# AN ANALYSIS OF THE EFFECTIVENESS OF THE STAY STRONG CANCER REHABILITATION PROGRAM

by

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## Table of Contents

## List of Tables

## List of Figures

## Abstract

Cancer and its treatment are associated with numerous short and long-term side effects. Randomized controlled trials (RCT) have shown that exercise improves fitness, which helps mitigate these side effects. However, RCTs are strict in terms of patient eligibility and exercise prescription which does not fully represent what occurs in a "real-world" setting. It remains unclear whether pragmatic exercise programs, which are open to everyone and utilize a more individualized exercise prescription produce similar benefits to RCTs. Therefore, the purpose of this study was to evaluate the impact of the SSCRP; a 12-week pragmatic program on physical fitness in cancer survivors (CS). Physical fitness was assessed pre- and post-intervention using RHR, 6MWT, 30CST, FFRT, and HGST. Wilcoxon signed rank tests showed significant improvements in all physical measures for the whole group and subgroups except for $HGST_{Non\text{-}dom}$ for males ($p=0.126$) and other cancer ($p=0.016$) and FFRT (0.029) in males.

## List of Abbreviations Used

| | |
|---|---|
| 30CST | 30-second sit to stand test |
| 6MWT | 6-minute walk test |
| ADL | Activity of daily living |
| ACSM | American College of Sports Medicine |
| BC | Breast cancer group |
| CS | Cancer survivor |
| CSEP | Canadian Society for Exercise Physiology |
| FFRT | Forward functional reach test |
| HGST | Handgrip strength test |
| $HGST_{dom}$ | Hand grip strength test results (dominant hand) |
| $HGST_{non\text{-}dom}$ | Hand grip strength test results (non-dominant hand) |
| MCID | Minimal clinical important difference |
| OC | Other cancer group |
| RCT | Randomized control trial |
| RHR | Resting heart rate |
| SSCRP | Stay strong cancer rehabilitation program |
| <65 | Younger group (under the age of 65) |
| ≥65 | Older group (65 years of age or older) |

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# Chapter 1: Introduction

In Canada cancer has reached epidemic levels with the expectation that 2 in every 5 Canadians will be diagnosed with the disease at some point in their lifetime (Brenner et al., 2022). Significant advances in prevention, screening, early detection, and treatment are responsible for a constant decline in the number of cancer related deaths (Brenner et al., 2022). This has led to the net 5-year survival rate recently reaching 64% across all cancers. Although this is good news, increasing survivorship numbers has emphasized the need for ongoing support after treatment, as completing treatment for cancer is only the first of many challenges that cancer survivors (CS) will face.

One challenge that CS face is the acute and chronic effects of cancer treatment. The most common treatments for cancer include chemotherapy, radiation therapy, surgical treatment, or a combination of these treatments. Other treatments include but are not limited to hormone therapy and immunotherapy. The exact combination of these treatments depends on many factors such as the type of cancer, the stage it has progressed to, and the tissues involved. Just as treatment differs between individuals, so to can the side effects in both incidence and severity. Side effects such as fatigue, muscle aches and weakness, and nausea can present early on or immediately after treatment. Others such as lymphedema, radiation induced peripheral neuropathy and reduced range of motion can emerge years after treatment, lasting long into survivorship (Mohan et al., 2019a). As these challenges can have a significant impact on the lives of CS there is a need to intervene to reduce these challenges.

Physical activity (PA) has been shown to reduce the incidence and severity of the negative effects of cancer and its treatment as well as their impact on the risk of comorbidities (Schmitz et al., 2019). PA and its effects are commonly explored using exercise, which is defined as structured and repetitive PA (Czosnek et al., 2021). Exercise has been shown to have positive health benefits across the cancer continuum and is safe and feasible for CS to perform (Campbell et al., 2019b). These benefits include but are not limited to reduced incidence of fatigue and an increase in cardiorespiratory fitness, muscular strength, and mobility. In addition to these direct health benefits, regular exercise can help reduce the risk of various comorbidities observed in CS such as diabetes, arthritis, and cardiovascular diseases as well as the risk for developing a second cancer (Campbell et al., 2019b; Kirkham et al., 2016; Sarfati et al., 2016). Overall, exercise has been shown to be safe to perform throughout the cancer experience and have a positive effect on physical, functional, and psychological quality of life (Campbell et al., 2019).

Much of what is known about research-based exercise interventions come from randomized control trials (RCT). These interventions are considered the gold standard and are generally very regimented to account for confounding variables, ensuring that results are reproducible. They focus on the efficacy and safety of the intervention in question. However, in the real-world there are numerous factors, such as incidence and severity of side effects caused by cancer and its treatment, that may impact the CS's ability to exercise (Hayes et al., 2019). Whereas a pragmatic trial may adjust exercise intensity and volume based on fatigue to ensure that the CS can complete some exercise. Pragmatic interventions also focus more on the effectiveness and feasibility of the intervention in question. It is unclear when the rigidity of the exercise program is lessened to ensure it is easily incorporated in their current lifestyle and sustainable throughout survivorship, whether exercise will have similar benefits in comparison to what has been observed in previously conducted RCTs.

Factors such as age, sex, and cancer diagnosis can impact physical function. For example, physical function is known to decrease with advancing age (Frederiksen et al., 2006; Isles et al., 2004; Simmonds, 2003; Tveter et al., 2014). Physical function also differs by sex. For example, upper body strength, lower body muscular endurance, exercise capacity, and balance all differ between males and females (Tveter et al., 2014). Finally, the wide variety in the severity and incidence of side effects from cancer and its treatment also can impact physical function (Schmitz et al., 2019). In fact, there are varying levels of evidence of the benefits of exercise for different cancers ranging from strong to limited (Schmitz et al., 2019). Since above factors impact physical function it is necessary to consider them when examining the efficacy of an exercise program.

The goal of this research study was to examine the effectiveness of a community-based exercise intervention and whether it could yield similar benefits as a more rigorous RCT design. The study consisted of secondary data analysis of the Stay Strong Cancer Rehabilitation Program (SSCRP) on the physical and functional fitness of cancer survivors. The SSCRP is a 12-week, community-based exercise program with bi-weekly supervised exercise sessions designed to minimize the negative side effects of cancer and its treatment while also improving fitness and quality of life. Exercise prescription was tailored to each participant’s individual needs and functional restrictions by the physiotherapist supervising the exercise sessions.

The objective of the SSCRP was to provide a community-based exercise program to CS in the Saint John (New Brunswick) area. The researchers hypothesized that participants would have improved physical health represented by improved scores across all variables of interest. Variables of interest were grip strength in both dominant and non-dominant hands (upper body strength), chair raise test (lower body muscular endurance), six-minute walk test, resting heart rate and post exercise heart rate (exercise capacity), and forward functional reach (balance). Specific research objectives of this study were:

1. To assess the effectiveness of the SSCRP by examining the differences (if any) between the pre-intervention and post-intervention measures for weight, resting heart rate, upper body strength, lower body muscular endurance, exercise capacity, and balance across all participants; and
2. To assess the effects of sex, age, and cancer diagnosis by stratifying the study population by age ($<65$ and $\geq 65$), sex (male and female), and cancer diagnoses (breast cancer and other cancer) and comparing the differences (if any) between the pre-intervention and post-intervention measures for upper body strength, lower body muscular endurance, exercise capacity, and balance.

# Chapter 2: Review of the Literature

Cancer death rates in Canada have decreased by 32% for males and 17% for females from 1988 to 2017. Despite this, the number of cancer diagnoses continues to rise and it is estimated that 43% of Canadians will develop cancer at some point in their lifetime (Brenner et al., 2022). With improvements in detection and treatment, the 5-year relative survival rate has increased to 64% across all cancer diagnoses (Brenner et al., 2022). Although increased survivorship is good news it does create new challenges for the health care system as the effects of cancer and its treatment can be long lasting. There are many different side effects of cancer and its treatment as it affects people in many ways.

## Cancer and the Challenges of Survivorship

While treatments have helped increase overall survival rates, they have costly physiological and physical side effects. These side effects can present during treatment as well as multiple points in survivorship, often affecting CS for the remainder of their lives. Acute effects such as fatigue, nausea, and hair loss can occur during or immediately after treatment while long term effects such as cardiotoxicity, peripheral neuropathy, and chronic pain can persist for years after treatment. All of these side effects can negatively affect physical function and fitness (Musanti et al., 2019). Ness et al. (2006) found that CS were more likely to experience physical performance limitations compared to age matched controls. These limitations were present in both recent (54.4%) and long-term (52.7%) CS (Ness et al., 2006). Recent CS were defined as completing treatment within the past 5 years and long-term CS were defined as completing treatment more than 5 years ago (Ness et al., 2006). This shows that while the fight against cancer continues to look more and more optimistic, there are still many challenges associated with lasting effects of the disease and its associated treatments.

