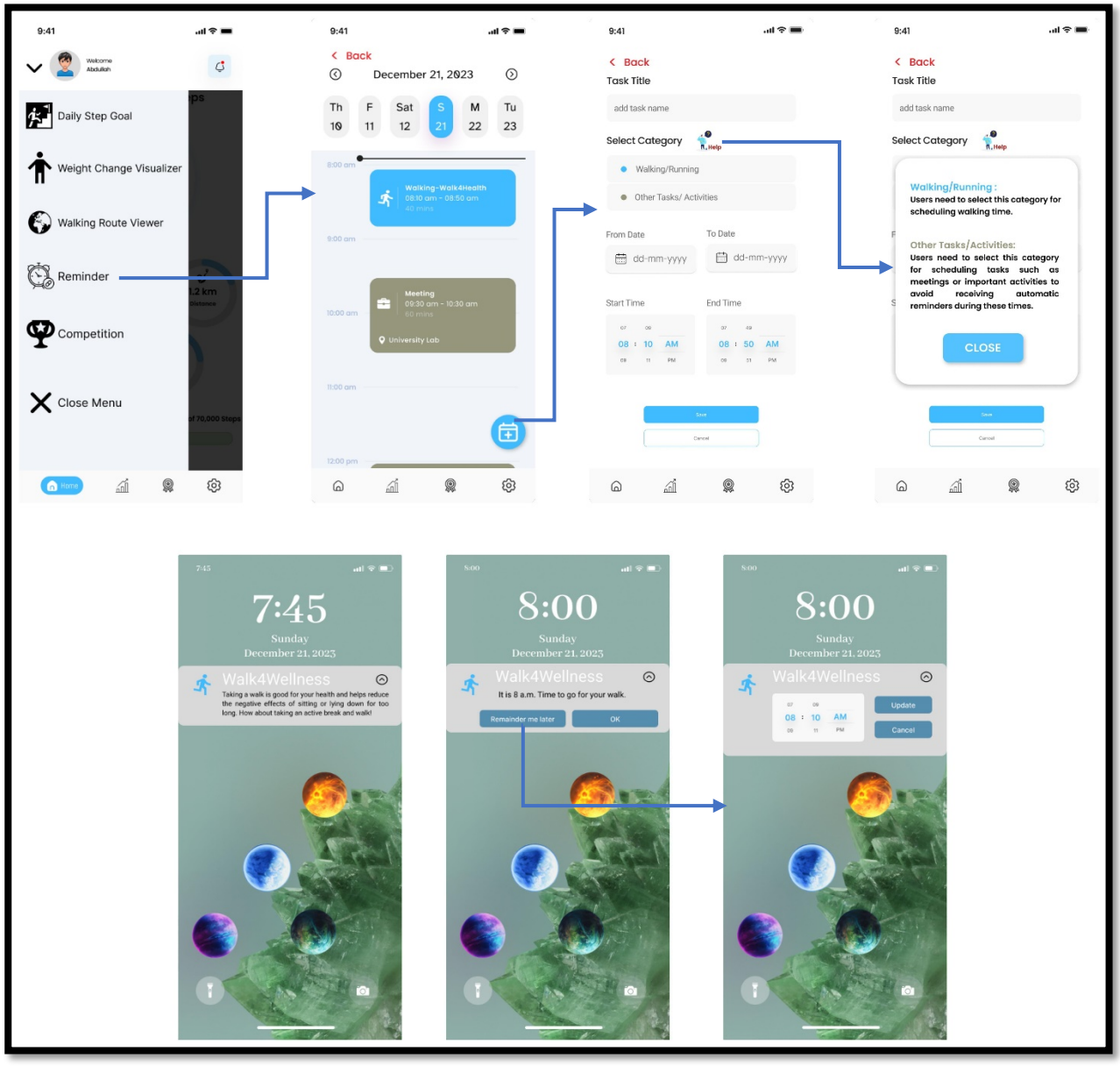


Figure 82: Reminder Strategy in the Arabic App.

7.1 Reward Strategy Implementation in Our Physical Activity App: Tailoring Incentives for Arabic and Non-Arabic Users

This section explores the implementation of the reward strategy within our future PA app, considering the distinct needs and preferences of Arabic and non-Arabic users. In the non-Arabic version of the app, the reward strategy is exclusively based on badges (IMPL-2), while in the Arabic version, a combination of point-based rewards (IMPL-1) and badge-based rewards (IMPL-2) is employed.

For non-Arabic users, the focus lies solely on badge-based rewards (IMPL-2), as shown in Figure 84. As users engage with the app and accumulate steps, they unlock a variety of badges that signify their progress and dedication. These badges serve as visual markers of achievement that inspire users to continue their journey towards fitness excellence. Each badge earned represents a unique milestone, reinforcing the user's commitment and providing satisfying recognition for their efforts. By collecting these badges, users not only receive acknowledgment for reaching targets but also experience a sense of accomplishment and pride in their dedication to PA.

Conversely, Arabic users benefit from a dual rewards system comprising both point-based (IMPL-1) and badge-based rewards (IMPL-2), as shown in Figure 83. Initially, users are rewarded with points as they make progress in their walking endeavors. These points serve as valuable markers of achievement, providing recognition for their efforts and motivating them to continue pursuing an active lifestyle. Significant milestones in their journey, such as reaching 10,000, 25,000, and 50,000 steps, are celebrated with substantial point rewards that symbolize their dedication and perseverance in achieving fitness goals.

In addition to point-based rewards, Arabic users also unlock badges as they accumulate points and progress through their journey. These badges, similar to those in the non-Arabic version, represent milestones and achievements, serving as visual reminders of progress and motivating users to strive for excellence. The combination of points and badges offers users both concrete and symbolic rewards for their commitment to PA, enhancing their overall experience and fostering continued engagement with the app.

In conclusion, the reward strategy implemented in our PA app serves as a vital motivator, encouraging users to increase their PA levels by providing a variety of incentives tailored to their cultural

preferences and motivational drivers. Whether through badges, points, or a combination of both, users are empowered to pursue their fitness goals with enthusiasm and turn their daily exercise routines into enjoyable and rewarding experiences.

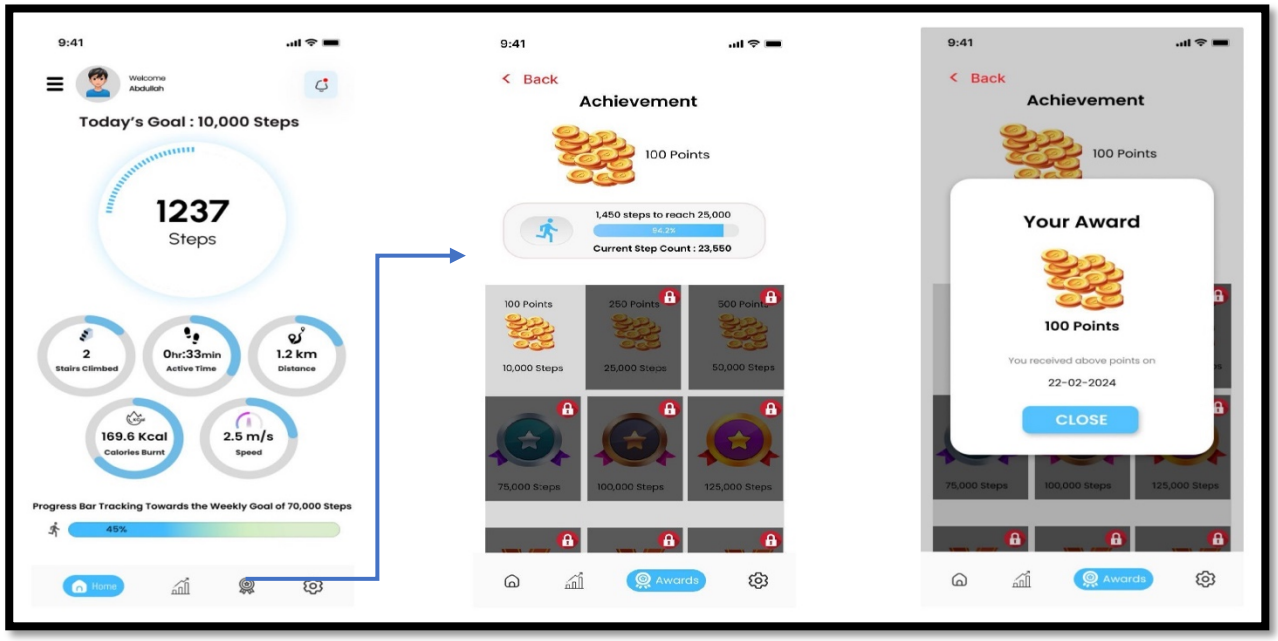


Figure 83: Reward Strategy in the Arabic App.

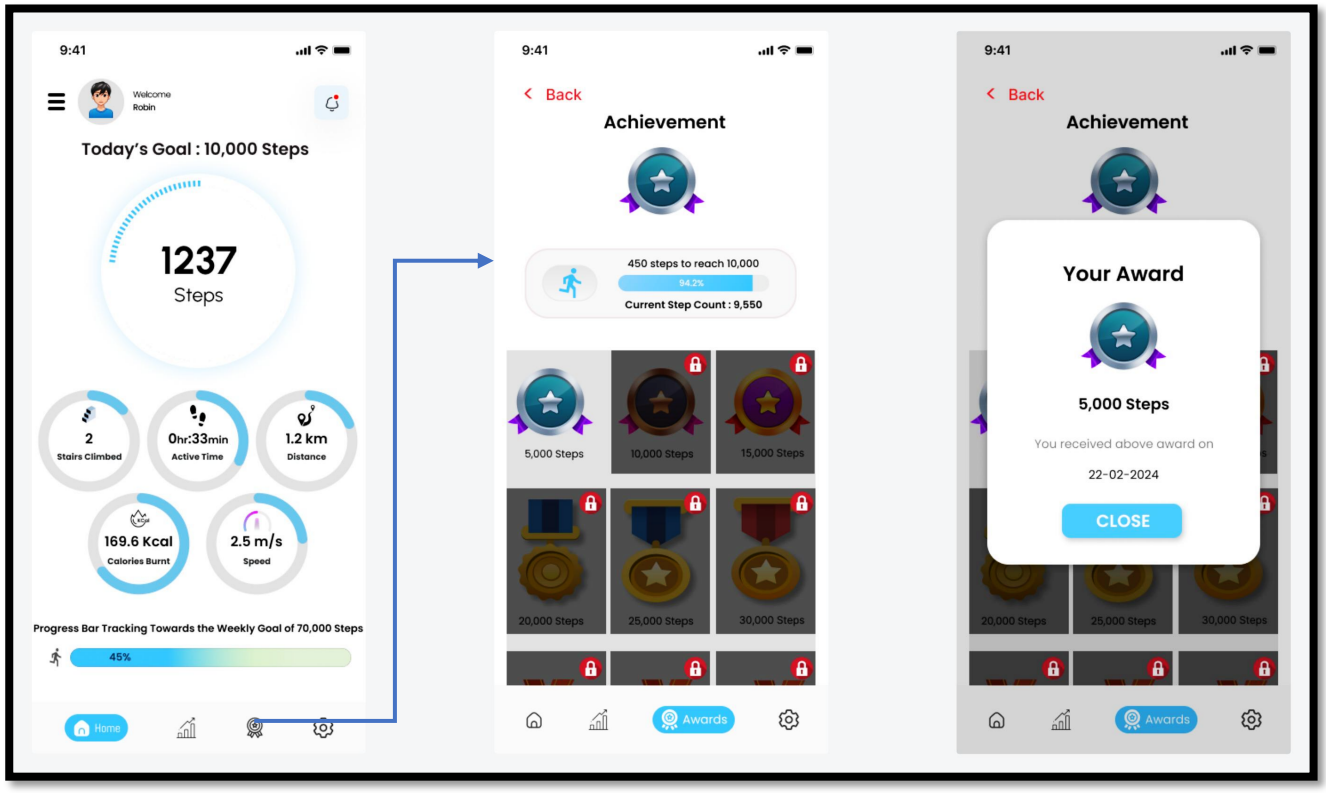


Figure 84: Reward Strategy in the Non-Arabic App.

7.1 Walking Challenges and Leaderboard Rankings within the Competition Strategy for Arabic and Non-Arabic Users

This section presents the integration of the competition strategy in both versions of our future PA app, 'Walk4Wellness,' tailoring it as leaderboard competition (IMPL-1) for Arabic and non-Arabic populations. Consequently, both versions of our PA app (Arabic and non-Arabic) offer identical features within the competition strategy.

In our PA app, the competition strategy enables users to create customized challenges with selected individuals, including friends, family, and colleagues. Users can view and participate in challenge groups. They also have the option to initiate new group challenges and set objectives, such as reaching a specific step count goal. Participants compete by tracking their step counts and are subsequently ranked based on their individual achievements. Visual leaderboard representations illustrate participants' positions in each challenge, displaying their relative rankings based on step count accomplishments (see Figure 85).

Furthermore, walking challenges serve as a means to engage loved ones in friendly competition, promote PA, and work towards shared goals [285]. Users can invite additional participants to join ongoing challenges, which can motivate newcomers to pursue excellence and obtain rewards. This feature facilitates the expansion of participant pools, fostering the pursuit of walking goals. Notifications under the notification tab inform users of invitations received for specific group challenges and allow them to accept or decline invitations.

The leaderboard displays the participant with the highest step count in each group challenge at the top position, with subsequent users ranked according to their step counts [308]. Moreover, participants beyond the top three are eligible for rewards, such as trophies for achieving at least 50% of the challenge target and badges for completing 75% of the target. This incentive system encourages users to engage in more challenges to earn valuable rewards, such as badges and trophies, for their participation and accomplishments.

Participation in challenges not only motivates users to walk with the intention of winning but also indirectly promotes walking for overall wellness. Users may find themselves increasing their step count to secure success in the competition, thereby enhancing their PA levels and overall health.

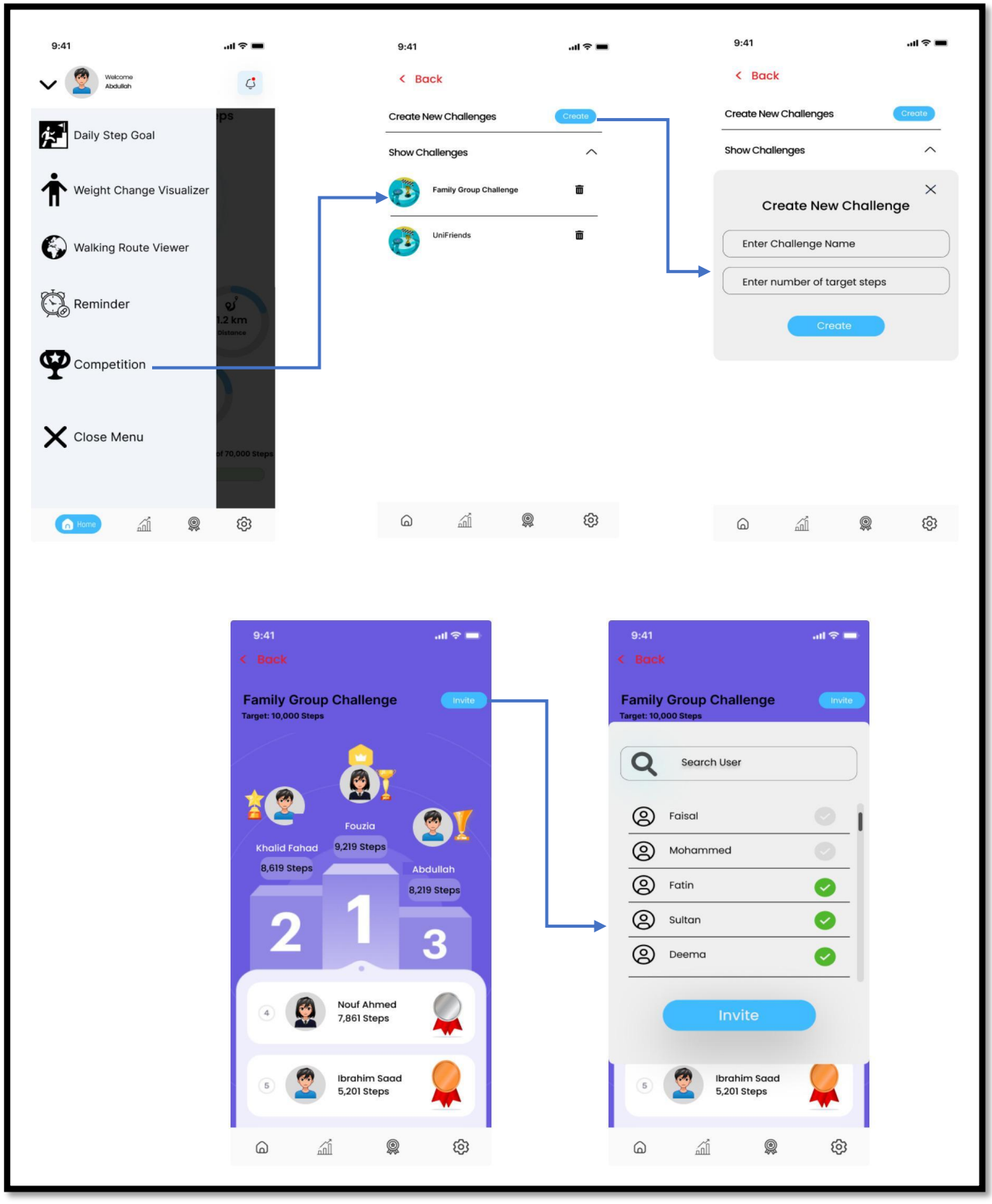


Figure 85: Competition Strategy in the Arabic App.

7.1.9 Map and Visual Walking Routes within the Tunneling Strategy for Arabic Users

This section highlights the implementation of the tunneling strategy in the Arabic version of our future PA app, 'Walk4Wellness,' tailoring it as map visualization for walking routes (IMPL-2) for Arabic users.