Depending on the type and stage of cancer, individualized treatment plans often incorporate a combination of treatment methods (Canadian Cancer Statistics Advisory Committee, 2021). While this increases the chances of survival, it also increases the number of side effects that can develop during and after treatment. These by-products of treatment can have multiple negative effects on physical, and functional fitness which in turn can impact the survivor's quality of life. This literature review focused on the physical and functional effects of cancer and its treatment and the challenges they present for CS throughout survivorship.

## Impact of Treatment on Fitness and Function

Most cancer treatment plans involve a combination of three methods, chemotherapy, radiation therapy, and surgical treatment. All of which impact physical fitness and function. Furthermore, the combination and target dose of each method differs depending on many factors such as the tissues involved, the tolerance of the tissue in question, the tissues and organs in proximity, and to what stage the cancer has developed to (Canadian Cancer Statistics Advisory Committee, 2021). This all plays a role on the impact of treatment on the individual.

### *Chemotherapy*

Chemotherapy is a treatment that involves using cytotoxic drugs that disrupts cell division (Carr et al., 2008). By their very nature they can disrupt the normal function of a wide variety of bodily systems such as the cardiovascular, gastrointestinal, and neurological (Carr et al., 2008). Side effects from chemotherapy are commonly classified as immediate, which present within 1-6 months after treatment or long-term which present after 6 months and can extend long into survivorship (Carr et al., 2008). A common immediate side effect caused by chemotherapy is nausea and vomiting, which can present within the first 24 hours after treatment is administered. Diarrhea is also a common side effect of various chemotherapeutic agents, leading to dehydration and electrolyte disturbance (Carr et al., 2008). Paired together, these side effects can disrupt CS's daily living or even be life threatening. These side effects generally present during or immediately after treatment. Chemotherapeutic drugs can also result in long-term effects on the cardiovascular system such as cytotoxicity in cancer patients (Minami et al., 2010). This results in cardiac abnormalities which affect roughly 1 in every 4 cancer survivors (Minami et al., 2010). These effects can manifest anywhere between 4 and 20 years after treatment has been completed (Minami et al., 2010). This damage to the heart can lead to a decrease in aerobic fitness and function, and in extreme cases lead to heart failure (Carr et al., 2008). Chemotherapeutic agents may also cause damage to both the central nervous system and the peripheral nervous system. These effects can cause a reduction in sensory and motor function in extremities, as well at neuropathic pain (Schirrmacher, 2019). Chemotherapy-induced peripheral neuropathy, a side effect that affects up to 40% of CS, causes a reduction in physical function and doubles the rate of falls (Winters-Stone et al., 2017). Altogether, the effects of chemotherapeutic agents are wide sweeping, negatively affecting physical function through a variety of mechanisms and presenting at multiple points throughout survivorship.

*Radiation Therapy*

Radiation therapy is another common treatment method for various cancers. It is an integral part of cancer treatment, with more than 60% of all cancer patients receiving radiation therapy at some point during their cancer experience (Mohan et al., 2019). This form of therapy involves the use of ionized radiation on the target area to attempt to achieve lethal effects on cancer cells while preserving healthy cells (Mohan et al., 2019b). This ionized radiation damages the genetic material of all cells it encounters, obstructing the cell's ability to repair and reproduce (Mohan et al., 2019). In general, cancer cells are not as efficient at repairing themselves compared to healthy tissue however, sensitivity to radiation varies across tissue type (Mohan et al., 2019). As a result of this, the dose and frequency of treatment varies across cancer types to ensure optimal cancer cell death and minimize cell death of non-cancer cells in the target tissue as well as the surrounding tissue (Mohan et al., 2019a).

The tissue damage caused by radiation therapy can lead to conditions such as radiation induced peripheral neuropathy, which is defined as delayed local damage to nerve tissue. The reduced sensory and motor function can have negative effects on balance and strength, negatively affecting CS's quality of life as well as their ability to perform activities of daily living (Delanian et al., 2012; Dilalla et al., 2020). Acute side effects of radiation therapy such as fatigue and alterations in taste present in more than 70% of CS and can last as long as 1-year after treatment is completed (Dilalla et al., 2020). Overall, radiation therapy can cause a variety of side effects that negatively affect CS, making it harder to perform both essential activities of daily living as well as PA.

*Surgical Treatment*

Surgical treatment, which involves the removal of affected tissues from the body is also used to treat various cancers. It can be used on its own to treat a variety of early-stage cancers or in conjunction with radiation therapy and chemotherapy. The primary goal of surgical treatment is to completely remove cancerous tissue from the body or to reduce the size of a tumor prior to chemotherapy and radiation therapy to increase their effectiveness. This form of treatment can cause various side effects such as decreased strength and function. This is caused by the disruption of tissue during surgery as well as the fibrosis, inflammation and formation of scar tissue during the healing process (Lovelace et al., 2019).

One surgical treatment commonly used for treatment of breast and cervical cancer is lymph node removal which involves the removal of lymph nodes at or around the affected area (Beesley et al., 2007; Lovelace et al., 2019). This procedure can lead to lymphedema, a build-up of fluid in the affected limb (Beesley et al., 2007; Lovelace et al., 2019). This manageable, but not curable condition can severely impact a survivors health related quality of life (Shaitelman et al., 2015). Incidence of lymphedema varies, however, as many as 40% of breast CS develop lymphedema at some point in survivorship (Ostby & Armer, 2015). Both upper and lower limb lymphedema have a negative effect on functional well-being, however, these effects have been shown to be heightened when the disease is present in the lower limbs (Dunberger et al., 2013).

Surgical treatment and radiation therapy have also been shown to cause chronic pain and neuropathy which can present immediately after treatment or later in survivorship (Delanian et al., 2012; Lovelace et al., 2019). Lancaster et al. (2016) reported that while the incidence of post mastectomy pain syndrome varies from 10 to 60% in breast CS recent literature suggests that 40% will experience chronic pain after surgery which could present longer than 3 months after treatment. While the exact mechanisms are not fully understood, it is thought to be a result of neuropathic pain. This could be a result of many factors such as surgical nerve damage, heightened sensitivity of sensory neurons, or damage to nerves caused by localized radiation therapy (Lancaster et al., 2016). Common risk factors for PMPS include increased levels of acute postoperative pain, complaints of pain in areas of the body not associated with the surgical site, and psychological factors such as depression, anxiety, and stress (Lancaster et al., 2016).

The wide variety in both incidence and severity of side effects of cancer and its treatment emphasizes the need for modifications to traditional fitness testing on cancer survivors or the use of alternative tests that are more accessible and less invasive (Sweegers et al., 2019). Increased fatigue is a common and debilitating condition that affects the majority of CS. Researchers need find a balance between accurate tests that are strongly correlated to health outcomes while also using accessible tests that are minimally invasive, being able to be performed safely for a wide range of participants. The combination of physical domains commonly used to assess the effects of exercise on cancer survivors include upper body strength, lower body muscular endurance, aerobic capacity, and balance (Sweegers et al., 2019). This combination of tests with general measures such as weight and resting heart rate allows researchers to get the whole picture on the physical health and functional abilities of participants.

Overall, treatment for cancer has a variety of negative side effects, many of which negatively affect physical health and function (Lovelace et al., 2019; Minami et al., 2010; Mohan et al., 2019). Various cancers have similar treatment methods, and while there are common negative side effects such as nausea, fatigue and pain, the incidence and severity of the effects these treatments have on CS differs between cancers. This suggests that while some interventions might yield positive benefits across different cancer types, recovery strategies should mirror treatment with a cancer diagnosis specific approach.

**Physical Activity Guidelines in the General Population**

Based on the positive and protective effects of exercise the Canadian Society for Exercise Physiology (CSEP) developed released the Canadian 24-hour movement guidelines for adults aged 18-64 and adults aged 65 years or older. The guidelines recommend that Canadians over the age of 18 accumulate at least 150 minutes of moderate to vigorous PA every week as well as perform resistance training twice a week and accumulate several hours of light PA such as standing (Ross et al., 2020). Guidelines for adults aged 65 years or older are the same, with the addition of a focus on performing PA that challenges balance, as this decreases with age (Dani et al., 2019; Ross et al., 2020). Accumulating this amount of PA has been shown to reduce all-cause mortality and chronic disease, increase physical strength and endurance as well as maintaining mobility, functional independence, bone health and mental health (Bushman, 2019; Ross et al., 2020).

The benefits of PA have been thoroughly investigated over the last several decades and the evidence supporting them is irrefutable (Warburton & Brendin, 2019). PA has a dose-dependent relationship with health, reducing the risk and severity of many chronic medical conditions such as cardiovascular disease, hypertension, and type 2 diabetes (Warburton & Brendin, 2019). PA has a positive dose-dependent relationship with aerobic fitness and muscular strength (Hegde, 2018). Structured and repetitive PA, commonly referred to as exercise has been consistently shown to increase muscular strength and function while also eliciting improvements in cardio-metabolic outcomes such as reduced systolic blood pressure, body mass index, and an increase in insulin sensitivity (Foster & Armstrong, 2018).

Meeting PA guidelines results in improved fitness and health, regardless of sex or age (Doyon et al., 2021). Among older adults, failure to meet aerobic PA guidelines can result in a 70% increased chance of deficits in performance of activities of daily living (ADL). Failure to meet guidelines for muscular training results in a 50% increased chance of ADL deficits (Doyon et al., 2021).

**Cancer specific exercise guidelines**

The American College of Sports Medicine (ACSM) originally outlined the effects of exercise on CS in 2010. Guidelines for exercise and cancer were similar to those of the general population with only minor differences. It was acknowledged that if a person with a chronic disease such as cancer could not meet these guidelines that they should do as much as they could and were recommended to avoid inactivity (Schmitz et al., 2010). In 2019, ACSM convened a second, international and multidisciplinary roundtable discussing the advances in exercise and cancer research over the past decade. From this they established new guidelines and considerations for exercise and its role in cancer prevention and survival. These new, evidence-based guidelines recommended to lower the duration and frequency of exercise from 150 minutes per week to 90 minutes per week (Schmitz et al., 2019). These new guidelines have outlined a focus to working their way up with intensity and duration and having the programs individually designed for the strengths and limitations of each individual and run by health care professionals. Factors such as the type of cancer, what stage the disease has progressed to, and the patient's health can all have a significant effect on their exercise tolerance and adherence (Schmitz et al., 2019).

Similarly, the Clinical Oncology Society of Australia published a position statement on exercise in cancer care in 2018. This report outlined guidelines in line with those of the general population, suggesting ≥150 minutes of moderate PA in addition to 2-3 resistance exercise sessions per week. However, they stress that exercise programs should be tailored to the individual's abilities and cancer diagnosis, and that trained healthcare providers should be prepared to modify exercise programs to the specific needs of CS (Cormie et al., 2018). Shockingly, they reported that 60-70% of people with cancer fail to meet the aerobic guidelines and 80-90% do not meet resistance exercise guidelines. This shows that while there are more and more studies advocating for the use of exercise in the treatment of cancer, there is a lack of appropriate programming (Cormie et al., 2018).

**Physical Activity in Cancer**

Just as the exercise guidelines for CS have evolved, so too has the understanding of the benefits and feasibility of exercise for various cancer populations. Courneya and Friedenreich, (2001) established a framework for PA and cancer control called "Physical exercise across the cancer experience" in which they identified that PA is safe and beneficial at all time points throughout the cancer experience, from diagnosis to end of life. The American College of Sports Medicine roundtable on exercise guidelines for CS supported this framework and recommended that the exercise program be tailored specifically to the type of cancer the individual has (Campbell et al., 2019b). They identified various positive benefits of PA for CS, however, they discovered that most of the research focused on breast cancer, cautioning the generalization of various positive benefits of PA and exercise across different cancer types.

Over the past decade, the positive benefits of exercise have been well documented among CS (Nakano et al 2018). Exercise has been proven to combat side effects of treatment and improve health outcomes for a variety of cancer diagnoses (Campbell et al., 2019b). Common benefits include but are not limited to increased muscular strength and mobility of both the upper and lower body, increased aerobic capacity and improved balance (Turner et al., 2018b).

CS have a widely reported deficiency in muscular strength and function due to cancer and its treatments. Handgrip strength is often diminished because of treatment. Regular exercise has been shown to combat this, eliciting an increase in grip strength (Cantarero-Villanueva et al., 2012; Lee & Vicil, 2020). Similarly, pragmatic and RCT exercise interventions have been shown to increase lower body strength and function across a variety of cancer diagnoses (Courneya et al., 2016; Kalter et al., 2016; Smith et al., 2016; Yee et al., 2019).

Exercise's cardiovascular benefits for CS are relative to those of the general population (Kirkham et al., 2016; Kirkham & Davis, 2015). Side effects such as cardiotoxicity, increased fatigue, and other comorbid cardiovascular conditions can present challenges to performing regular exercise (Kirkham et al., 2016; Kirkham & Davis, 2015). Many RCTs have measured the effects of exercise on the distance traveled in the six-minute walk test (6MWT), stating that moderate intensity aerobic exercise performed 3-5 days per week for 20-60 minutes can improve aerobic fitness (Kirkham et al., 2016). This volume and intensity exceeds the current exercise guidelines for CS.

Side effects of treatment such as RIPN and CIPN can negatively affect the mobility and balance of CS putting him at an increased risk for falls (Campbell et al., 2019b; Morishita et al., 2018). Age is also shown to have a negative effect on balance well also increasing the risk of injury from a fall (Wildes et al., 2015). Fortunately, a combination of aerobic and resistance training can help combat these physical and neuropathic deficiencies (Guo et al., 2022).

**Translating Research Into Care**

The majority of literature exploring exercise's effect on CS has come from RCTs (Campbell et al., 2019b). This study design is often considered the gold standard for clinical development as they have a very rigid structure to isolate the treatment effects being examined (Zuidgeest et al., 2017). This rigid structure commonly includes both highly selective inclusion criteria and a very strict treatment protocol (Zuidgeest et al., 2017). The wide variety in both incidence and severity of negative side effects from cancer and its treatment can cause CS ability to tolerate exercise to fluctuate day to day (Campbell et al., 2019a). Thus, may participants could be excluded from the study if they believe they were unable to perform the desired volume or intensity of exercise consistently.

Other factors such as sex, age, and cancer diagnosis can also affect CS response to exercise (Sweegers et al., 2019). Age has an inverse relationship with performance in all of the abovementioned areas of physical function and has been established as the most significant moderating factor (Frederiksen et al., 2006; Isles et al., 2004; Simmonds, 2003; Tveter et al., 2014). It is also well established that males generally have greater upper body strength, lower body muscular endurance, exercise capacity, and balance when compared to age matched females (Tveter et al., 2014). The combination of both general and cancer specific side effects also make it an important moderator on physical function (Schmitz et al., 2019). In fact, there are varying levels of evidence of the benefits of exercise for different cancers ranging from strong to limited (Schmitz et al., 2019). Therefore these factors need to be considered when studying exercise in a CS population.

**Study objectives**

Conversely, pragmatic trials are used to assess how effects of treatment observed in RCTs translate to a real-world setting (Zuidgeest et al., 2017). Instead of looking to control and limit possible confounding factors to explore the efficacy and safety of exercise, these trials assess the real-world effectiveness of interventions across a broad patient group (Ford & Norrie, 2016). Additionally, they explore how feasible an intervention is and whether it can be scaled into a larger, wider sweeping program. For example, the SSCRP did not have any inclusion criteria related to age sex, or cancer diagnosis except that prospective participants had to be over the age of 18. A recent review on the implementation of pragmatic cancer specific exercise programs by Purdy et al., (2022) supports this claim, suggesting that these types of exercise programs are both sustainable and scalable. It also allows for a comparison of the impact an exercise intervention has on a wide variety of CS, in this case stratified by age, sex, and cancer diagnosis (Ford & Norrie, 2016).

The research objectives of the SSCRP were to provide a rehabilitative exercise program to CS and record performance pre and post intervention for future analysis. The specific research objectives of this study were;

1. To assess the effectiveness of the SSCRP by examining the differences (if any) between the pre-intervention and post-intervention measures for weight, resting heart rate, upper body strength, lower body muscular endurance, exercise capacity, and balance across all participants; and
2. To assess the effects of sex, age, and cancer diagnosis by stratifying the study population by age (<65 and ≥65), sex (male and female), and cancer diagnoses (breast cancer and other cancer) and comparing the differences (if any) between the pre-intervention and post-intervention measures for upper body strength, lower body muscular endurance, exercise capacity, and balance.