In the Arabic version of our PA app, the tunneling strategy empowers users to discover walking routes and estimated travel times between two chosen locations. By accessing the hamburger icon on the home screen, users can opt for the 'Walking Route Viewer' feature. This prompts the display of a map interface where users can input their desired starting point and destination. Upon entering both the starting and destination locations, the map displays a walking route, outlining the optimal path for users to follow. Additionally, the estimated time for completing the journey on foot is provided. This feature leverages real-time mapping technology [90], enhancing the user experience through intuitive interactions. By simplifying the process of discovering walking or running routes, users are motivated to engage with this feature, as it fosters enthusiasm for PA through an accessible and engaging interface. In Figure 86, an example illustrates the most suitable walking path between (7 Grams Café) in Dammam Cornish district and (Sedar Company) in Dammam city in Saudi Arabia, along with the estimated time to complete the journey.

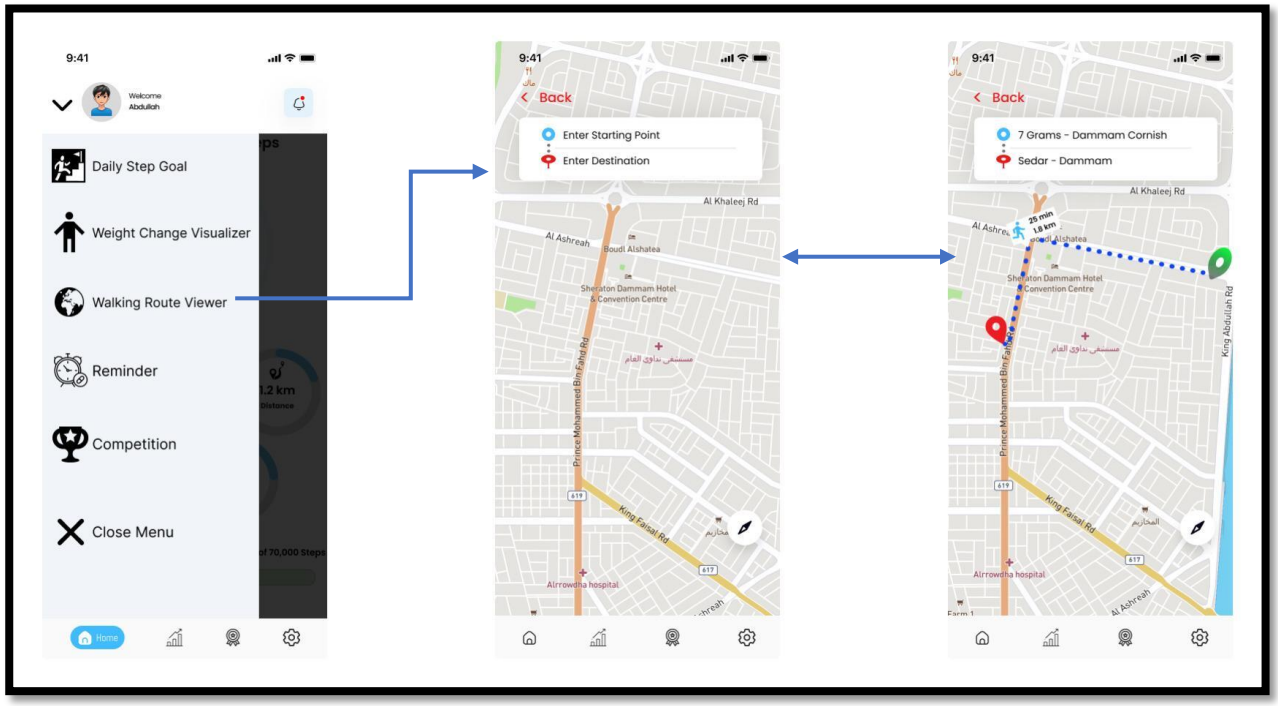


Figure 86: Tunneling Strategy in the Arabic App.

7.1.10 Current and Target Body Measurements and Shape within the Simulation Strategy for Arabic Users

This section illustrates the implementation of the simulation strategy in the Arabic version of our future PA app, 'Walk4Wellness,' tailoring it as educational tips/images with current and target body-shape simulation (IMPL-2) for Arabic users.

In the Arabic version of our PA app, the simulation strategy utilizes user-input parameters such as gender, height, weight, and age to generate visual representations of the user's current body shape alongside their target goal body shape. This comparative visualization serves as a powerful motivational tool for users striving for fitness, particularly in the context of increasing their daily step count. Users are motivated to progress towards their step count goals by visualizing how their efforts align with their desired body shape.

The process begins with users inputting their personal details, including their gender, height, age, current body weight, and targeted body weight, into the “Weight Change Visualizer” screen. Using

this information, the “Weight Change Visualizer” screen generates two visual representations using the Meshcapade tool [182]: one displaying the user's current body shape and another presenting their desired or target body shape.

By offering users a side-by-side comparison of their current and desired body shapes (as illustrated in Figure 87), the simulation strategy provides a clear visualization of the progress they aim to achieve. This visual feedback serves as a significant motivator, enabling users to visualize the potential outcomes of their efforts.

Moreover, the simulation strategy prioritizes user comfort by providing the option to hide the preview images if users experience any discomfort regarding their body shape. This feature demonstrates sensitivity to user preferences to ensure a positive and empowering experience.

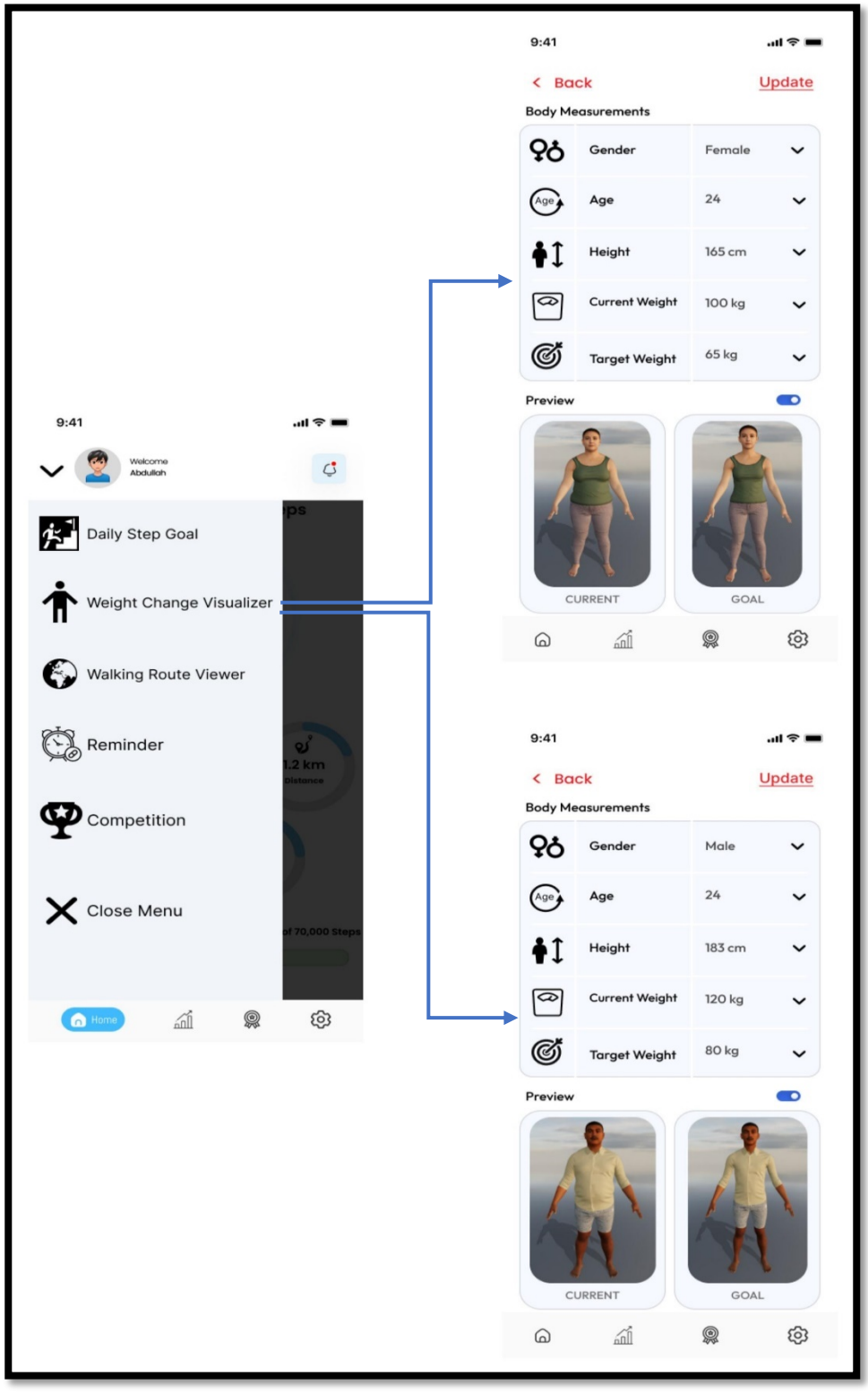


Figure 87: Simulation Strategy in the Arabic App.

7.2 Proposed Model Architecture for the Future PA Application (Walk4Wellness)

This section offers an overview of the architecture proposed for our future PA app, 'Walk4Wellness,' as illustrated below (refer to Figure 88), adapted from [85].

Sensors:

- **Accelerometer**: This component detects the device's acceleration in three-dimensional space. Analyzing peaks and valleys in acceleration patterns allows for step detection [290].
- **Barometer/Altitude Sensor**: Some smartphones feature barometric or altitude sensors capable of detecting altitude changes. These changes indicate stair climbing or descending [260].
- **Global Positioning System (GPS)**: GPS provides location data, enabling speed calculation by tracking position changes over time, which is particularly useful for outdoor activities with available GPS signals [133].

Sensor Adaptor: Acts as an intermediary between the device's embedded sensors and our application.

User Profile: The application generates user profiles based on registration details. These profiles inform recommendations for target step counts and track user behavior for personalized suggestions.

Knowledge Base: A knowledge base is constructed within the smartphone environment to store alert messages and user profiles.

Alert Generation: When the application detects that the user has been inactive (e.g., not walking or running) for extended periods, it generates an alert message. These alerts are not sent when the user is engaged in other scheduled activities or events (e.g., meetings or appointments). Additionally, users are notified about their scheduled walking times.

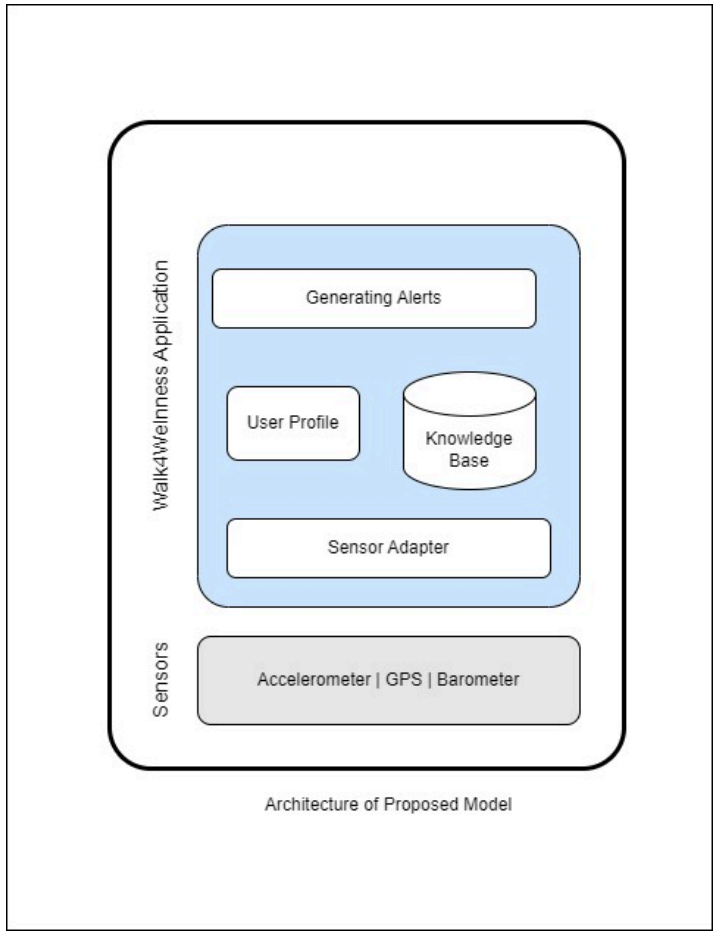


Figure 88: The Architecture of the Proposed Model.

7.3 Conclusion and Future Work

This chapter provides wireframe designs for our 'Walk4Wellness' mobile app that are tailored for both Arabic and non-Arabic users. These designs are developed based on insights from our user study (online survey) to ensure a user-friendly approach. I introduced two versions of the app while highlighting their features and differences. Detailed screenshots are presented with each design, providing a clear understanding of the interface. For future work, I aim to design the real-world mobile app for the two versions tailored for Arabic and non-Arabic users followed by evaluating both apps through a user study.

8 CHAPTER 8: CONCLUSION

Persuasive physical activity (PA) apps are effective tools for promoting behavior change, yet most existing ones lack a tailored approach in their design. When considering persuasive technologies (PTs) to manage sedentary behavior (SB), there is a pressing need for technology aimed at enhancing health and preventing diseases by specifically targeting individual behaviors or activities to increase PA levels. Over time, there has been growing interest in the research and design of such technologies for healthcare applications. Despite this interest, a gap remains in understanding how to optimize the design of mobile PA apps to maximize their effectiveness.

This dissertation investigates the design of a tailored persuasive mobile app to promote PA among both Arabic and non-Arabic adults while considering their motivational appeals. It also examines the effectiveness of tailored mobile PA apps. To contribute to this research field, the dissertation offers guidelines for customizing persuasive PA interventions to address this research question. It is comprised of six distinct stages:

1. **Stage 1: Identifying Persuasive Technology Platforms:** In the first stage, a systematic review of 170 articles on PTs for promoting PA and reducing SB revealed that mobile and handheld devices were the most frequently employed technology platforms.
2. **Stage 2: Identifying Initial Persuasive Strategies:** In the second stage, a systematic review of 80 articles on mobile phone-based technology platforms for promoting PA and reducing SB revealed common strategies, with wearable activity trackers and sensors being frequently used.
3. **Stage 3: Identifying Persuasive Strategies and Their Implementations:** A comprehensive systematic review of 198 articles on mobile-based PT interventions in the third stage identified the twelve most commonly employed strategies and how they were implemented.
4. **Stage 4: Designing and Conducting the User Study:** In the fourth stage, a large-scale user study involving 1100 participants (from Arabic and non-Arabic populations) was conducted, focusing on mobile and handheld devices. Twenty-four high-fidelity prototypes, each representing a different persuasive strategy, were designed and presented for participant evaluation.

5. **Stage 5: Mapping Persuasive Strategies and their Implementations to App Features:** The final stage involved mapping the implementations of persuasive strategies to app features based on our comprehensive literature reviews, user study results, and design guidelines for both Arabic and non-Arabic populations.

This dissertation thus contributes to the understanding of how tailored persuasive PA apps can effectively promote behavior change and provides valuable insights and guidance for researchers and designers in this field.

8.1 Findings and Contributions

The dissertation makes several significant contributions based on the findings from each module of the research (see Figure 2):

Module 1: Examination of Persuasive Technology Platforms and Research Trends

Findings:

- PTs are effective in promoting PA and discouraging SB, with approximately 80% of the reviewed studies reporting successful outcomes.
- The most frequently employed technology platforms are mobile and handheld devices, along with activity trackers and sensors.
- Persuasive strategies like tracking/self-monitoring, reminders, personalization, goal setting, rewards, and social support are found to be the most effective in PT design for PA and SB.

Contributions:

- Provides a foundation for understanding the effectiveness of PTs in promoting health and wellness in the domains of PA and SB.
- Highlights trends in persuasive strategies, target audiences, and technological platforms.
- Offers insights into limitations and recommendations for advancing future research.

Module 2: Evaluation of Mobile Phone-based Technology Platforms Alone and in Combination with Other Technologies

Findings:

- The analysis of 80 studies on mobile phone-based PTs reveals trends in the domain of PA and SB, including technology platforms, behavior change theories, and persuasive strategies.
- The strengths and weaknesses of existing mobile phone-based PT interventions are discussed.

Contributions:

- Provides insights into the effectiveness of mobile phone-based PTs in promoting PA and discouraging SB.
- Highlights trends in technology platforms, behavior change theories, and persuasive strategies.
- Offers suggestions to inform future research in mobile PT interventions for motivating PA and discouraging SB.

Module 3: Examination of Persuasive Strategies and Their Implementation in Mobile-based Interventions

Findings:

- A comprehensive review of 198 articles on mobile-based PTs in the PA and SB domains identifies the most commonly used persuasive strategies and their implementations.
- Gaps and limitations in the current literature are identified, and recommendations for future research are provided.

Contributions:

- Offers a thorough understanding of the persuasive strategies used in designing mobile-based PTs for PA and SB.
- Highlights how persuasive strategies are implemented differently.
- Identifies gaps and limitations in the existing literature and suggests directions for future research.

Module 4: Tailoring Persuasive Strategies and Implementations to App Features Across Arabic and Non-Arabic Populations

Findings:

- A large-scale user study involving diverse populations (Arabic and non-Arabic) assesses the persuasiveness and effectiveness of various persuasive strategy implementations.

- Variations in the perceived persuasiveness of different strategy implementations are observed, with differences between Arabic and non-Arabic populations.
- The study links the effectiveness of strategy implementations to behavior change stages and motivational constructs.
- Qualitative insights into user preferences and dislikes are provided.