# Chapter 3: Methods

## Study Design and Procedures

This study used a pragmatic, pre and post study design, examining data from the SSCRP. The program was designed and implemented by the clinical/community team in Saint John, New Brunswick. It consisted of a 12-week community-based exercise intervention held at the YMCA of Greater Saint John. It was designed to aid in the recovery from cancer and the side effects of its treatment. The program data used in the current study was collected between September 2016 and September 2018. The resulting data was deidentified and sent to Dalhousie University in Halifax, Nova Scotia for analysis. This study received ethical approval from Horizon Health Network (reference #2015-2256). Analysis was conducted at Dalhousie University. Additional ethical approval was not required due to the reciprocal agreement between Horizon Health Network and Dalhousie Research Ethics Board. There were no conflicts of interest for any of the researchers.

## Participants

The study population consisted of CS that had received cancer treatment at the St. John Regional Hospital. The inclusion criteria for participants were that they were CS 19 years of age or older. Participants were excluded if they were still undergoing chemotherapy at the time of enrollment. All CS also had to receive medical clearance from their oncologist before beginning the exercise program. Prospective CS were given a brochure at the oncology department of the St. John Regional Hospital outlining the SSCRP.

CS participating in the exercise program had the option to decline having their data included in the research data set. This did not affect their ability to participate in the program or the services offered to them as part of the program.

**Procedures**

How participants moved through the program is shown in Figure 1.

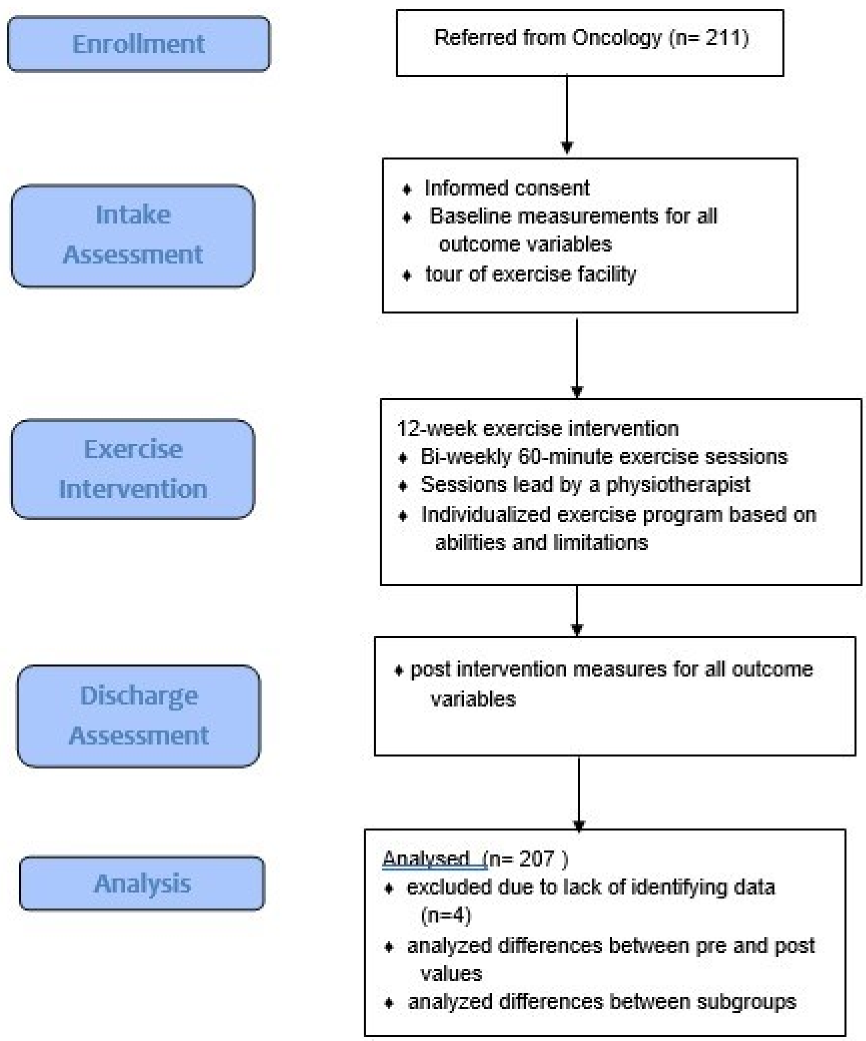


Figure 1: Participant flow

*Initial Appointment*

The initial intake appointment took place at the YMCA Saint John where the participants were familiarized with the exercise facility and equipment. Participants then completed the intake form and assessment. A nurse conducted the physiological measures (weight, blood pressure, resting heart rate, post exercise heart rate) and 6MWT. Once they recovered from the 6MWT the physiotherapist conducted the remaining tests which included bilateral handgrip strength (HGST), 30-second sit to stand test (30CST), and the forward functional reach test (FFRT). The physiotherapist also assessed whether CS had upper or lower body neuropathy as well as shoulder range of motion. Data from these assessments was used to help individualize exercise programs based on the individual's abilities. The entire baseline assessment lasted approximately 30 minutes. The intake form (Appendix A) was used to collect each participant's sex, date of birth, name of care providers, diagnosis, history of disease and treatments, reported symptoms from treatment(s), self-reported level of PA prior to the beginning of the exercise program and personal goals they had for the program. The intake form also included the results from the participant's initial assessment which includes the HGST, 30CST, 6MWT, and FFRT.

*Exercise Program*

CS returned to the YMCA the week after their initial appointment at which time an on-site physiotherapist guided them through individualized exercise programs designed according to their medical history and baseline outcome measures. Exercise programs consisted of a combination of resistance and aerobic exercise based on the results of the physiotherapist's initial assessment. For example, if a CS was found to have neuropathy of the lower body or poor balance that would make them a fall risk, they would perform their aerobic exercise on a cycle ergometer instead of a treadmill.

Resistance training was performed using the available machines and free weights at the YMCA facility. For the next 12 weeks the physiotherapist and nurse were on site two times per week for 3 hours to assist and supervise CS. CS were encouraged to come to the facility during these supervised times, but they also had access to the exercise facility at their leisure, allowing them to adjust their exercise schedule to best fit with their lifestyle and schedule. Adherence data for the supervised sessions was not collected. Similarly, the frequency and duration of visits to the exercise facility outside of the supervised sessions was not monitored.

*Discharge Assessment*

After the completion of the 12-week exercise program, participants returned for a second assessment. Participants repeated all tests performed during the initial intake assessment and the values were recorded (Appendix A).

**Outcome Measures**

Outcome measures were assessed pre-intervention and post-intervention. The primary outcome measures were weight, resting heart rate (RHR), upper body muscular strength measured by grip strength, lower body muscular endurance, exercise capacity, and balance. The outcome measures included weight and resting heart rate measured as per the American College of Sport Medicine’s (ACSM) guidelines for exercise testing (Swain et al., 2014). Age, sex, cancer diagnosis and treatment were recorded at baseline.

Upper body strength (kgs of static force) was measured using the HGST. The participants held a dynamometer at their side and squeezed as hard as they could. They completed 3 trials and the average of the 3 was calculated (Cantarero-Villanueva et al., 2012). The test was performed in both dominant and non-dominant hands. This test is moderately correlated with other health indicators such as upper body mobility and fitness level in cancer survivors (Cantarero-Villanueva et al., 2012).

Lower body muscular endurance was measured using the 30CST. CS were instructed to sit in a 17 inch (43.2 cm) tall folding chair, cross their arms over their chest and then rise to a full stand and back to a seated position as many times as they could within 30 seconds (Jones et al., 1999). The number of repetitions completed was then recorded. This test has been shown to be a valid indicator of lower body muscular endurance for older adults (Jones et al., 1999).

Functional exercise capacity was measured using the 6MWT. The participants walked as far as they could in six minutes around the walking track at the YMCA of Greater Saint John and their distance traveled (in meters) was recorded (Crapo et al., 2002). Participants set their own pace and a chair was provided if they needed to take breaks. Post exercise heart rate was also recorded upon the completion of the test (Guyatt et al., 1985).

Balance was measured using the FFRT, in which the participant stood on the floor with their dominant arm held in 90 degrees of forward flexion and their non-dominate arm at their side. They then reached as far forward as they could without losing balance and/or moving their feet. Three trials were completed, and the furthest distance (cm) was recorded (Duncan et al., 1990). Distances less than 25cm have been strongly correlated with an increased fall risk (Duncan et al., 1990).

**Data Analysis**

Statistical analyses were performed using SPSS Statistics (version 27). Descriptive statistics were used to describe the data. The data was assessed for normality which showed that the data was not normally distributed. Issues with normality included non-normal distribution due to skewness and kurtosis. Thus, non-parametric statistics were used for the analysis.

The first objective of the study was to determine pre-post changes in weight, RHR, HGST, 30CST, 6MWT, AHR, and FFRT. To do this a Wilcoxon sign-ranked test was used. Given that the different outcomes had different sample sizes, each analysis used all the available data for a given outcome. Once these analyses were complete, the analysis was rerun using complete data to determine if the results were similar or not (Appendix B).

The second objective explored the potential impact of age, sex, and cancer diagnosis on each outcome over time. To do so, two groups were created for each variable. Specifically, sex was dichotomized into male and female, age was dichotomized into <65 and ≥65 and the cancer diagnoses were dichotomized into BC and OC. Once the dichotomies were completed, a Wilcoxon signed rank test was performed for each group to example potential change over time. Then, Mann Whitney U tests were used to compare differences at each time point. Combining these analyses allowed for the examination of potential interactions over time for each group. This was done using the full data set and the repeated using a subset of participants that had complete data for all variables of interest. This subset analysis is presented in Appendix B.

HGST values for both dominant and non-dominant were converted from absolute to relative values ($\frac{\text{Kg of force}}{\text{Kg of bodyweight}}$) to help adjust for extreme outliers. Significance level was adjusted for multiple comparisons ($p = \frac{0.05}{8}$) for a corrected significance level of p=0.00625. Effect size was also used to examine the strength of the effects the SSCRP had on all variables of interest. An effect size of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect. The larger the effect size, the more important the result.

# Chapter 4: Results

## Participant Characteristics

A total of 207 cancer survivors completed the 12-week intervention. Participant characteristics and treatment information are presented in Table 1. Upon enrollment in the study, 47% of males and 53% of females self-reported that they had had been regularly exercising prior to enrolling in the SSCRP. The study population consisted of 32 unique cancer diagnoses (Table 2). The three most prevalent cancer types were breast (n=100), bowel (n=25), and prostate (n=16). For analysis, these were collapsed into two groups [breast cancer (n=100) and other cancers (n=107)]. This was done to ensure there was adequate power to examine potential differences in outcomes between cancer groups. Out of these 207 participants, 132 (64%) had missing pre- or post-data for certain variables, and only 75 participants had complete pre- and post-data for all variables of interest (Appendix B).

## Primary Outcome Measures

As outlined in Table 3, a Wilcoxon Signed Rank Test revealed statistically significant improvement in dominant hand HGST, non-dominant HGST, 30CST, 6MWT, AHR, and FFRT. No significant changes were noted for weight and resting heart rate. Analysis of participants with complete data for all variables of interest replicated these results (Appendix B).

## Subgroup Outcome Measures

### *Sex*

Within the male group, a Wilcoxon Signed Rank Test revealed statistically significant improvement in 30CST, 6MWT, and an increase in average heart rate after the

6MWT (AHR). No significant changes were noted for weight, RHR, dominant hand HGST, non-dominant HGST, and FFRT. Values are outlined in Table 4.

When analyzing the female group (Table 5), a Wilcoxon Signed Rank Test revealed statistically significant increases in dominant hand HGST, non-dominant hand HGST, 30CST, 6MWT, AHR and FFRT. No significant changes were noted for weight and RHR.

As outlined in Table 6, a Mann Whitney U test revealed significant differences between males and females in pre intervention values for weight, dominant hand HGST, and non-dominant HGST values. No significant differences between males and females were found in pre intervention measures for RHR, 30CST, 6MWT, AHR, and FFRT. Table 7 illustrates that significant differences in post intervention values were found for weight, dominant hand HGST and non-dominant HGST. No significant differences were found in post intervention measures for RHR, 30CST, 6MWT, AHR, and FFRT. Analysis on participants with complete data for all variables of interest replicated these results (Appendix B).

In summary, weight differed between males and females at both baseline and post intervention, but weight did not change significant within sex over the course of the intervention. RHR did not differ between sex and there were no significant impact of the intervention on RHR for each sex. Males had significantly greater HGST scores for both dominant and non-dominant hands at baseline and post-intervention in comparison to females. Interesting only females saw significantly improved their HGST over the intervention. Although there were no differences between males and females for 30CST, 6MWT, and AHR at both baseline and post-intervention and both males and females significantly improved their scores for all variables. FFRT did not differ significantly between males and females at baseline or post intervention. Interestingly, only females significantly improved their FFRT scores over the course of the intervention.

*Age*

As outlined in Table 8, a Wilcoxon Signed Rank Test revealed statistically significant improvement in dominant hand HGST, non-dominant hand HGST, 30CST, 6MWT, AHR, and FFRT for the <65 group. No significant changes were noted for weight, and RHR.

When the ≥65 group was examined (Table 9), a Wilcoxon Signed Rank Test revealed statistically significant increases in dominant hand, non-dominant hand HGST, 30CST, 6MWT, AHR, and FFRT. No significant changes were noted for weight, and RHR.

As outlined in Table 10, a Mann Whitney U test revealed significant differences in pre intervention values between the <65 and ≥65 groups for both dominant and non-dominant hand HGST, 30CST, 6MWT, AHR, and FFRT. No significant differences were found in pre intervention measures for weight and RHR. Table 11 shows significant differences in post intervention measures for dominant hand HGST, non-dominant hand HGST, 30CST, 6MWT, AHR, and FFRT. No significant differences were found in post intervention measures for weight and RHR. Analysis on participants with complete data for all variables of interest replicated these results (Appendix B).

In summary, weight and RHR did not differ by age nor were they impacted by the exercise intervention in either of the age cohorts. The <65 group had significantly greater HGST values for both dominant and non-dominant hands at baseline and post intervention when compared to the ≥65 group. Both age groups also saw significant increases in HGST scores for both hands. For 30CST, 6MWT, AHR, and FFRT, the <65 group had significantly greater baseline and post-intervention scores in comparison to the ≥65 group. However, both age groups had significant improvements in 30CST, 6MWT, AHR, and FFRT scores over the duration of the intervention.

*Cancer Diagnosis*

For the BC group (Table 12), a Wilcoxon Signed Rank Test revealed statistically significant increases in dominant hand HGST, non-dominant HGST, 30CST, AHR, and FFRT. No significant changes were noted for weight, and RHR. Within the OC group, a Wilcoxon Signed Rank Test revealed statistically significant increases in dominant hand HGST, 30CST, AHR, and FFRT. No significant changes were noted for weight, RHR and non-dominant hand HGST (Table 13).

A Mann Whitney U test revealed that there were no significant differences between the BC and OC groups for weight, RHR, dominant hand HGST, non-dominant hand HGST, 30CST, 6MWT, AHR, and FFRT for both pre-intervention (Table 14) and post-intervention (Table 15) measures. Analysis on participants with complete data for all variables of interest replicated these results (Appendix B).

In summary, weight and RHR did not differ by cancer diagnosis nor were they impacted by the exercise intervention in either of the cancer groups. There were no significant differences between the BC and OC groups for dominant and non-dominant hand HGST values at baseline or post-intervention. Both cancer groups significantly improved their HGST score in their dominant hand over the intervention. In contrast, HGST non-dominant HGST scores only improved in the BC group. Significant improvements in 30CST, 6MWT, AHR, and FFRT scores for both BC and OC groups after completion of the exercise intervention. Of note, none of the aforementioned variables differed between BC and OC at baseline or post intervention.

Table 1: Participant characteristics

| | n= (%) | Sex M/F | Age | Chemotherapy | Hormone Therapy | Radiation Therapy | Currently Exercising |
|---|---|---|---|---|---|---|---|
| Males | 55 (27%) | 55/0 | 61.42±12.24 | 36 | 7 | 23 | 26 |
| Females | 152 (73%) | 0/152 | 58.88±10.62 | 102 | 71 | 102 | 80 |
| <65 | 132 (64%) | 22/53 | 70.56±4.99 | 46 | 31 | 41 | 29 |
| ≥65 | 75 (36%) | 33/99 | 53.30±8.42 | 92 | 47 | 84 | 77 |
| BC | 100 (48%) | 0/100 | 57.89±11.04 | 66 | 70 | 75 | 59 |
| OC | 107 (52%) | 55/52 | 61.10±10.99 | 72 | 8 | 50 | 47 |

*Note.* Participants had to have completed chemotherapy and radiation therapy prior to enrolling in the study.

Table 2: Cancer diagnoses for the study population

| Cancer Diagnosis | n= (%) |
|---|---|
| Breast | 100 (48%) |
| Bowel | 25 (12%) |
| Prostate | 16 (8%) |
| Lymphoma | 10 (5%) |
| Lung | 8 (4%) |
| Ovarian | 6 (3%) |
| Other | 42 (20%) |

*Note.* Diagnoses with n<5 were collapsed into the “other” group. n=207.