Contributions:

- Empirical investigation of the persuasiveness and effectiveness of diverse persuasive strategy implementations.
- Proposes practical guidelines for tailoring persuasive systems based on user preferences and behavior change stages.
- Establishes connections between behavior change theories and motivation theory.
- Outlines future research directions, including the real-world application of design recommendations and exploration of strategy implementations in different contexts.

This summary clearly highlights both the key findings and contributions of each module in the dissertation. In conclusion, this dissertation contributes valuable knowledge to the field of PT and human-computer interaction by offering insights into the effectiveness of PTs, the impact of personalized systems, and the variations in strategy implementations. It provides practical guidance for designing persuasive systems tailored to user preferences and behavior change stages and outlines directions for future research in the PA domain.

8.2 Limitations and Future Work

This dissertation represents an initial effort towards tailoring persuasive PA applications to align with cultural values and stages of behavior change, validating the effectiveness of diverse persuasive strategies and their implementations across Arabic and non-Arabic populations. While this study has uncovered interesting and noteworthy results, it concurrently reveals a multitude of prospects for further exploration.

Future research can explore the potential effects of user experience on the persuasiveness of PA apps and their effectiveness while exploring the role of enjoyment and competence in this relationship. Additionally, there may be effects linked to distinct user characteristics such as gender, age, and

personality traits that can potentially influence how users perceive strategies and their impact on behavior. Consequently, tailoring strategies to individual personality types could enhance the efficacy of persuasive PA apps. Our findings emphasize the effectiveness of aligning persuasive strategies and preferred implementations with user recommendations, particularly accounting for cultural variations among Arabic and non-Arabic populations. Furthermore, an avenue for investigation lies in the comparison between single and multiple persuasive strategies to determine the optimal number of strategies required for users to engage in PA behavior.

Moving forward, future research will implement the study's design recommendations within real-world persuasive systems to assess their practical efficacy. The future research will also examine user preferences for specific implementations across various behavior change stages while evaluating the impact of less favored strategies and their implementations on motivating users. Further exploration will cover additional variations of each strategy and their influence on user motivation, expanding the applicability of these insights to diverse behavioral domains like smoking cessation, mental health, and healthy eating. Moreover, the study will assess the persuasiveness of strategies and their implementations in relation to specific user characteristics, including personality traits, while exploring cultural variations within specific regions rather than taking a broad population approach. In this section, I provided scenarios and examples of how the wireframes (prototypes) can be utilized in actual PA applications for designing various user studies. The wireframes, which incorporate multiple persuasive strategies, can be constructed in single or dual implementations. They can be evaluated as a comprehensive app with all features (mixed-strategy) and compared with individual or specific sets of strategies and features (e.g., tailored single-strategy, tailored multi-strategy, contra-tailored single strategy). Participants can be divided into several groups (e.g., intervention group, control group-single strategy, control group-mixed strategy) by assigning different designs of the PA app. This division will facilitate the evaluation and comparison of the persuasiveness and effectiveness of the app features. Future research can also evaluate the performance of PA apps by comparing them to existing interventions in the PA domain and examining whether the cultural and motivation-based model approach leads to improved user performance. As part of future work, I will seek the necessary permissions and approval from the Dalhousie Research Ethics Board to make the collected data and analysis files available on the Open Science Framework.

In summary, based on our findings, I have provided some ideas and insights to guide future research, both in terms of systematic reviews and user studies and evaluations, as shown below. Table 30 and Table 31 provide a brief description of these ideas.

Future Systematic Reviews:

- **Evaluation of Target Populations by Age Demographics:**
    - Future research should evaluate studies on PTs in promoting PA and SB according to different age demographics, including older adults, teenagers, and children.
- **Analysis of Technology Platforms:**
    - There is a need to analyze PTs based on each technology platform used in their design to understand their effectiveness and usability better.
- **Leveraging User Feedback for PT Design and Innovation:**
    - It is recommended to evaluate user reviews and feedback for existing PTs (applications, systems, or devices) to inform and advance the design of future PTs for PA and SB.
    - Future research should extend to mobile phone apps available online and in app stores to gain insights into users' needs and perceptions based on user reviews and assessments of the apps. This will aid in developing mobile phone-based PTs.
- **Incorporation of Behavior Change Theories:**
    - Studies should employ behavior change theories in persuasive designs. Researchers and developers should illustrate how these theories are linked to design features, as theory-based designs tend to be more effective.
- **Mixed Method Evaluation:**

- Designers should employ both quantitative and qualitative methods to achieve a comprehensive evaluation of persuasive systems. The mixed method approach provides richer insights by revealing both quantitative and qualitative outcomes.

- **Description and Implementation of Persuasive Strategies:**
  - Future research should clearly describe the persuasive strategies employed and their implementations. More review papers are needed to address the various implementations of each persuasive strategy in PA and SB domains and other areas such as healthy diet, smoking cessation, and mental health.

- **Standard Measurement of Effectiveness:**
  - There is a need to provide standard measurements for the effectiveness of each persuasive strategy and each implementation. Future research should also offer clear and unified classifications for each persuasive strategy's implementation with possible examples.

- **Investigation of Effective Strategies:**
  - Future work should investigate the most effective strategies or combinations of strategies that yield the best results, as the literature lacks a clear view of this aspect.

Future User Studies and Evaluations:

- **Real-world Implementation:**
  - Future research endeavors should implement the design recommendations derived from this study in actual persuasive systems to assess their real-world effectiveness.

- **Behavior Change Transitions:**
  - Researchers should explore whether users exhibit preferences for specific implementations as they transition between different stages of behavior change.

- **Examination of Less Favored Strategies:**
    - There is a need to examine less favored strategies and their corresponding implementations to compare their impact on motivating target users.
- **Investigation of Additional Implementations:**
    - Future studies should investigate additional implementations of each strategy and their effects on user motivation.
- **Broader Application to Other Behavioral Domains:**
    - The applicability of findings should be extended to other behavioral domains such as smoking cessation, mental health, and healthy eating.
- **Assessment Based on Specific Characteristics:**
    - Researchers should assess the persuasiveness of strategies and their implementations on individuals based on specific characteristics such as age, gender, and personality traits.
- **Investigation of Cultural Variations:**
    - Future research should investigate a comparison between specific cultures within particular countries rather than studying broad populations.

Table 30: Future Systematic Reviews.

Focus Area	Description
Age Demographics	• Evaluate PTs promoting PA and SB for different age groups (older adults, teenagers, children).
Technology Platforms	• Analyze PTs based on the technology platforms used in their design.
User Feedback	• Assess user reviews and feedback for existing PTs to inform future designs.
Behavior Change Theories	• Use behavior change theories in PT designs and demonstrate their relation to design features.
Mobile Applications	• Extend research to mobile apps available online and in app stores for insights into user needs and perceptions.
Mixed Method Evaluation	• Employ both quantitative and qualitative methods for comprehensive evaluations.

Persuasive Strategies	• Detail the implementation of persuasive strategies across various domains and technology platforms.
Standard Measurement for Effectiveness	• Provide standard measures and classifications for the effectiveness of strategies.
Effective Strategies	• Identify the most effective strategies or combinations of strategies.

Table 31: Future User Studies and Evaluations.

Focus Area	Description
Real-World Implementation	• Implement design recommendations in actual PTs to assess real-world effectiveness.
Behavior Change Transitions	• Explore user preferences during different stages of behavior change.
Less Favored Strategies	• Examine less favored strategies and their impact on motivation.
Additional Implementations	• Investigate additional implementations of each strategy and their effects on motivation.
Broader Application	• Apply findings and adapt wireframes for different behavioral domains, such as: o smoking cessation o mental health o healthy eating o alcohol reduction
Specific Characteristics	• Assess strategy persuasiveness based on age, gender, and personality traits.
Cultural Variations	• Compare the effectiveness of strategies across different cultures within countries.
Scenarios and Examples	• Provide scenarios and examples of how wireframes (prototypes) can be utilized in actual PA apps for designing various experimental user studies.
Implementation Strategies	• Construct wireframes with multiple persuasive strategies as: o Single implementations o Dual implementations
Evaluation Methods	• Evaluate wireframes as a comprehensive app with all features (mixed-strategy). • Compare with individual or specific sets of strategies and features, including: o Tailored single-strategy o Tailored multi-strategy o Contra-tailored single strategy
Participant Groups	• Divide participants into several groups, such as: o Intervention group o Control group-single strategy o Control group-mixed strategy
Evaluation Objectives	• Assign different designs of the PA app to these groups to: o Evaluate persuasiveness o Compare effectiveness of the app features

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APPENDIX A. PERMISSION TO USE

In presenting this thesis in partial fulfilment of the requirements for PhD's in computer science degree from the Dalhousie University, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the Dalhousie University in any scholarly use which may be made of any material in my thesis.

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Dalhousie University,
Halifax, Nova Scotia, Canada B3H 1W5

APPENDIX B. PUBLICATIONS

1. Aldenaini, N., Alqahtani, F., Orji, R. and Sampalli, S. 2020. Trends in Persuasive Technologies for Physical Activity and Sedentary Behavior: A Systematic Review. Frontiers in Artificial Intelligence. 3, (Apr. 2020), 7. DOI:https://doi.org/10.3389/frai.2020.00007.
2. Aldenaini, N., Oyebode, O., Orji, R. and Sampalli, S. 2020. Mobile Phone-Based Persuasive Technology for Physical Activity and Sedentary Behavior: A Systematic Review. Frontiers in Computer Science. (2020). DOI:https://doi.org/10.3389/fcomp.2020.00019.
3. Aldenaini, N., Orji, R. and Sampalli, S. 2020. How effective is personalization in persuasive interventions for reducing sedentary behavior and promoting physical activity: A systematic review. CEUR Workshop Proceedings (2020).
4. Aldenaini, N., Alslaity, A., Sampalli, S. and Orji, R. 2022. Persuasive Strategies and Their Implementations in Mobile Interventions for Physical Activity: A Systematic Review. International Journal of Human-Computer Interaction. (2022). DOI:https://doi.org/10.1080/10447318.2022.2075573.
5. Aldenaini, N., Alhasani, M., Orji, R., Sampalli, S. Investigating the Impact of Persuasive Strategy Implementation Choices on Physical Activity Promotion among Arabic and Non-Arabic Populations: Towards Tailoring Persuasive Technologies. (*In Progress*)
6. Aldenaini, N., Oyebode, O., Orji, R., Sampalli, S. Examining the Effectiveness of Persuasive Strategy Implementation Choices in Promoting Physical Activity: Towards Tailored Persuasive Systems Based on Stages of Behavior Change and Motivation among Arabic and Non-Arabic Populations. (*In Progress*)
7. Aldenaini, N., Chan, G., Orji, R., Sampalli, S. Tailoring the Design of Persuasive Systems for Promoting Physical Activity: Proposing Guidance, Insights, and Perspectives on Addressing Cultural Differences among Arabic and Non-Arabic Populations. (*In Progress*)
8. Aldenaini, N., Pusuluru, G., Orji, R., Sampalli, S. Evaluating Two Initial Mobile

Application Designs for Promoting Walking Among Both Arabic and Non-Arabic Populations: A Pilot Study. (*In Progress*)

APPENDIX C. RESEARCH ETHICS BOARD APPROVAL

DALHOUSIE UNIVERSITY
Research Services

Social Sciences & Humanities Research Ethics Board
Letter of Approval

May 19, 2021
Noora Aldenaini
Computer Science\Computer Science

Dear Noora,

REB #: 2021-5495
Project Title: Investigating the Implementations of Persuasive Strategies for Physical Activity

Effective Date: May 19, 2021
Expiry Date: May 19, 2022

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans*. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Effective March 16, 2020: Notwithstanding this approval, any research conducted during the COVID-19 public health emergency must comply with federal and provincial public health advice as well as directives from Dalhousie University (and/or other facilities or jurisdictions where the research will occur) regarding preventing the spread of COVID-19.

Sincerely,

Dr. Karen Foster, Chair

APPENDIX D. INSTRUMENTS USED IN THE DISSERTATION

Section 1: Demographic

1. Please choose your age range:

- ○ 18-25
- ○ 26-35
- ○ 36-45
- ○ 46 or more

2. Please choose your gender:

- ○ Male
- ○ Female
- ○ Other

3. What is the highest level of education you have completed?

- ○ Less than High school
- ○ High School or equivalent
- ○ College diploma
- ○ Bachelor's degree
- ○ Master’s degree
- ○ Doctoral degree
- ○ Other (please specify)_____

4. What is your current level of study if you are a student?

- ○ Undergraduate
- ○ Taught Postgraduate (e.g. MSc)

- ○ Research Postgraduate (e.g. Ph.D)
- ○ I am not a Student

5. What is your marital status?

- ○ Single
- ○ Married
- ○ Widowed
- ○ Divorced
- ○ Separated
- ○ Other (please specify) _____

6.What is your Current employment status?

- o Full-time job
- o Part-time job
- o Not working seeking employment
- o Not working not seeking employment

7.What is your country of residence?

Please select a country …….

8.What is your country of origin?

Please select a country…….

9.Overall, what is the state of your health in the past four weeks? (Health includes mental, social and physical health)

- o Poor
- o Fair
- o Good

- Very good
- Excellent
- I am not sure

10. Have you been diagnosed with any chronic diseases (e.g. Diabetes, Hypertension, Coronary heart disease, Stroke, Arthritis, Cancer, Epilepsy and Seizures, Obesity, Chronic Oral disease)
- Yes
- No

11. How much time do you usually spend sitting or reclining on a typical day (i.e., total time spent sitting at work, in an office, reading, watching television, using a computer, doing hand craft like knitting, resting, etc.)?

Hours ☐

12. Do you currently use a walking or fitness application to track your step counts or your general physical activity progress (e.g. Fitbit Mobile Track, Google Fit)?
- Yes
- No

13. Have you previously use a walking or fitness application to track your step counts or your general physical activity progress (e.g. Fitbit Mobile Track, Google Fit)?
- Yes
- No

14. Could you please inform us about the walking or fitness applications you currently use or previously? Please, choose all applicable.
    - Map My Run
    - Google Fit
    - Fitbit Mobile Track

- Strava
- Apple Health
- Charity Mile
- Foothpath
- World Walking
- Walkmeter
- Steps App
- Pacer
- All Trails
- Map My Walk
- Argus
- Virtual Walk
- MotionX GPS
- Endomondo
- Footpath Route Planner
- Go Jauntly
- Alpine Quest
- Nike + (NRC)
- Sportracrtive
- Walking App
- Out Doors
- My Steps (خطواتي)
- BetterMe Walk
- Other (please specify)…….

15. Please, provide your feedback, comments, and recommendations to justify your rating!

Section 2: Motivational Appeal Test Questions (adapted from [209])

	1-Strongly Disagree	Disagree	Neutral	Agree	5-Strongly Agree
The app would capture and hold my attention.	1	2	3	4	5
The app has some contents that stimulates my curiosity.	1	2	3	4	5
The content of the app would be relevant to me.	1	2	3	4	5
I can relate with the content of this app.	1	2	3	4	5
The content of the app makes sense to me.	1	2	3	4	5
The content of the app would be useful to me.	1	2	3	4	5
It would be easy to understand and use the app.	1	2	3	4	5
The app would help me control my physically active.	1	2	3	4	5
The app would build my confidence in my ability to be physically active.	1	2	3	4	5
I would really enjoy using the app.	1	2	3	4	5
It would be a pleasure to work with an app like this.	1	2	3	4	5
The app would help me accomplish my behavior goal.	1	2	3	4	5

Section 3: Perceived Persuasiveness Test Questions (Adapted from [76] [213])

	1-Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	7-Strongly Agree
This feature would convince me to increase my physical activity level (e.g. step counts).	1	2	3	4	5	6	7
This feature would influence me to reduce the time spent sedentary (e.g. sitting).	1	2	3	4	5	6	7
This feature would be personally relevant for me	1	2	3	4	5	6	7
This feature would make me reconsider my physical activity behaviors.	1	2	3	4	5	6	7
The feature will make me use the app	1	2	3	4	5	6	7
I find the feature useful	1	2	3	4	5	6	7

Section 4: Stage of Change Test Questions (adapted from [103] [218])

Based on your physical activity performance, please select the option that best applies to you.

PHYSICAL ACTIVITY	
1. I do not engage in regular exercise and have no intention to start exercising in the future.	◯
2. I am not exercising currently but planning to start within six months.	◯

3. I am seriously considering to start exercising and have taken some steps toward this objective.	◯
4. I have been exercising consistently for up to six months.	◯
5. I have maintained an active lifestyle for more than six months.	◯

Section 5: Survey Questions and the Corresponding Questions (in Arabic Language)

خطة الدراسة : أسئلة الاستبيان

الدراسة ١: المعلومات الشخصية

1. الرجاء اختيار الفئه العمرية الخاصة بك

- o ١٨-٢٥
- o ٢٦-٣٥
- o ٣٦-٤٥
- o ٤٦ و اكبر

2. الرجاء اختيار جنسك

- o ذكر
- o انثى
- o اخرى

3. ما هو أعلى مستوى تعليمي أتممته؟

- o أقل من الثانوية العامة
- o الثانوية العامة أو ما يعادلها

- دبلوم الكلية
- درجة البكالوريوس
- درجة الماجستير
- درجة الدكتوراه
- أخرى (يرجى التحديد) .....

4. ما هو المستوى الدراسي الحالي إذا كنت طالبًا؟
- المرحلة الجامعية
- الدراسات العليا التدريسية (مثل ماجستير)
- الدراسات العليا البحثية (مثل الدكتوراه)
- أنا لست طالب

5. ما هي حالتك الاجتماعية؟
- اعزب/عزباء
- متزوج/ة
- أرمل/ة
- مطلق/ة
- منفصل/ة
- أخرى (يرجى التحديد).....

6. ما هو وضعك الوظيفي الحالي؟
- وظيفة بدوام كامل
- وظيفة بدوام جزئي
- لا اعمل ، ابحث عن وظيفة
- لا اعمل ولا ابحث عن وظيفة

7. ما هو بلد إقامتك؟

الرجاء اختر دولة .....

8. ما هو بلدك الأصلي؟

الرجاء اختر دولة .....

9. كم من الوقت تقضيه عادة في الجلوس أو الاتكاء في يوم عادي (أي إجمالي الوقت الذي تقضيه في العمل ، أو في المكتب ، أو القراءة ، أو مشاهدة التلفزيون ، أو استخدام الكمبيوتر ، أو القيام بالأشغال اليدوية مثل الحياكة ، والراحة ، إلخ)؟

عدد [ ]

10. بشكل عام ، ما هي حالة صحتك في الأسابيع الأربعة الماضية؟ (الصحة تشمل الصحة العقلية والاجتماعية والبدنية)

- ○ ضعيفة
- ○ مقبولة
- ○ جيدة
- ○ جيدة جدا
- ○ ممتازة
- ○ لا اعرف

11. هل تم تشخيصك بأي أمراض مزمنة (مثل السكري ، ارتفاع ضغط الدم ، أمراض القلب التاجية ، السكتة الدماغية ، التهاب المفاصل ، السرطان ، الصرع والنوبات ، السمنة ، أمراض الفم المزمنة)؟

- ○ نعم
- ○ لا

12. هل تستخدم حالياً تطبيق للمشي أو اللياقة البدنية لتتبع عدد خطواتك أو تقدم نشاطك البدني العام مثل (Google Fit , Fitbit Mobile Track)؟

- ○ نعم
- ○ لا

13. هل استخدمت مسبقاً تطبيق للمشي أو اللياقة البدنية لتتبع عدد خطواتك أو تقدم نشاطك البدني العام مثل (Google Fit , Fitbit Mobile Track)؟

- ○ نعم
- ○ لا

14. هل يمكنك إبلاغنا عن تطبيقات المشي أو اللياقة البدنية التي تستخدمها حالياً أو التي استخدمتها سابقاً؟ من فضلك يرجى تحديد كل ما ينطبق

- Map My Run
- Google Fit
- Fitbit Mobile Track
- Strava
- Apple Health
- Charity Mile
- Foothpath
- World Walking
- Walkmeter
- Steps App
- Pacer
- All Trails
- Map My Walk
- Argus
- Virtual Walk
- MotionX GPS
- Endomondo
- Footpath Route Planner
- Go Jauntly
- Alpine Quest
- Nike + (NRC)
- Sportracrtive
- Walking App
- Out Doors
- My Steps (خطواتي)
- BetterMe Walk
- أخرى (يرجى التحديد).....

15. من فضلك ، قدم ملاحظاتك وتعليقاتك وتوصياتك لتبرير تقييمك!

16. تخيل أنك تستخدم التطبيق أعلاه لتتبع نشاطك البدني. فضلاً ، يرجى الرد على الأسئلة التالية!

	أرفض بشدة	ارفض	ارفض قليلا	محايد	موافق قليلا	موافق	موافق بشدة
هذه الميزة ستحفزني على زيادة مستوى نشاطي البدني (مثل عدد الخطوات).	1	2	3	4	5	6	7
ستؤثر هذه الميزة علي لتقليل الوقت المستغرق في الجلوس (مثل الجلوس).	1	2	3	4	5	6	7
ستكون هذه الميزة مناسبة لي شخصيًا	1	2	3	4	5	6	7
هذه الميزة ستجعلني أعيد النظر في سلوكيات النشاط البدني.	1	2	3	4	5	6	7
هذه الميزة ستجعلني أستخدم التطبيق	1	2	3	4	5	6	7
أجد هذه الميزة مفيدة	1	2	3	4	5	6	7

17. فكر في كيفية استخدام التطبيق أعلاه في الحياة الواقعية لتتبع نشاطك البدني. إلى أي مدى توافق على العبارات التالية:

	ارفض بشده	ارفض	محايد	موافق	موافق بشدة
سوف يلفت و يجذب التطبيق انتباهي.	1	2	3	4	5
يحتوي التطبيق على بعض المحتويات التي تثير فضولي.	1	2	3	4	5
سيكون محتوى التطبيق مناسبًا لي.	1	2	3	4	5
يمكنني ان اتعلق بمحتوى هذا التطبيق.	1	2	3	4	5
محتوى التطبيق منطقي بالنسبة لي.	1	2	3	4	5

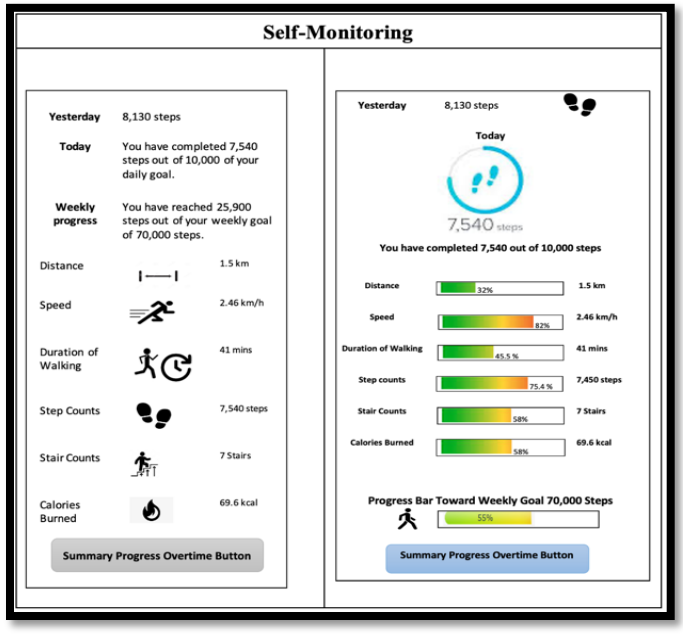
سيكون محتوى التطبيق مفيدًا بالنسبة لي.	1	2	3	4	5
سيكون من السهل فهم واستخدام التطبيق.	1	2	3	4	5
سيساعدني التطبيق في التحكم في نشاطي البدني (مثل: المشي او الجري).	1	2	3	4	5
سيزيد التطبيق ثقتي في القدرة على التحكم نشاطي البدني (مثل: المشي او الجري).	1	2	3	4	5
سأستمتع حقًا باستخدام التطبيق.	1	2	3	4	5
سيكون من دواعي سروري استخدام تطبيق مثل هذا.	1	2	3	4	5
سيساعدني التطبيق في تحقيق هدفي السلوكي في النشاط البدني.	1	2	3	4	5

18. وفقاً لمستوى نشاطك البدني، يرجى تحديد الخيار الأفضل لك

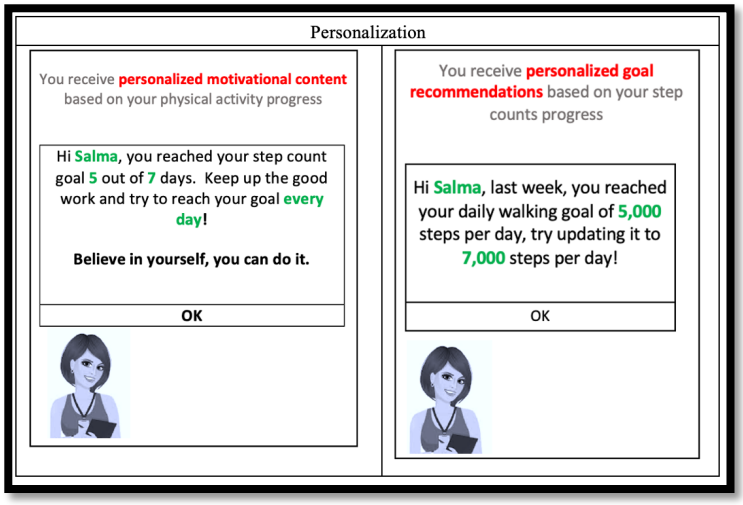
	النشاط البدني
◯	لا امارس التمارين الرياضية و ليس لدي أي رغبة لبدء التمرين في المستقبل
◯	.لا امارس التمارين الرياضية حالياً و لكنني أخطط للبدء خلال الستة اشهر القادم
◯	افكر بجدية في بدء التمارين الرياضية و اتخذت بعض الخطوات نحو هذا الهدف
◯	لقد كنت امارس التمارين الرياضية باستمرار لمدة تصل إلى ستة أشهر
◯	لقد حافظت على نمط حياة نشط لأكثر من ستة أشهر