Table 3: Wilcoxon Signed Rank Test results for whole group

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 88 | 81.87 | 81.19 | -2.119 | 0.034 | 0.23 |
| RHR (bpm) | 110 | 76 | 78 | -1.972 | 0.049 | 0.19 |
| $HGST_{Dom}$ ($kg_{relative}$) | 88 | 0.3381 | 0.3186 | -5.655 | 0.000 | 0.60 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 88 | 0.3072 | 0.2869 | -5.041 | 0.000 | 0.54 |
| 30CST (repetitions) | 109 | 17 | 12 | -8.778 | 0.000 | 0.82 |
| 6MWT (m) | 107 | 581 | 536 | -8.513 | 0.000 | 0.82 |
| AHR (bpm) | 99 | 120 | 110 | -6.433 | 0.000 | 0.65 |
| FFRT (cm) | 107 | 36 | 33 | -5.401 | 0.000 | 0.52 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 4:Wilcoxon Signed Rank Test results for the male group

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 21 | 89.09 | 89.58 | -0.532 | 0.601 | 0.12 |
| RHR (bpm) | 29 | 75 | 78 | -1.144 | 0.252 | 0.21 |
| $HGST_{Dom}$ ($kg_{relative}$) | 21 | 0.4683 | 0.4281 | -2.207 | 0.027 | 0.48 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 21 | 0.4496 | 0.4012 | -1.529 | 0.126 | 0.33 |
| 30CST (repetitions) | 28 | 17 | 13.5 | -4.574 | 0.000 | 0.86 |
| 6MWT (m) | 29 | 595 | 545 | -4.493 | 0.000 | 0.83 |
| AHR (bpm) | 28 | 118 | 108 | -3.501 | 0.000 | 0.66 |
| FFRT (cm) | 28 | 37.5 | 35 | -2.182 | 0.029 | 0.41 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 5: Wilcoxon Signed Rank Test results for the female group

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 67 | 77.56 | 78.47 | -2.124 | 0.034 | 0.26 |
| RHR (bpm) | 81 | 76 | 78 | -1.556 | 0.120 | 0.17 |
| $HGST_{Dom}$ ($kg_{relative}$) | 67 | 0.3180 | 0.2915 | -5.453 | 0.000 | 0.67 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 67 | 0.2887 | 0.2701 | -5.094 | 0.000 | 0.62 |
| 30CST (repetitions) | 81 | 16 | 12 | -7.517 | 0.000 | 0.84 |
| 6MWT (m) | 78 | 580.5 | 533 | -7.222 | 0.000 | 0.82 |
| AHR (bpm) | 71 | 121 | 113 | -5.405 | 0.000 | 0.64 |
| FFRT (cm) | 79 | 34 | 32 | -4.885 | 0.000 | 0.55 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 6: Pre-intervention Mann Whitney U results – male/female

| | n= (m/f) | $Median_{Male}$ | $Median_{Female}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 21/67 | 89.58 | 78.47 | -2.787 | 0.005 | 444.0 | 0.316 |
| RHR (bpm) | 29/81 | 78 | 78 | -0.299 | 0.768 | 1130.5 | 0.481 |
| $HGST_{Dom}$ ($kg_{relative}$) | 21/67 | 0.4281 | 0.2915 | -3.348 | <0.001 | 385.0 | 0.273 |
| $HGST_{Non-dom}$ ($kg_{relative}$) | 21/67 | 0.4012 | 0.2701 | -3.754 | <0.001 | 320.0 | 0.227 |
| 30CST (repetitions) | 28/81 | 13.5 | 12 | -0.696 | 0.490 | 1034.0 | 0.456 |
| 6MWT (m) | 29/78 | 545 | 533 | -0.102 | 0.921 | 1116.5 | 0.494 |
| AHR (bpm) | 28/71 | 108 | 113 | -1.675 | 0.094 | 778.5 | 0.392 |
| FFRT (cm) | 28/79 | 35 | 32 | -2.622 | 0.008 | 737.0 | 0.333 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non-dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at $p=0.05$ and corrected to $p=0.00625$ for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 7: Post-intervention Mann Whitney U results – male/female

| | n= m/f | $Median_{male}$ | $Median_{female}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 21/67 | 89.09 | 77.56 | -2.849 | 0.004 | 412.5 | 0.293 |
| RHR (bpm) | 29/81 | 75 | 76 | -0.608 | 0.547 | 1085.0 | 0.462 |
| $HGST_{Dom}$ ($kg_{relative}$) | 21/67 | 0.4683 | 0.3180 | -3.108 | 0.002 | 386.0 | 0.274 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 21/67 | 0.4496 | 0.2887 | -3.646 | $<0.001$ | 331.0 | 0.235 |
| 30CST (repetitions) | 28/81 | 17 | 16 | -0.156 | 0.878 | 1111.5 | 0.049 |
| 6MWT (m) | 29/78 | 595 | 580.5 | -1.108 | 0.270 | 973.0 | 0.430 |
| AHR (bpm) | 28/71 | 118 | 121 | -0.661 | 0.512 | 909.0 | 0.457 |
| FFRT (cm) | 28/79 | 37.5 | 34 | -2.160 | 0.030 | 802.0 | 0.363 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at $p=0.05$ and corrected to $p=0.00625$ for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 8: Wilcoxon Signed Rank Test results for the <65group

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 50 | 81.42 | 80.29 | -1.288 | 0.198 | 0.18 |
| RHR (bpm) | 64 | 77 | 78 | -2.075 | 0.038 | 0.26 |
| $HGST_{Dom}$ ($kg_{relative}$) | 50 | 0.3951 | 0.3913 | -4.416 | 0.000 | 0.62 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 50 | 0.3542 | 0.3453 | -3.261 | 0.001 | 0.46 |
| 30CST (repetitions) | 64 | 19 | 13.5 | -6.795 | 0.000 | 0.85 |
| 6MWT (m) | 62 | 660 | 570 | -6.609 | 0.000 | 0.84 |
| AHR (bpm) | 57 | 134 | 117 | -5.203 | 0.000 | 0.69 |
| FFRT (cm) | 60 | 37.5 | 35 | -3.412 | 0.001 | 0.44 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at $p=0.05$ and corrected to $p=0.00625$ for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 9: Wilcoxon Signed Rank Test results for the >65 group

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 38 | 82.28 | 86.18 | -1.753 | 0.080 | 0.28 |
| RHR (bpm) | 46 | 72.5 | 78.5 | -0.407 | 0.648 | 0.06 |
| $HGST_{Dom}$ ($kg_{relative}$) | 38 | 0.2964 | 0.2745 | -3.531 | 0.000 | 0.57 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 38 | 0.2874 | 0.2580 | -3.928 | 0.000 | 0.64 |
| 30CST (repetitions) | 45 | 15 | 11 | -5.594 | 0.000 | 0.81 |
| 6MWT (m) | 45 | 525 | 408 | -5.424 | 0.000 | 0.81 |
| AHR (bpm) | 42 | 111.5 | 104.0 | -3.787 | 0.000 | 0.58 |
| FFRT (cm) | 47 | 33 | 29 | -4.477 | 0.000 | 0.65 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at $p=0.05$ and corrected to $p=0.00625$ for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 10: Pre-intervention Mann Whitney U results – <65/>65

| | $n_{=}$ <65/>65 | Median<65 | $\text{Median}_{\geq 65}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 50/38 | 80.29 | 86.18 | -1.203 | 0.231 | 892.5 | 0.470 |
| RHR (bpm) | 64/46 | 78 | 78.5 | -0.573 | 0.569 | 1377.5 | 0.468 |
| $HGST_{Dom}$ ($kg_{relative}$) | 50/38 | 0.3913 | 0.2745 | -3.465 | <0.001 | 556.0 | 0.293 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 50/38 | 0.3453 | 0.2580 | -3.673 | <0.001 | 514.0 | 0.271 |
| 30CST (repetitions) | 64/45 | 13.5 | 11 | -3.351 | <0.001 | 897.5 | 0.312 |
| 6MWT (m) | 62/45 | 570 | 408 | -4.599 | <0.001 | 666.5 | 0.239 |
| AHR (bpm) | 57/42 | 117 | 104.0 | -3.594 | <0.001 | 689.5 | 0.288 |
| FFRT (cm) | 60/47 | 35 | 29 | -3.679 | <0.001 | 825.5 | 0.293 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 11: Post-intervention Mann Whitney U results - <65/>65

| | n= <65/>65 | Median<65 | $\text{Median}_{\geq 65}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 50/38 | 81.42 | 82.28 | -0.960 | 0.340 | 836.0 | 0.440 |
| RHR (bpm) | 64/46 | 77 | 72.5 | -0.288 | 0.775 | 1424.5 | 0.484 |
| $\text{HGST}_{\text{Dom}}$ ($\text{kg}_{\text{relative}}$) | 50/38 | 0.3951 | 0.2964 | -3.372 | <0.001 | 507.0 | 0.267 |
| $\text{HGST}_{\text{Non-dom}}$ ($\text{kg}_{\text{relative}}$) | 50/38 | 0.3542 | 0.2874 | -3.243 | 0.001 | 565.0 | 0.297 |
| 30CST (repetitions) | 64/45 | 19 | 15 | -3.423 | <0.001 | 885.0 | 0.307 |
| 6MWT (m) | 62/45 | 660 | 525 | -5.397 | <0.001 | 540.0 | 0.194 |
| AHR (bpm) | 57/42 | 134 | 111.5 | -4.069 | <0.001 | 622.5 | 0.260 |
| FFRT (cm) | 60/47 | 37.5 | 33 | -3.199 | 0.001 | 901.5 | 0.320 |