APPENDIX E. USER STUDY PROTOTYPES

1. Self-monitoring Strategy

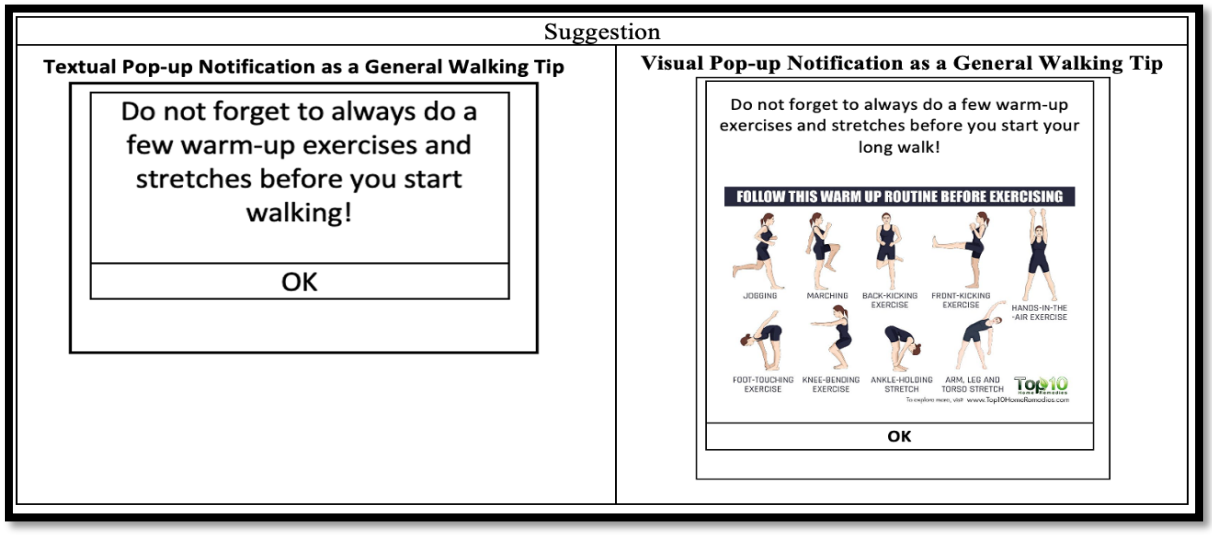


2. Personalization Strategy

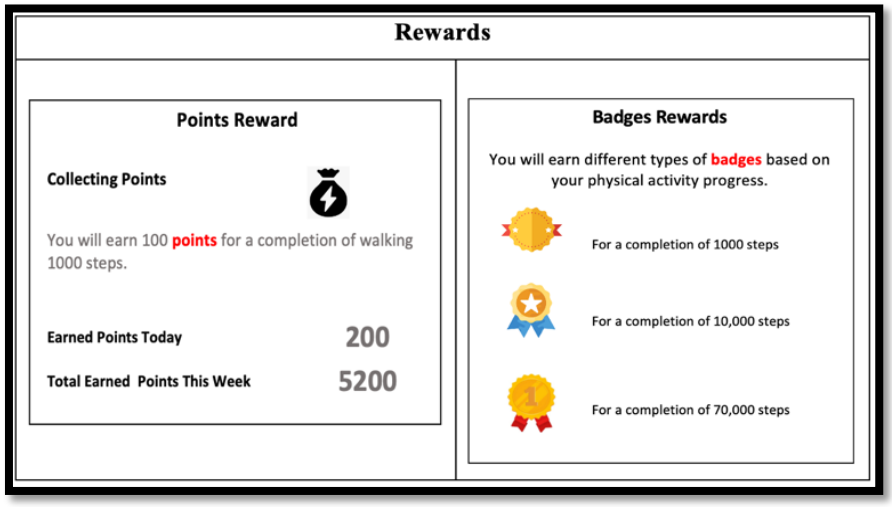


3. Goal-setting Strategy

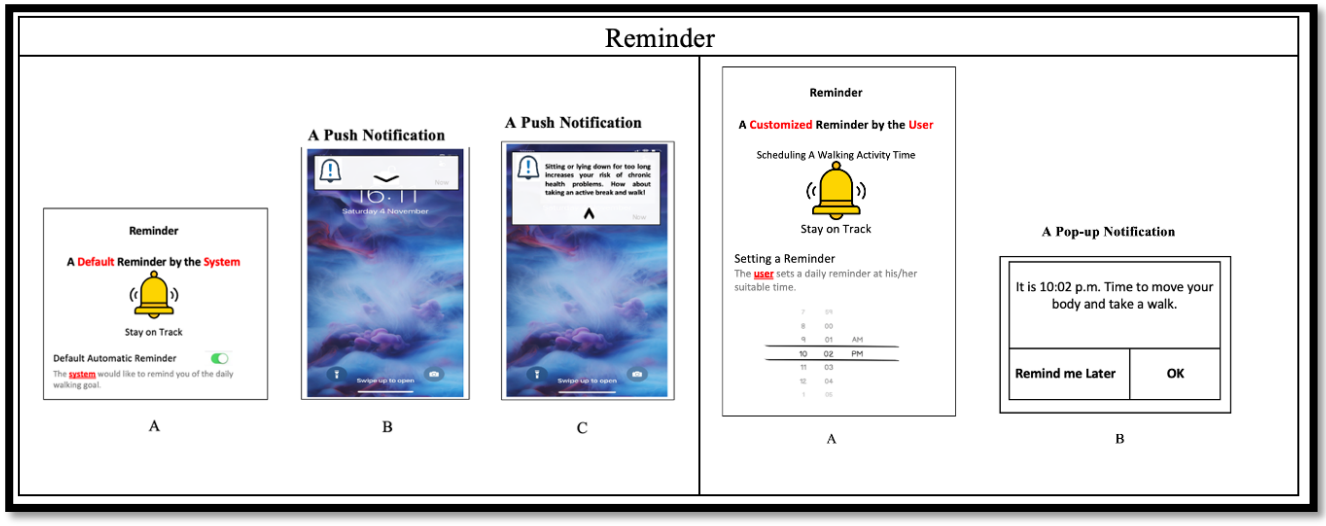
4. Suggestion Strategy



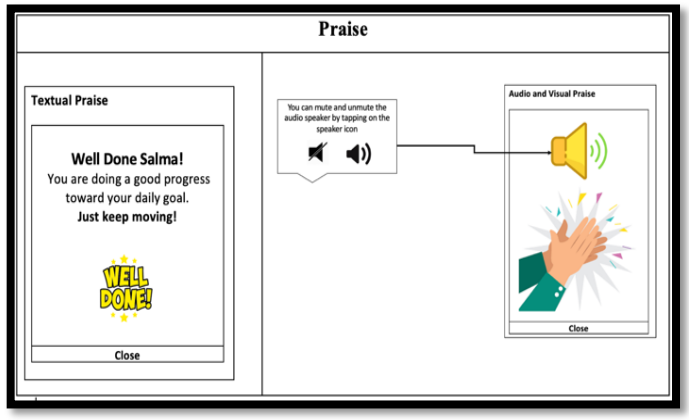
5. Reward Strategy



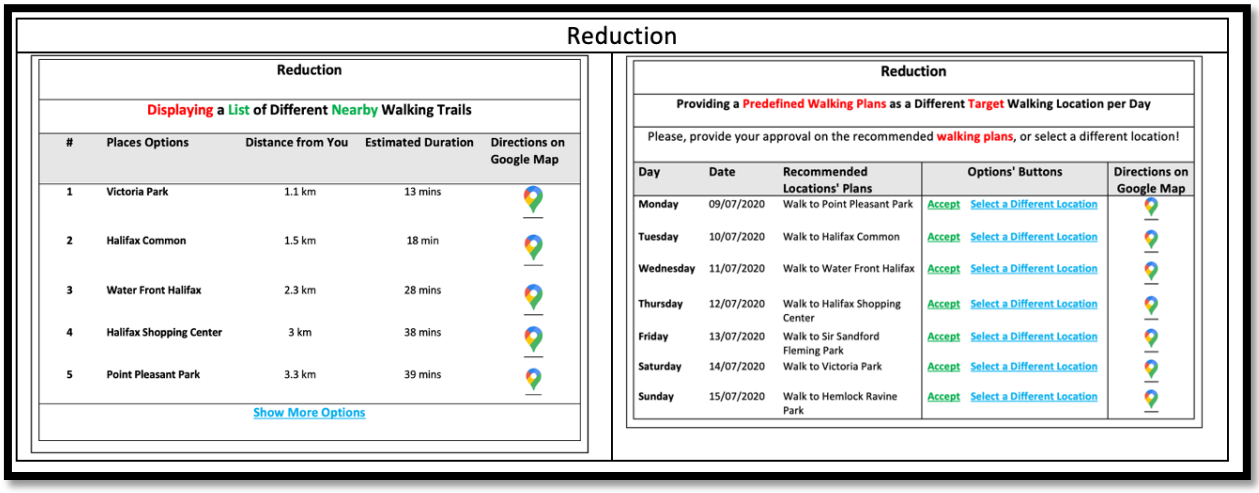
6. Reminder Strategy



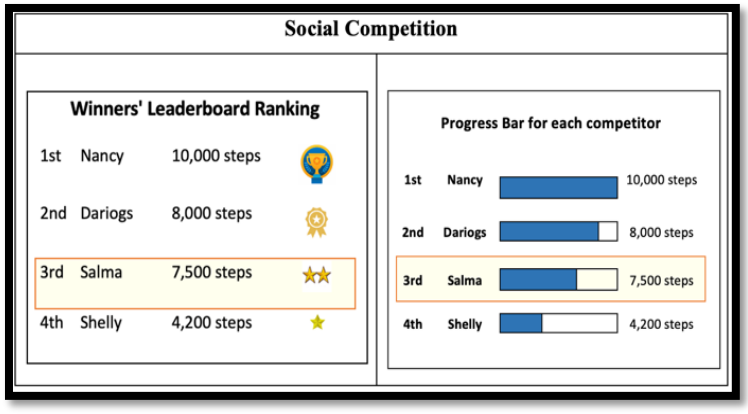
7. Praise Strategy



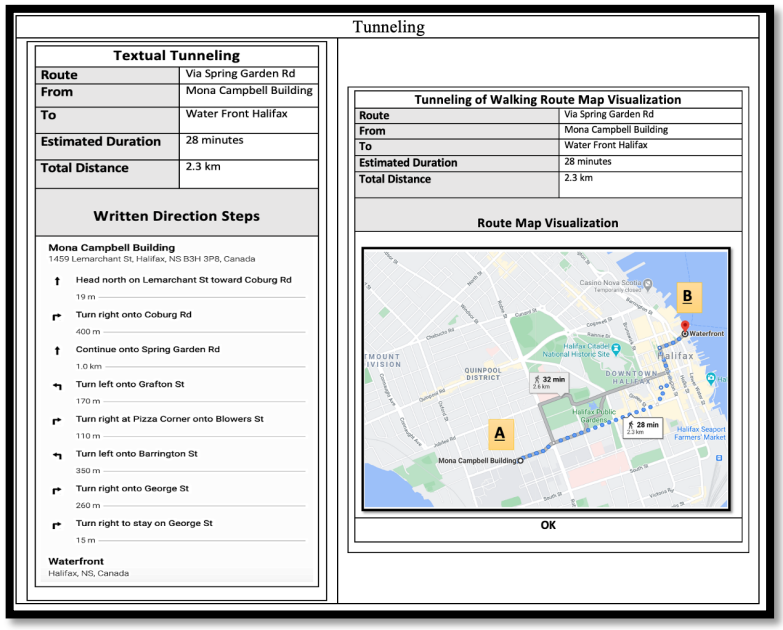
8. Reduction Strategy



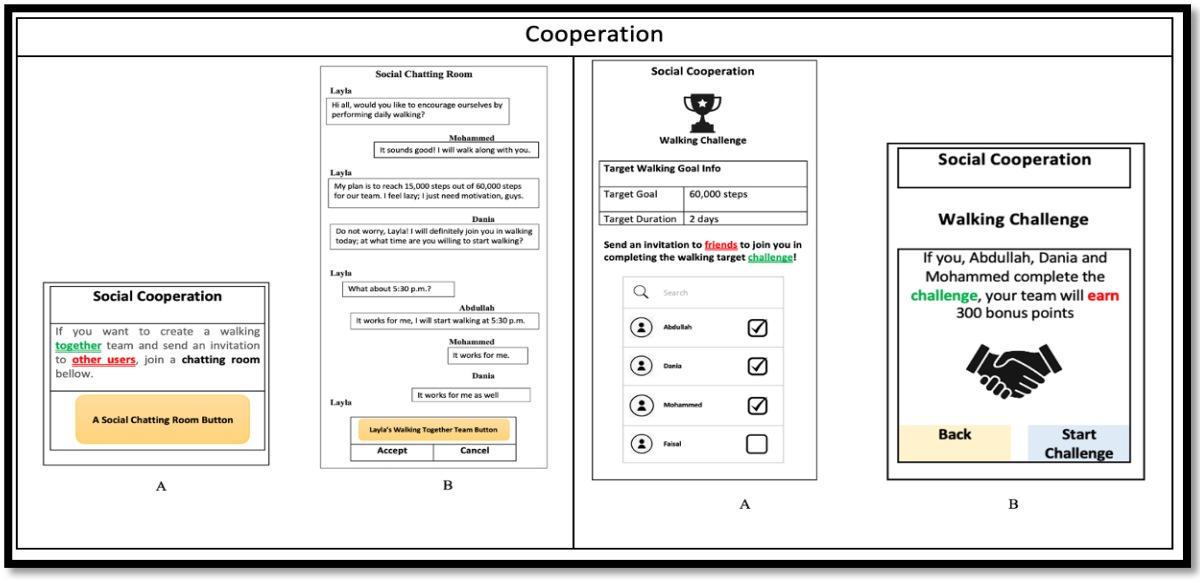
9. Social Competition Strategy



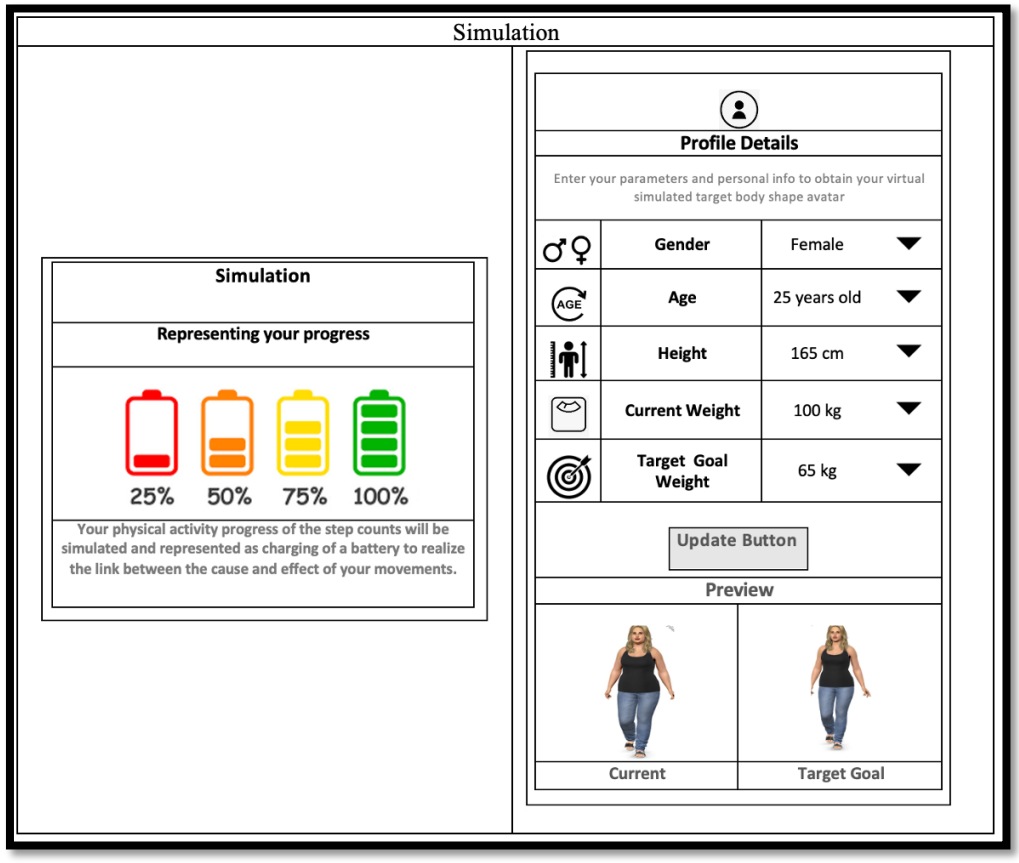
10. Tunneling



11. Social Cooperation Strategy



12. Simulation Strategy


Simulation
Simulation
Representing your progress
25%
50%
75%
100%
Your physical activity progress of the step counts will be simulated and represented as charging of a battery to realize the link between the cause and effect of your movements.
Profile Details
Enter your parameters and personal info to obtain your virtual simulated target body shape avatar
Gender
Female
Age
25 years old
Height
165 cm
Current Weight
100 kg
Target Goal Weight
65 kg
Update Button
Preview
Current
Target Goal

APPENDIX F. INTERFACES OF THE WALK4WELLNESS APP

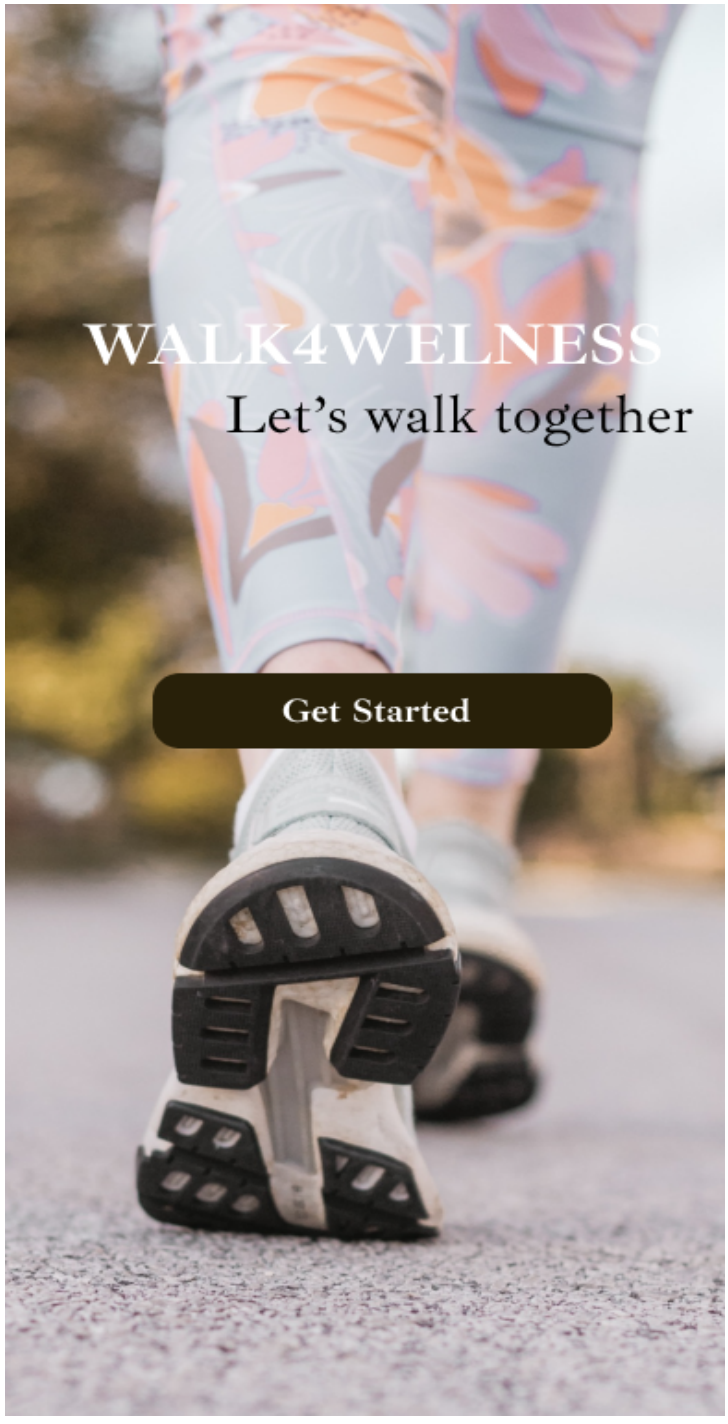


Figure 89: Welcome Screen.

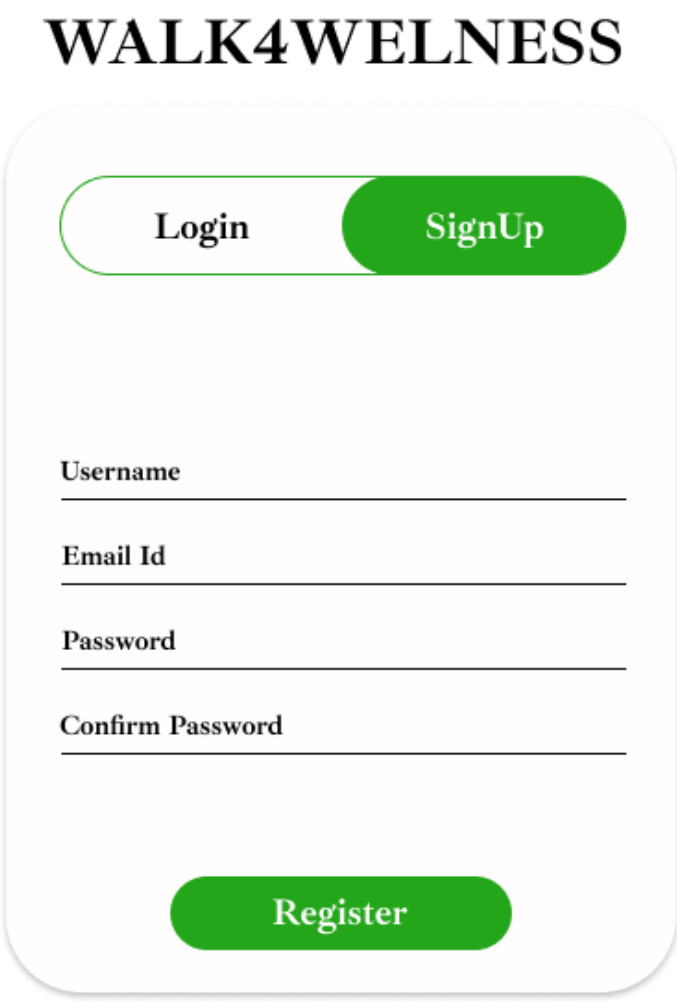


Figure 90: Signup screen for New Users.

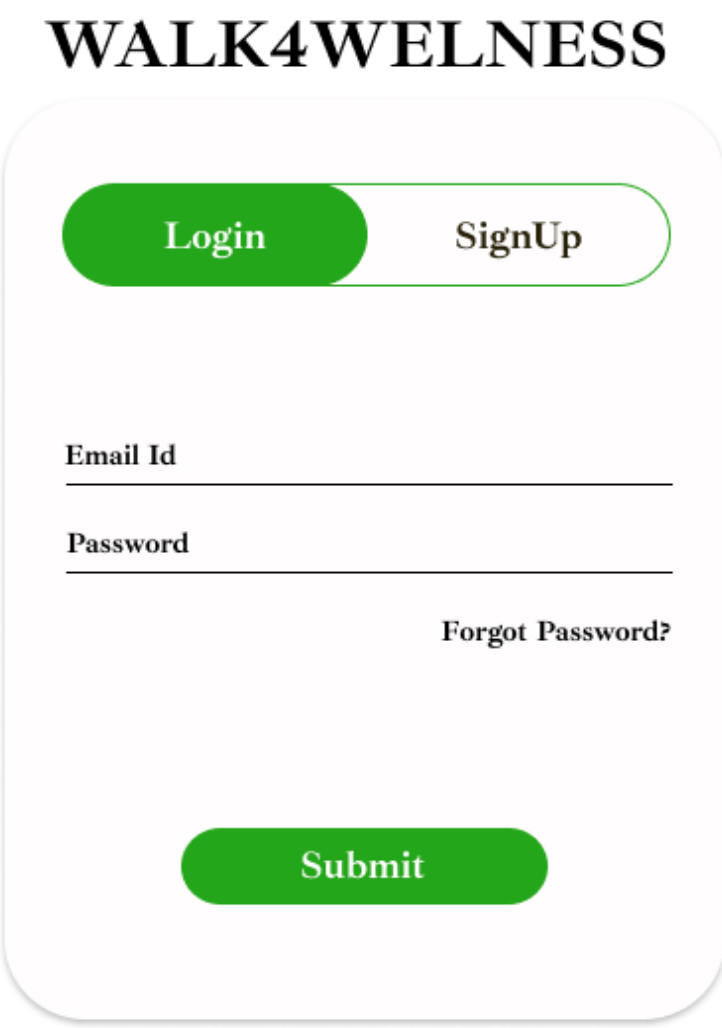


Figure 91: Login Screen for User.

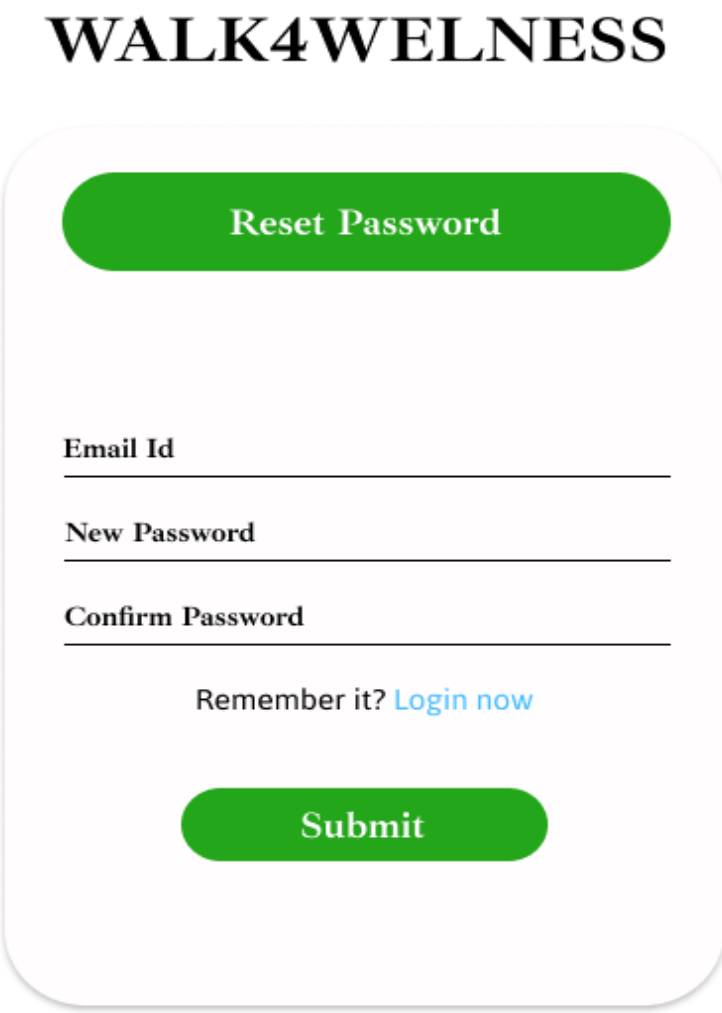


Figure 92: Forgot Password Screen.

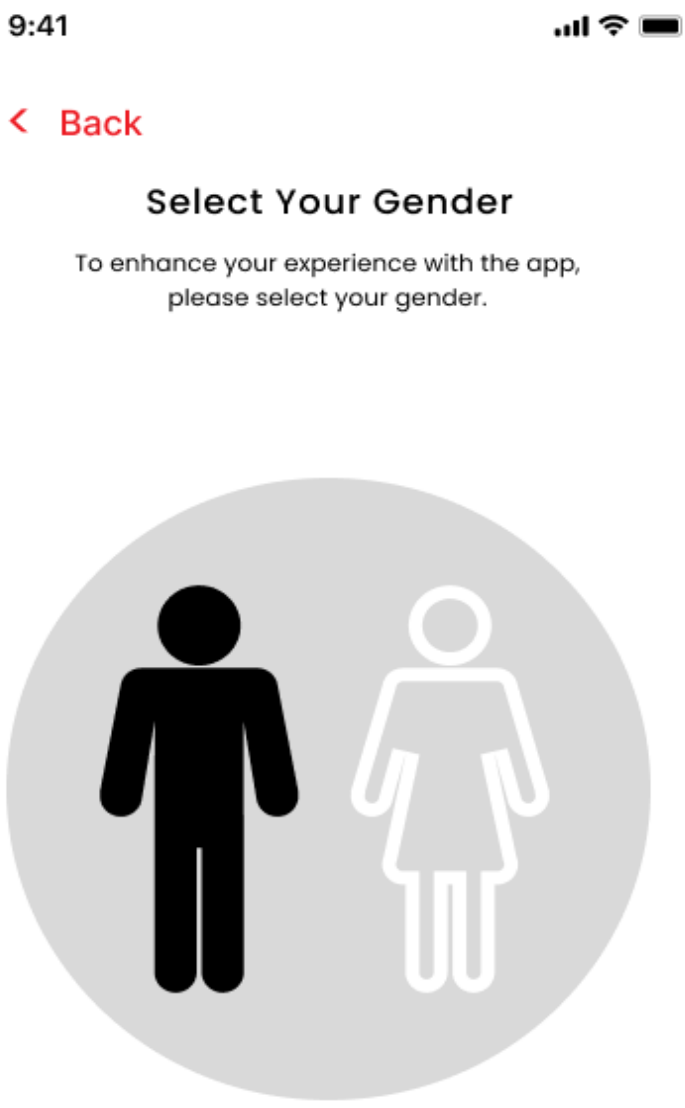


Figure 93: Select Gender Screen.

Figure 94: Gender Selected as Male.

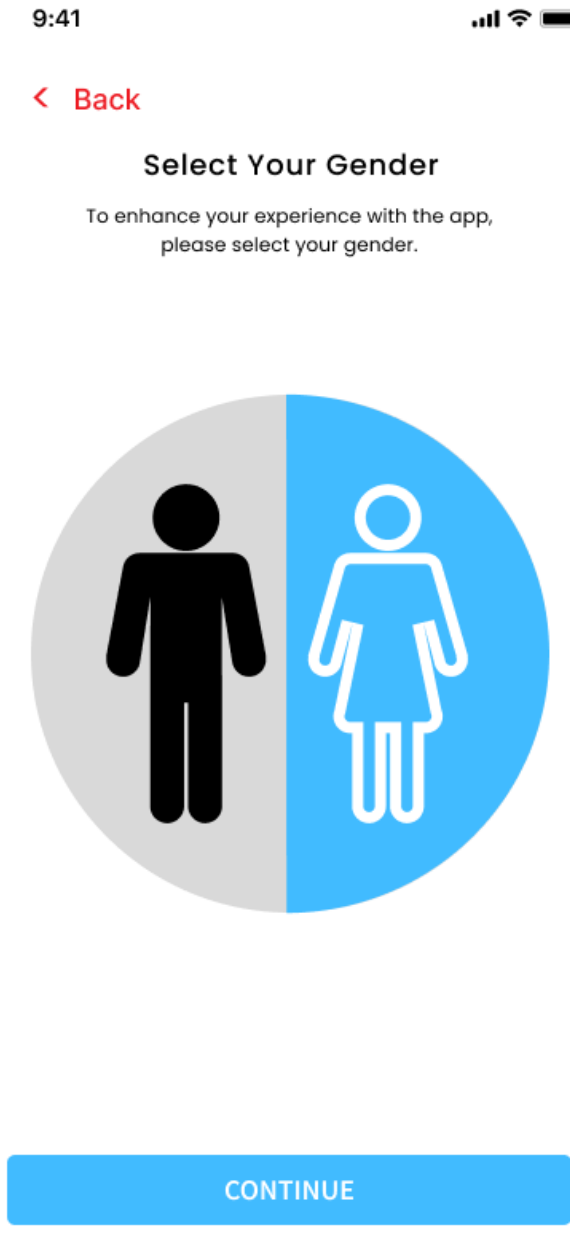


Figure 95:Gender Selected as Female.

Figure 96: Select Age Screen.

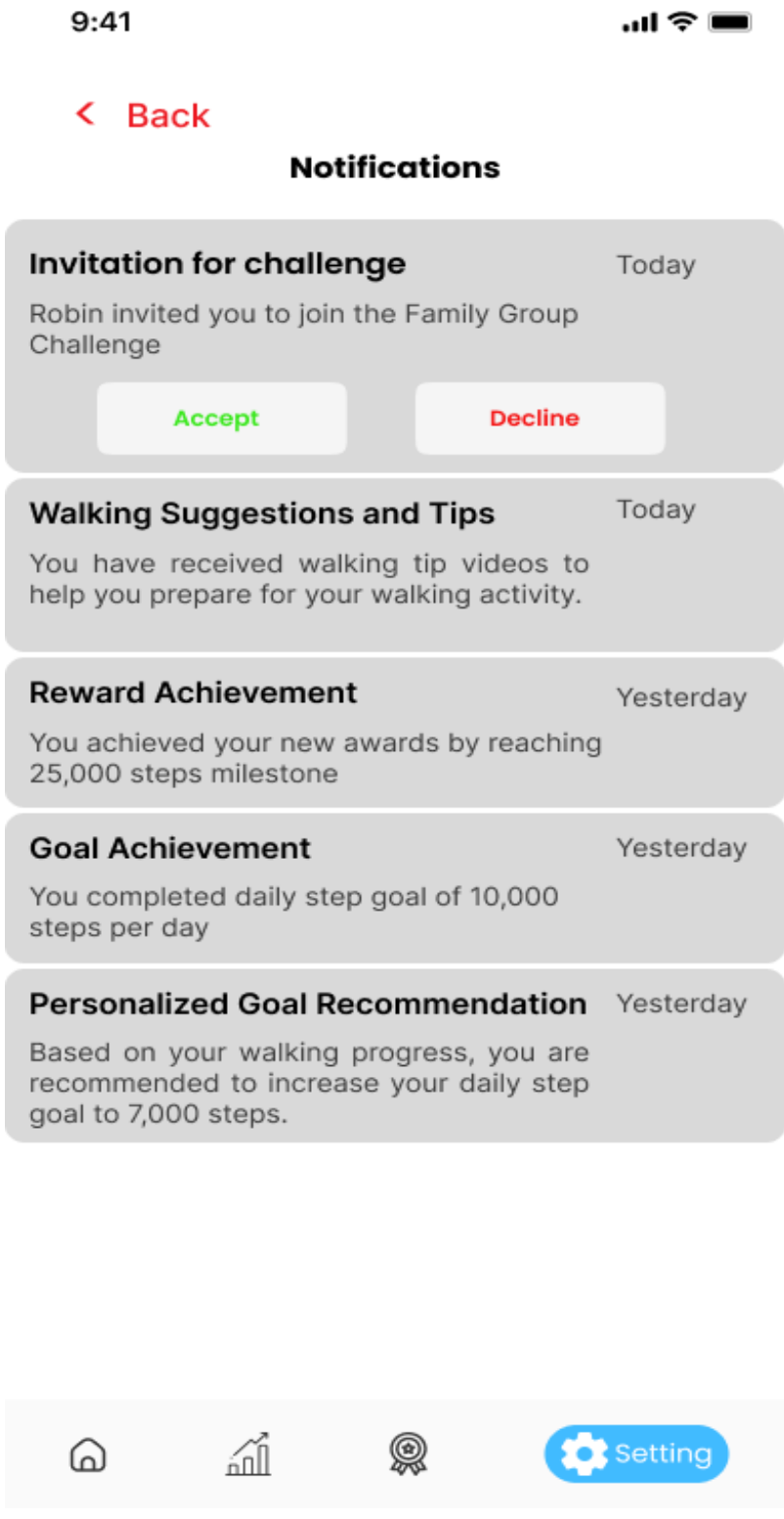


Figure 97: In-App Notifications in the Non-Arabic App.

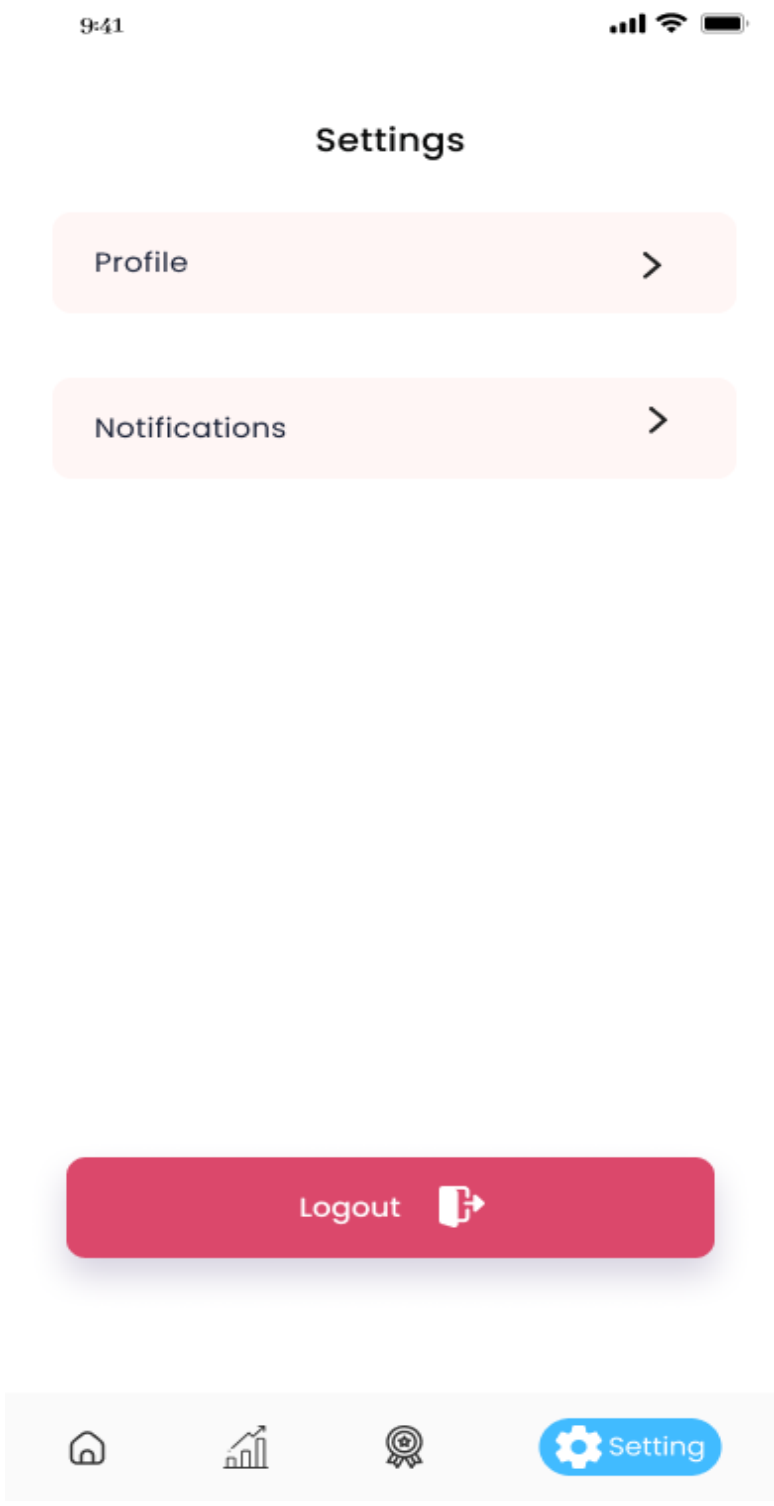


Figure 98: Settings Screen in the Non-Arabic App.

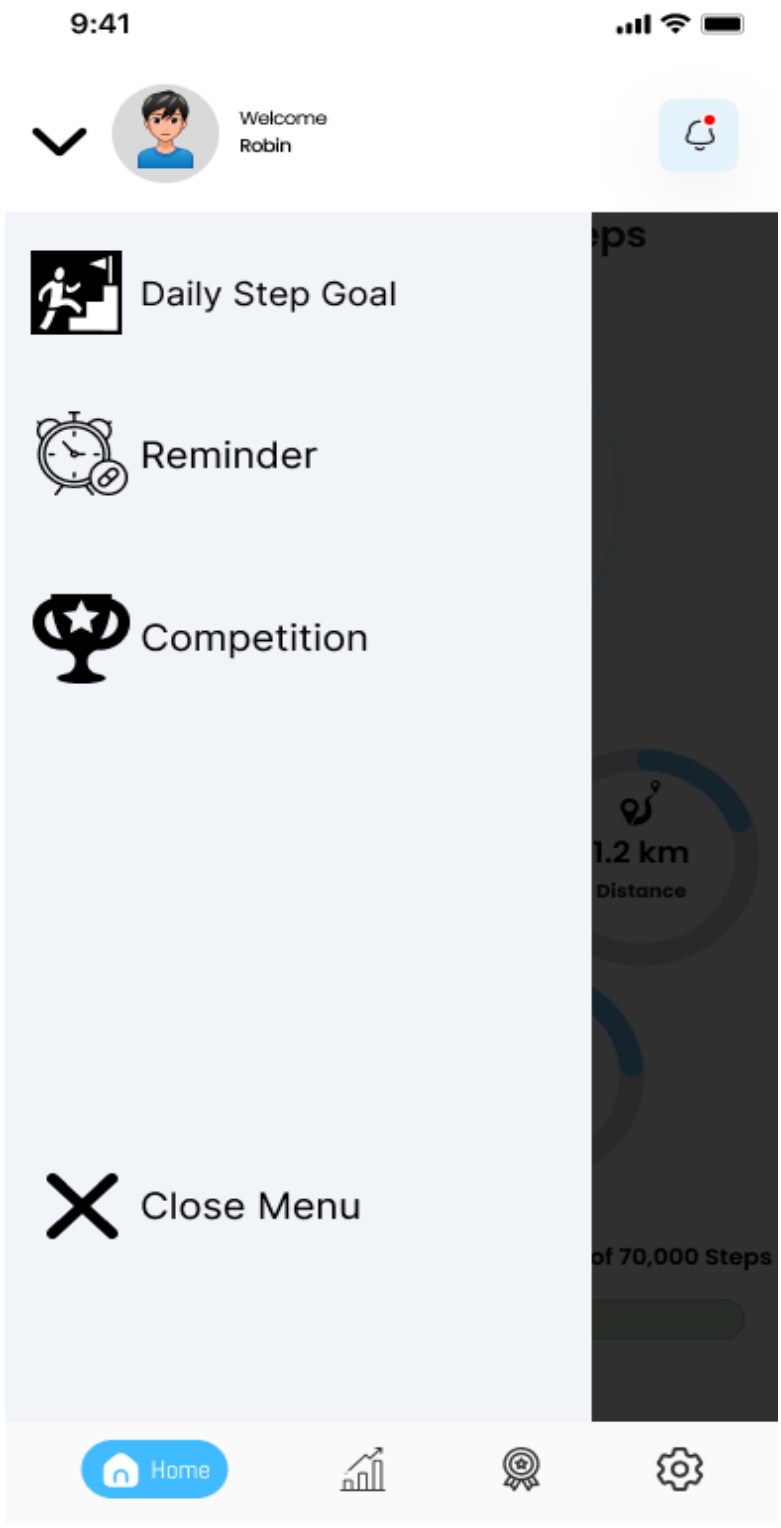


Figure 99: Strategies in Home Screen Menu in the Non-Arabic App.