*Note.* RHR = resting heart rate, $\text{HGST}_{\text{dom}}$ = hand grip strength test for dominant hand, $\text{HGST}_{\text{non-dom}}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 12: Wilcoxon Signed Rank Test results for the BC group

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 49 | 78.02 | 79.83 | -2.262 | 0.024 | 0.32 |
| RHR (bpm) | 55 | 77 | 78 | -1.422 | 0.155 | 0.19 |
| $HGST_{Dom}$ ($kg_{relative}$) | 49 | 0.3122 | 0.3072 | -4.143 | 0.000 | 0.59 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 49 | 0.2887 | 0.2358 | -4.701 | 0.000 | 0.67 |
| 30CST (repetitions) | 54 | 14 | 11 | -6.182 | 0.000 | 0.84 |
| 6MWT (m) | 53 | 620 | 560 | -6.087 | 0.000 | 0.84 |
| AHR (bpm) | 47 | 122 | 113 | -4.050 | 0.000 | 0.61 |
| FFRT (cm) | 53 | 35 | 32 | -4.304 | 0.000 | 0.59 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at $p=0.05$ and corrected to $p=0.00625$ for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 13: Wilcoxon Signed Rank Test results for the OC group

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 39 | 83.46 | 85.46 | -0.747 | 0.455 | 0.12 |
| RHR (bpm) | 55 | 74 | 78 | -1.445 | 0.148 | 0.19 |
| $HGST_{Dom}$ ($kg_{relative}$) | 39 | 0.3625 | 0.3401 | -3.893 | 0.000 | 0.62 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 39 | 0.3351 | 0.3233 | -2.406 | 0.016 | 0.39 |
| 30CST (repetitions) | 55 | 15 | 12 | -6.262 | 0.000 | 0.84 |
| 6MWT (m) | 54 | 573.5 | 500 | -6.011 | 0.000 | 0.82 |
| AHR (bpm) | 52 | 118.5 | 109 | -4.922 | 0.000 | 0.68 |
| FFRT (cm) | 54 | 36 | 33 | -3.310 | 0.001 | 0.45 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 14: Pre-intervention Mann Whitney U results – BC/OC

| | n= BC/OC | $Median_{BC}$ | $Median_{OC}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 49/39 | 79.83 | 85.46 | -1.555 | 0.121 | 791.5 | 0.414 |
| RHR (bpm) | 55/55 | 78 | 78 | -0.209 | 0.836 | 1477.5 | 0.488 |
| $HGST_{Dom}$ ($kg_{relative}$) | 49/39 | 0.3072 | 0.3401 | -1.262 | 0.210 | 827.0 | 0.433 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 49/39 | 0.2358 | 0.3233 | -1.718 | 0.087 | 751.0 | 0.393 |
| 30CST (repetitions) | 54/55 | 11 | 12 | -1.706 | 0.088 | 1204.5 | 0.406 |
| 6MWT (m) | 53/54 | 560 | 500 | -2.057 | 0.039 | 1101.0 | 0.385 |
| AHR (bpm) | 47/52 | 113 | 109 | -1.644 | 0.101 | 987.5 | 0.404 |
| FFRT (cm) | 53/54 | 32 | 33 | -0.369 | 0.715 | 1372.0 | 0.479 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 15: Post-intervention Mann Whitney U results – BC/OC

| | n= BC/OC | $Median_{BC}$ | $Median_{OC}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 49/39 | 78.02 | 83.46 | -2.849 | 0.079 | 746.5 | 0.391 |
| RHR (bpm) | 55/55 | 77 | 74 | -0.853 | 0.396 | 1370.0 | 0.453 |
| $HGST_{Dom}$ ($kg_{relative}$) | 49/39 | 0.3122 | 0.3625 | -1.600 | 0.111 | 765.0 | 0.400 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 49/39 | 0.2887 | 0.3351 | -1.466 | 0.144 | 781.0 | 0.409 |
| 30CST (repetitions) | 54/55 | 14 | 15 | -1.245 | 0.215 | 1280.0 | 0.431 |
| 6MWT (m) | 53/54 | 620 | 573.5 | -1.050 | 0.296 | 1262.5 | 0.441 |
| AHR (bpm) | 4752 | 122 | 118.5 | -1.111 | 0.269 | 1063.5 | 0.435 |
| FFRT (cm) | 53/54 | 35 | 36 | -0.406 | 0.687 | 1366.0 | 0.477 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

# Chapter 5: Discussion

The positive benefits of exercise for CS are well documented with most of this information coming from RCTs (Campbell et al., 2019b). These studies generally have strict inclusion criteria and rigorous structure to control for as many confounding factors as possible. This makes it easier to evaluate the safety and efficacy of an exercise intervention (Ford & Norrie, 2016). In contrast, pragmatic exercise trials focus on incorporating the patient and community in the treatment process, helping to identify possible confounding variables while still delivering the highest standard of care possible (Patsopoulos, 2011). This allows researchers to evaluate the effectiveness and feasibility of an exercise intervention as well as whether the intervention is scalable  However, questions still exist around whether an exercise intervention in a pragmatic trial provides the same level of benefit as observed RCTs (Purdy et al., 2022). Therefore, the purpose of this study was to evaluate the impact of the SSCRP, a 12-week community-based exercise program for CS, on physical fitness and function. Overall, this study showed that the 12-week individualized exercise program significantly improved upper body muscular strength, lower body muscular endurance, exercise capacity, and balance in participating cancer survivors. This suggests that a community-based exercise program can elicit positive benefits in a diverse group of cancer survivors, similar to those that have been reported from RCTs.

The significant improvements observed between pre, and post intervention tests suggests that the SSCRP can positively affect physical health and function of CS. It is important to consider the real-world applications of these results as statistical significance does not always translate to clinical significance. The minimally clinically important difference (MCID) represents the magnitude of a change in values required to warrant a change in a patient's management (Jaeschke et al., 1989). With no age matched control group, the best way to validate the effectiveness of the SSCRP is to compare the magnitude of the observed improvements to established thresholds for clinical significance (MCID) as well as consider effect size.

**Weight**

Weight was not found to significantly change because of the SSCRP and the difference between pre and post values were shown to have a small effect size (r=0.23). This is similar to the findings of another pragmatic trial by Courneya et al., (2016) who observed no change in weight over the 1-year intervention. Conversely, Lee and Vicil, (2020) observed significantly lower post-test bodyweight compared to pre-test measures for their intervention group. This contrasts with their control group who showed no significant differences between pre and post-test measures. Of note, Lee and Vicil, (2020) used a RCT design, with standardized, progressive exercise sessions while Courneya et al., (2016) tailored exercise sessions to the limitations participants. This could suggest that RCTs are better suited to improve bodyweight and BMI however the populations examined differed greatly with Courneya et al., (2016) examining colon CS and Lee and Vicil, (2020) examining breast CS.