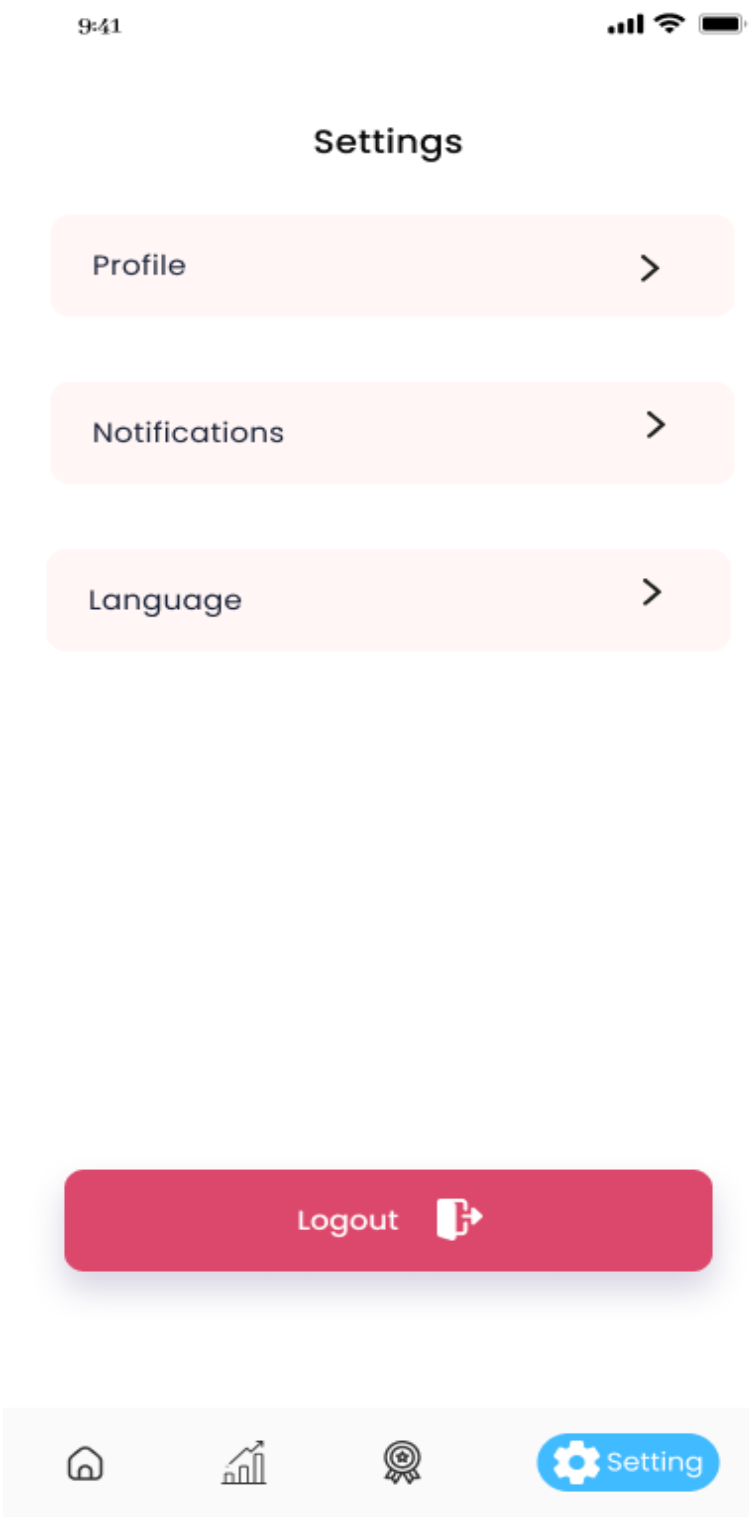


Figure 100: Settings Screen in the Arabic App.

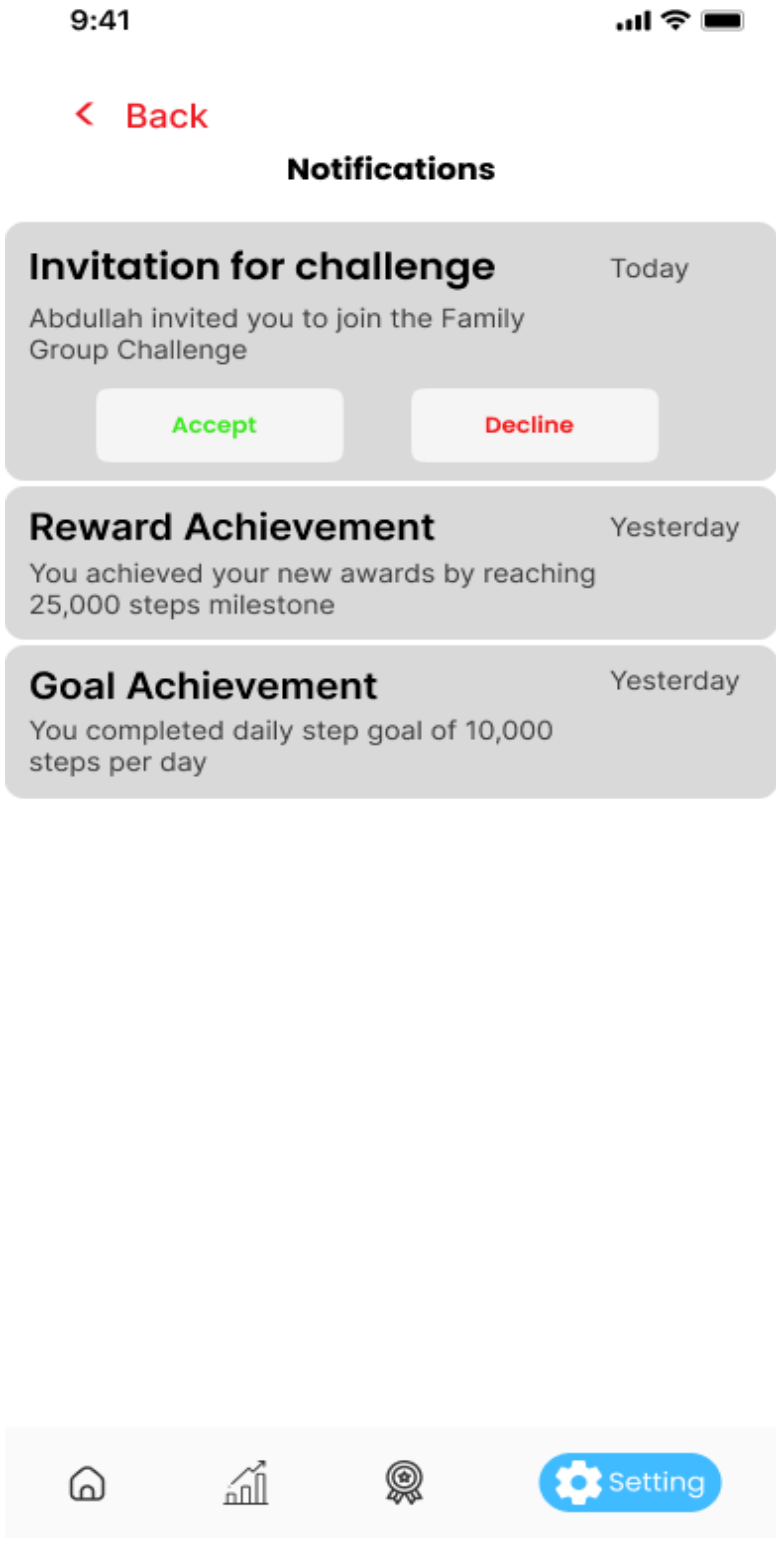


Figure 101: In-App Notifications in the Arabic App.

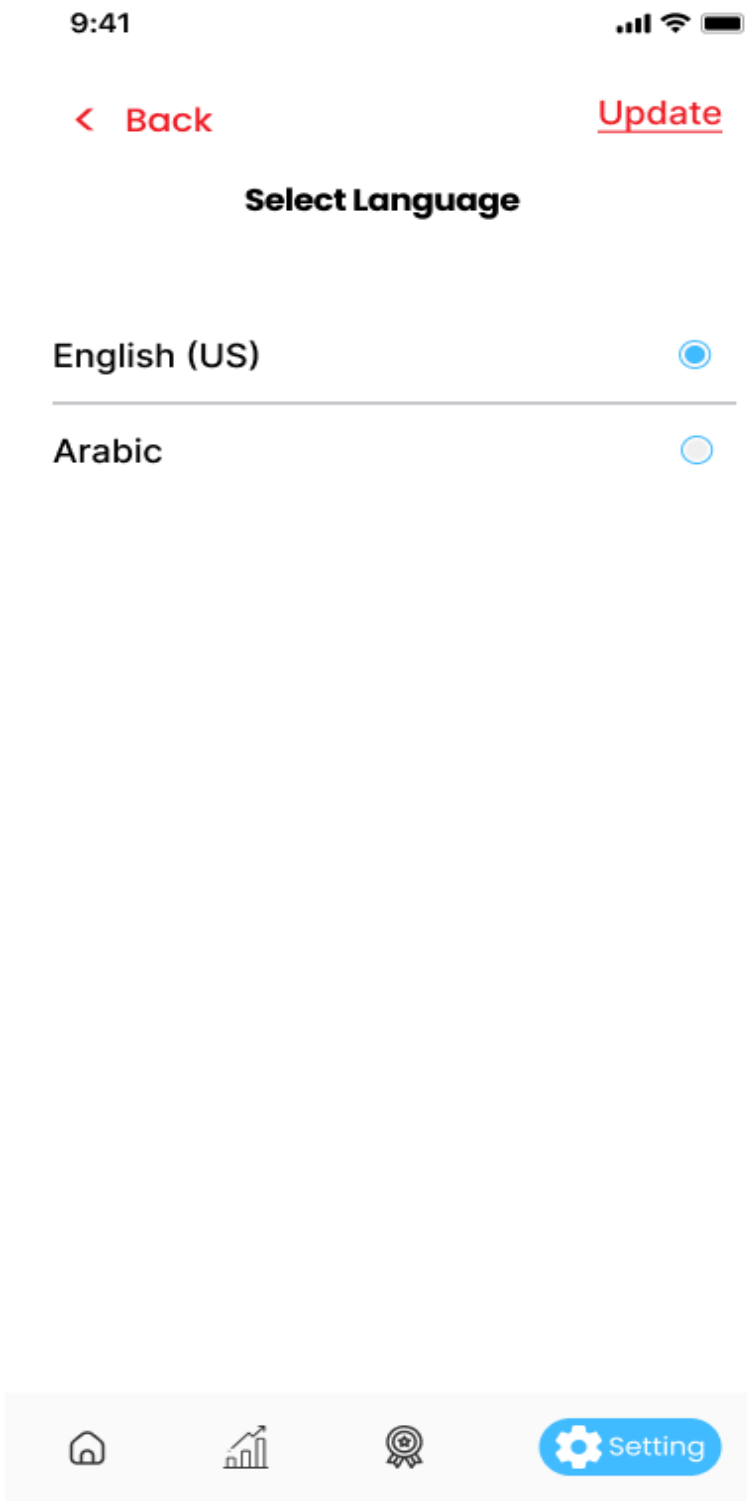


Figure 102: Select Language Screen in the Arabic App.

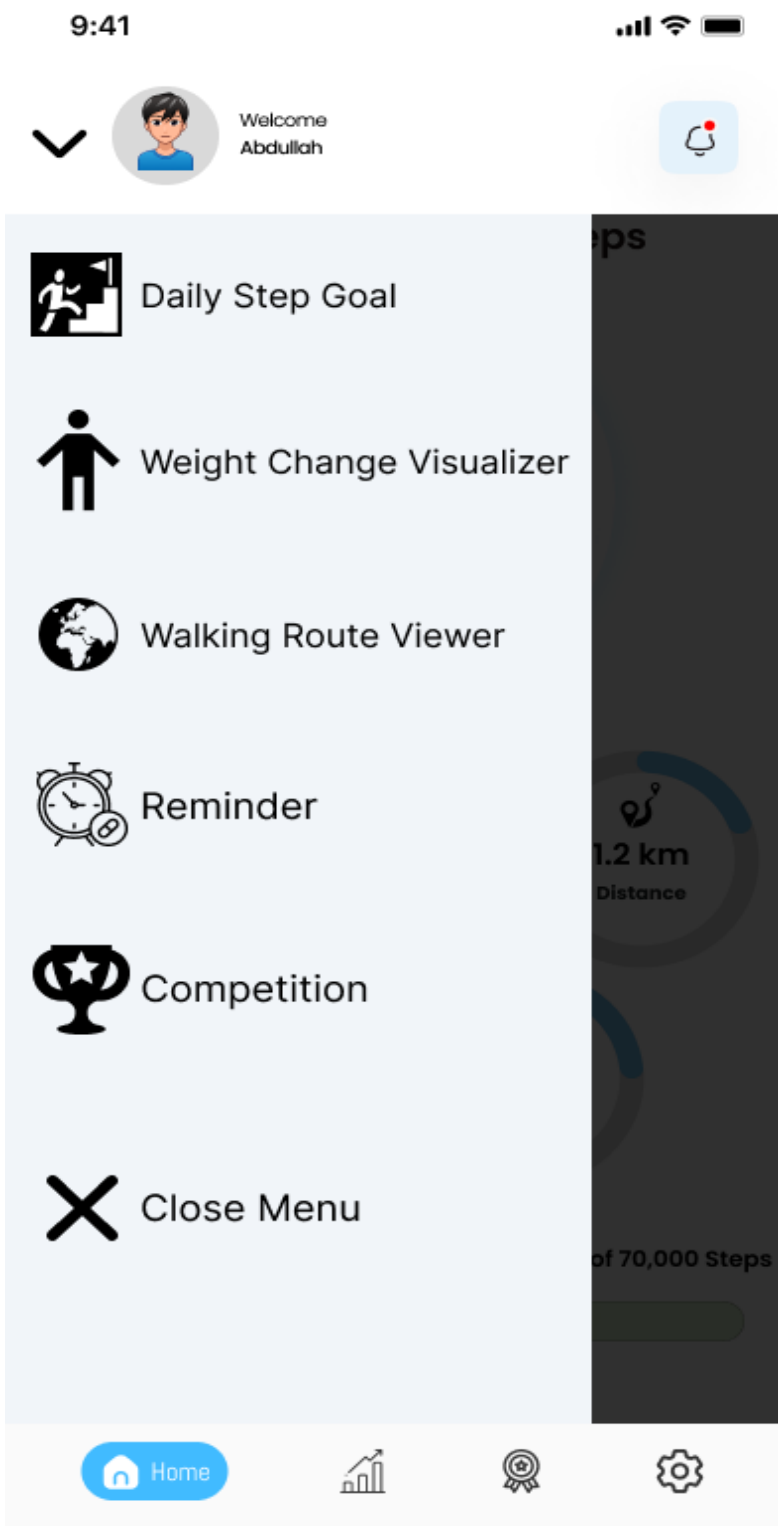


Figure 103: Strategies in Home Screen Menu in the Arabic App.

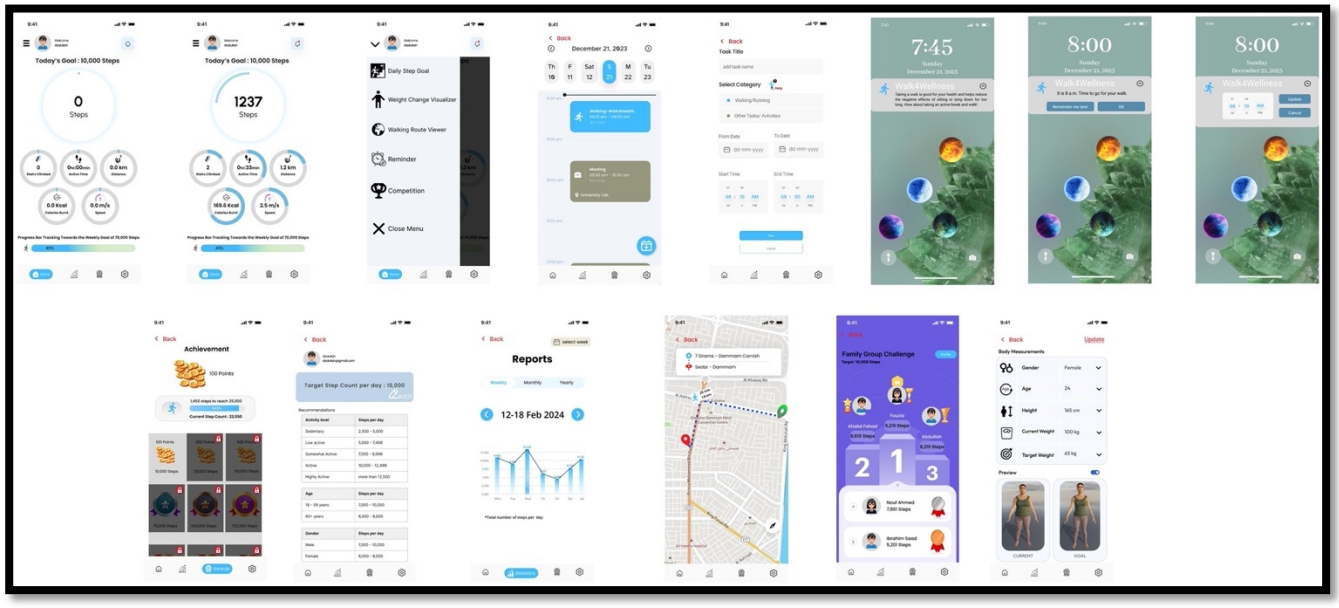


Figure 104: Overview of the Main Strategies and Features in the Arabic Version of 'Walk4Wellness' App.

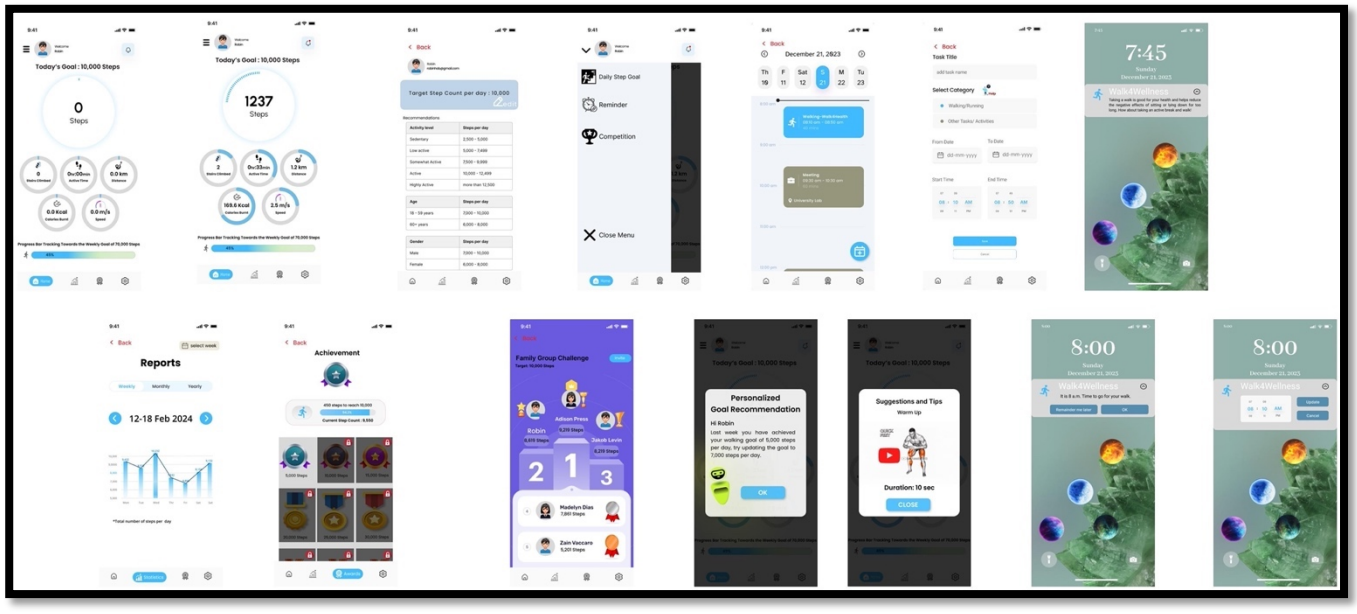


Figure 105: Overview of the Main Strategies and Features in the Non-Arabic Version of 'Walk4Wellness' App.

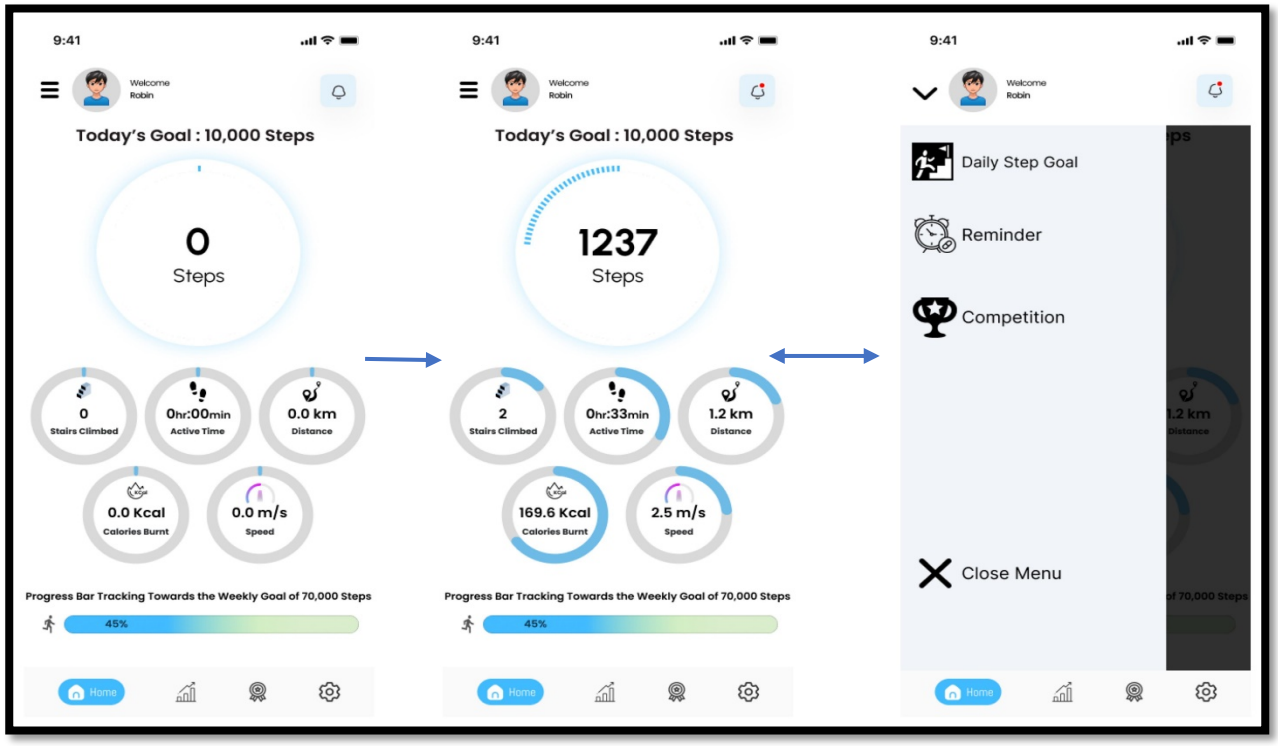


Figure 106: Self-Monitoring Strategy in the Non-Arabic App.

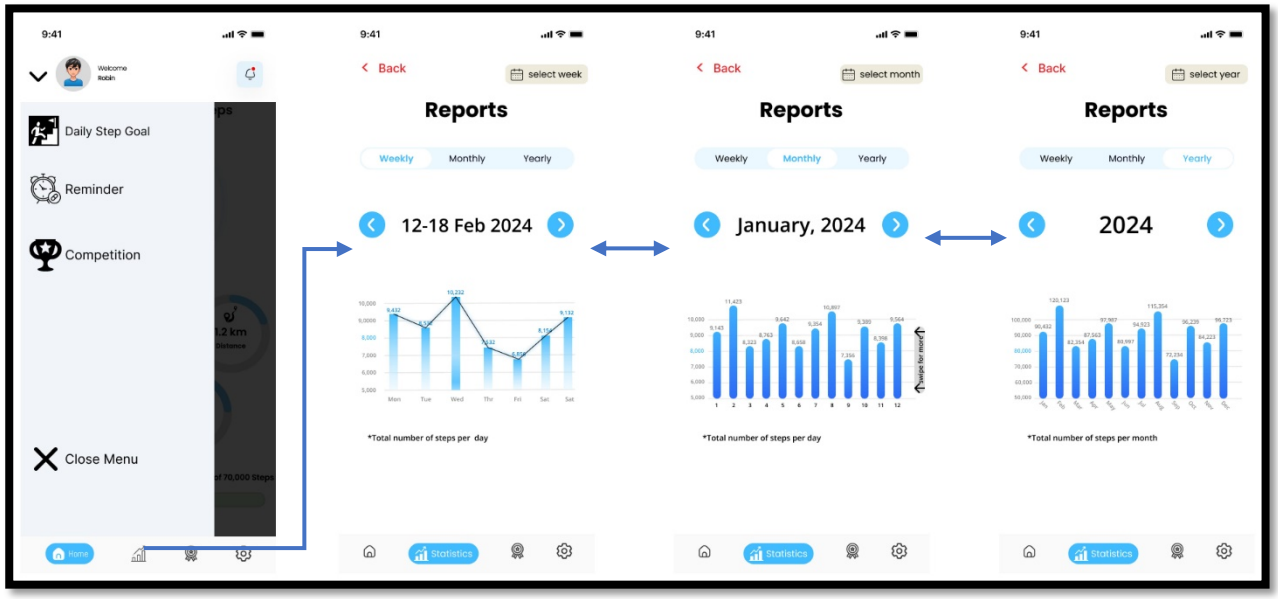


Figure 107: The Charts and Reports of Self-Monitoring Strategy in the Non- Arabic App.

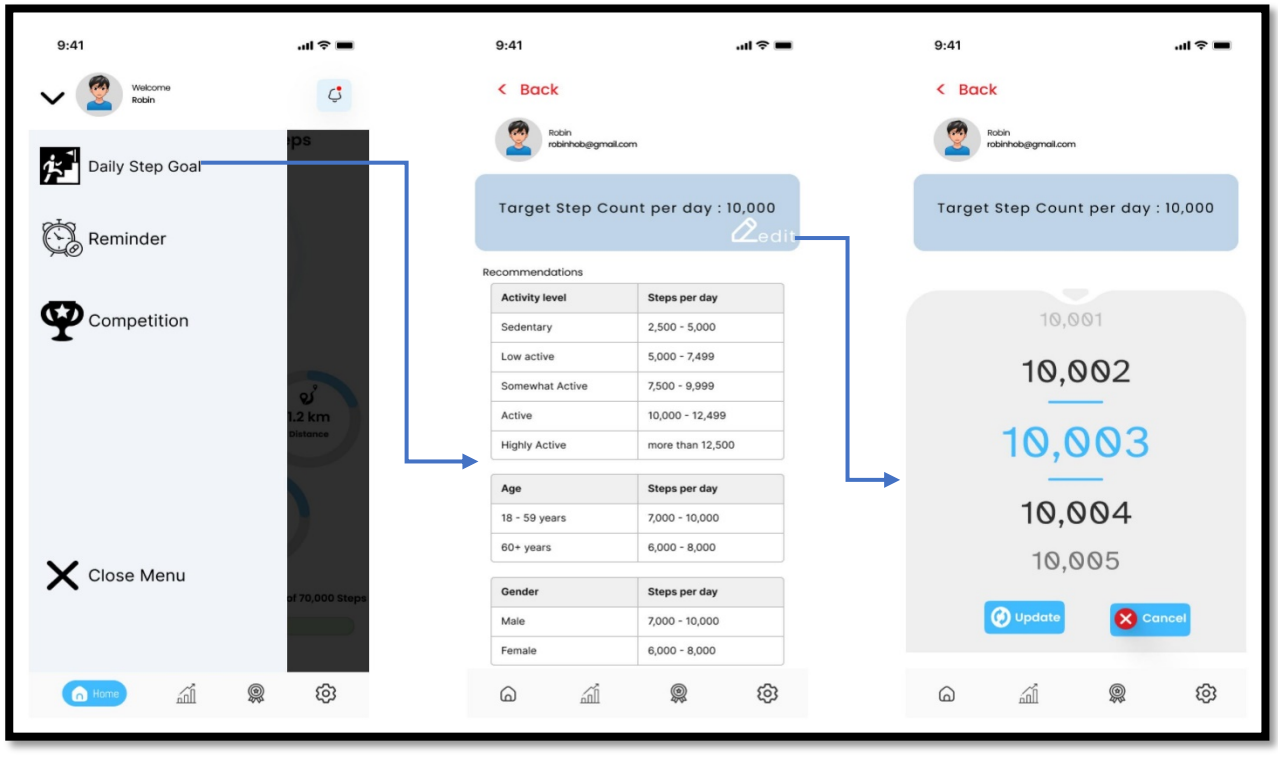


Figure 108: Goal Setting Strategy in the Non-Arabic App.

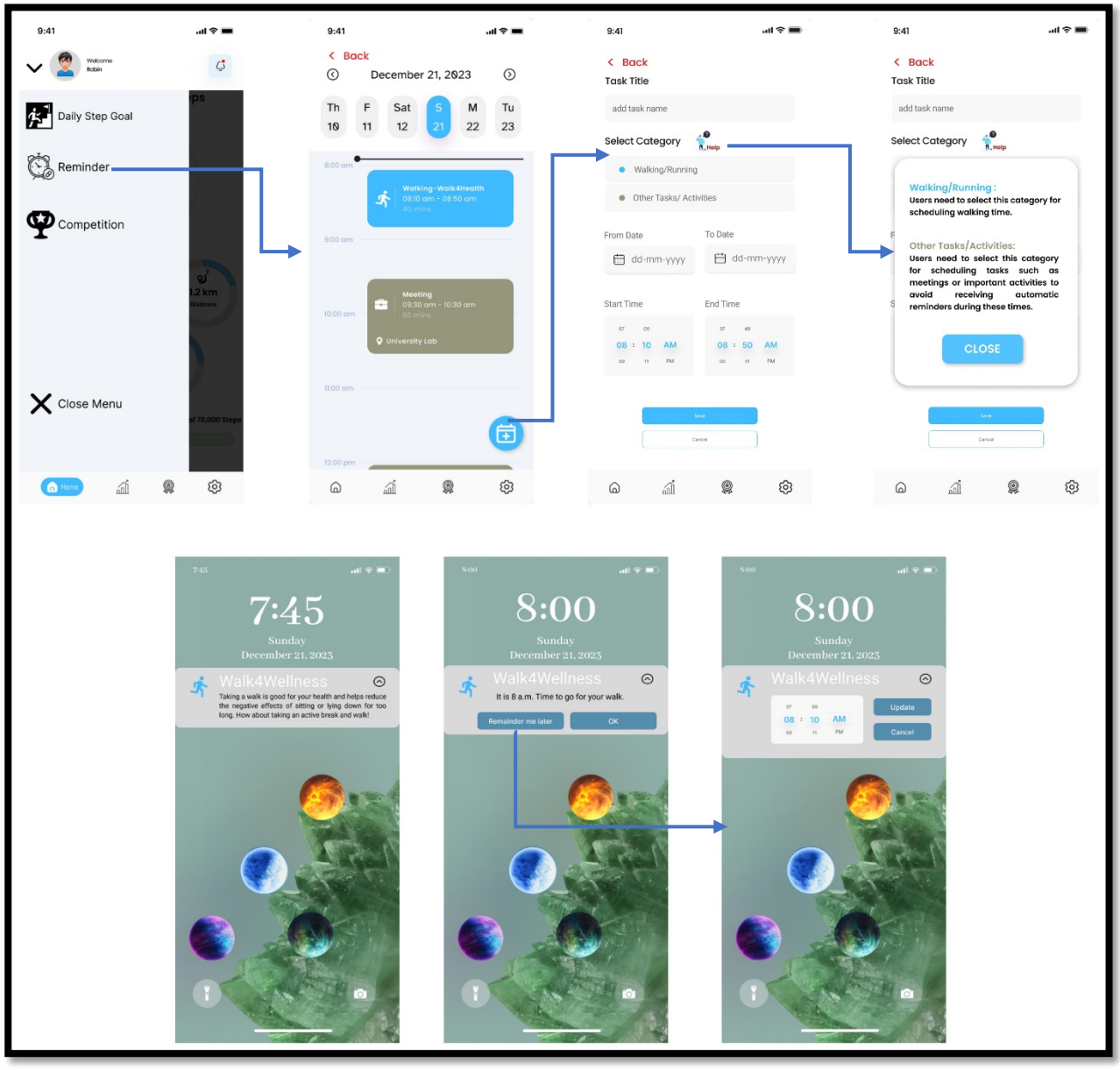


Figure 109: Reminder Strategy in the Non-Arabic App.

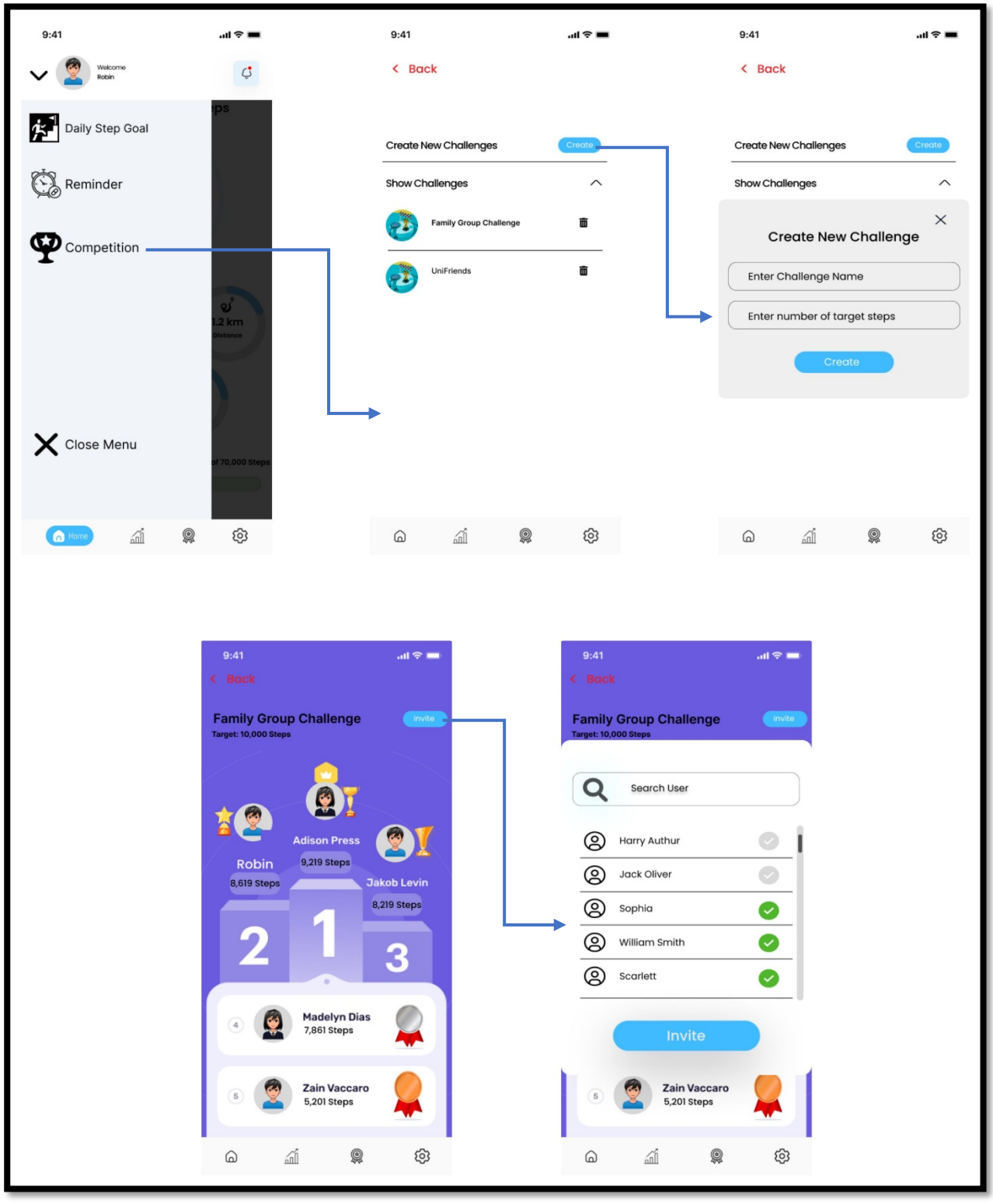


Figure 110: Competition Strategy in the Non-Arabic App.