**Strength**

Upper body strength was shown to significantly increased because of the SSCRP. This was represented by an 8.8% increase in relative dominant hand grip strength and a 6.2% increase in relative non-dominant hand grip strength. This study found that there was an increase in grip strength for both dominant (2.18±3.09 kg) and non-dominant

(1.83±3.38 kg) hands. These absolute increases are similar to RCT's exploring the effects of regular exercise on CS. For example, Lee and Vicil (2020) observed a significant increase in grip strength values of 3.05 kg. This was achieved with three 50-minute sessions per week consisting of a combination of bodyweight and aerobic training. Aerobic training intensity was set as a percentage of heart rate reserve and all participants performed the same bodyweight exercises with volume and intensity for both increasing incrementally as the 8-week intervention progressed. Marker et. al., (2018) also observed a significant increase in grip strength of 1.0 kg over a 3-month intervention. Similar to the current study, participants attended two 50-minute exercise sessions conducted in small groups. The program was designed based off the specific impairments in cardiorespiratory fitness and musculoskeletal strength. Each session was highly modifiable based off participants' goals, and health status (Marker et al., 2018). Of note, Lee and Vicil (2020) studied only BC survivors and used an RCT design while Marker et al., (2019) included participants with a variety of cancer diagnoses and used a pragmatic design. Together these findings suggests that pragmatic trials result in improvements in grip strength like those observed in RCTs.

Increases of 5.0 to 6.5 kg have been suggested to be indicative of meaningful changes in grip strength (Bohannon, Richard, 2019). However, MCID for grip strength range from 0.04 kg to 6.9 kg (0.8% to 19.5%). In this study, the observed average increases in HGST values for dominant (2.18 kg) and non-dominant (1.83 kg) are in the lower range of reported values. This suggests that the observed improvements to grip strength could be clinically significant however, more research is needed to confirm this.

## Exercise Capacity

Lower body muscular endurance demonstrated an increase of 33% in repetitions performed during the 30CST. The initial values observed in this study were similar to those of other clinical populations (Courneya et al., 2016; Kalter et al., 2016; Kampshoff et al., 2015; Ozcan Kahraman et al., 2020; Petersen et al., 2017; Zanini et al., 2019). The average increase of 4.39±3.18 repetitions between intake and discharge assessments for this study was comparable to the 2-3 repetitions MCID values found in similar clinical populations (Petersen et al., 2017; Zanini et al., 2019) For example, Courneya et al., (2016) saw a similar average increase of 4.1 repetitions over a one-year period in colon CS. Similar to the SSCRP, the researchers modified their exercise program for the abilities and needs of colon CS (Courneya et al., 2016). Smith, Broomhall, and Crecelius (2016) found that significant improvements in the 30CST can be achieved in as little as 12 bi-weekly, one-hour exercise sessions completed within 6-10 weeks. They observed an average increase of 3 repetitions over the duration of the intervention, prescribing a combination of aerobic and light weight resistance exercise. Progressive exercise plans were designed based on the individual goals and baseline measures of each participant.

SSCRP participants also showed an increase in functional aerobic capacity, outlined by an average increase of 89.99±81meters traveled in the 6MWT. Courneya et al. (2016) observed an average increase of 59m in distance traveled among colon cancer survivors after 1 year of structured exercise. Similarly, Yee et al. (2019) saw an average increase in distance of 40m after 8 weeks and further improved to 49 m after 16 weeks of structured exercise. Both exercise interventions observed similar initial values (535±126 m and 531.4±136 m respectively) (Courneya et al., 2016; Yee et al., 2019) to the current investigation (524.35±155 m). Both exercise interventions consisted of two 1-hour long exercise sessions per week and these sessions were run by health care professionals (exercise physiologists, personal trainers, and physiotherapists). The duration of the exercise interventions differed from each other and the current study. Courneya et al., (2016) aimed to increase PA over the first 6-months of the exercise program and maintain those activity levels for up to 3 years after enrollment. Yee et al., (2019) lasting 8-weeks and the SSCRP lasting 12-weeks. All incorporated supervised and unsupervised exercise sessions. Adherence to supervised sessions was high. However, it dropped off dramatically for the optional/unsupervised sessions (Courneya et al., 2016; Yee et al., 2019). This suggests that duration or type of intervention (RCT or pragmatic) does not necessarily equate to greater improvements and that the supervised component of the exercise interventions has the greatest impact.

Across various clinical populations MCID values for the 6MWT were shown to range between 14-70 meters (Bohannon & Crouch, 2017). This observed increase of 89.99±81meters (17%) is in line with these values and more than double the MCID value found in lung cancer survivors (42 m) (Bohannon & Crouch, 2017)

The SSCRP did not have any significant effect on the RHR of CS ($p=0.049$) and this relationship was shown to have a small effect size ($r=0.19$). Conversely, a significant increase in post exercise heart rate was observed between pre and post intervention measures.  Positive physiological adaptations of regular physical exercise include increased performance as measured by an increase in distance traveled in the 6MWT as well as an increase in $O_2$ efficiency as measured by a decrease in heart rate for a similar workload (Scott et al., 2018). The observed increase of 11.5% in post exercise heart rate is in complete contradiction of this. This could be attributed to a change in fitness level or simply caused by participants being more familiar with the 6MWT. Since they were more familiar with the tests for the post intervention assessment and likely have higher fitness, they may push themselves harder. Side effects of treatment for cancer have been known to negatively affect cardiorespiratory health making it difficult to determine the exact reason for this unexpected increase in heart rate (Pai & Nahata, 2000). Further research is needed to explorer the effects of these factors on exercise capacity before definite conclusions can be drawn.

**Balance**

Balance was shown to increase as a result of the SSCRP, outlined by an average increase of 8.3% for forward functional reach. Side effects of cancer and its treatment can negatively affect balance resulting in an increased risk of falls (Morishita et al., 2018). Balance was shown to increase by 8.3% for an average increase of 2.72 centimeters of forward reach. Baseline data show that participants in the current study were not considered to be at an increased risk of falling. This is indicated by a score of 25 cm or less in the FFRT (Duncan et al., 1990). Other studies have explored the relation between lower body strength/function and balance, identifying a positive correlation between the two (Morishita et al., 2018; Musanti et al., 2019). This suggests that regular physical exercise has a positive effect on balance which is an area of concern for cancer survivors. By reducing the risk of falling, exercise becomes safer and more accessible, further increasing both physical performance and quality of life (Ozcan et al., 2005). Of note, whether or not improving balance is a focus of an exercise intervention, CS's balance function should be assessed prior to enrollment as there is a potential for impairment or injury (Morishita et al., 2018).

### Sex Differences in Outcome Measures

It has been well established that sex influences performance in upper body strength, lower body muscular endurance, exercise capacity, and balance (Tveter et al., 2014). The largest difference in values between males and females was in the HGST for both dominant (37.79±10.7 kg and 23.81±6.1 kg), and non-dominant (36.40±10.9 kg and 22.03±5.2 kg) with males having greater pre intervention values than females in both tests. This is in line with previous literature as normative values for this test are greater for males across all age groups (Tveter et al., 2014). In males there was an observed increase in both dominant (6.4%) and non-dominant (4.4%) hand grip strength. However, neither difference was significant ($p=0.027$ $r=0.48$ and $p=0.126$ $r=0.33$ respectively). In females there was a significant increase in both dominant (8.8%) and non-dominant (8.6%) HGST scores with a large effect size for both ($r=0.67$ and $r=0.62$ respectively). The observed HGST values for males were also closer to normative values for a healthy adult population (Tveter et al., 2014) while the female group was more comparable to HGST scores of female cancer survivors, specifically BC survivors (Lee & Vicil, 2020). This could suggest that upper body strength was less affected in males although caution should be used when drawing this conclusion as females outnumbered males by nearly 3:1. This large difference in sample size between males ($n=55$) and females ($n=152$) could also suggest that there could be unexplored barriers to males participating in exercise interventions such as predisposition to exercise or pre-intervention exercise levels. Females, specifically Caucasian breast cancer survivors have been found to be the overwhelming majority of participants in exercise interventions (Turner et al., 2018a). This could lead to a misrepresentation of the effects of exercise interventions on CS as there are well established sex differences for many of the tests used in this study (Tveter et al., 2014). As this was a pragmatic trial and there was no targeted recruitment, further research is required to confirm this.

Performance in the 30CST and 6MWT improved regardless of sex showing that the SSCRP is efficient at improving both lower body muscular function and aerobic capacity. Males (35.77±6.48 cm) and females (31.60±5.52 cm) were not at an increased risk for falls and both subgroups increased their balance scores (5.2% and 9.6% respectively). However, the increase in males was not significant, despite having a moderate effect size (r=0.41). One likely explanation for this is the same as the HGST values in that observed values in the male group are more similar to those of a healthy adult population which is 34.94±3.90 cm (Dani et al., 2019). Women also generally have higher risk for falls, especially as age increases (Franse et al., 2017). This shows the importance of assessing initial values and designing programs around individual needs and limitations.

**Cancer Specific Differences in Outcome Measures**

Significant increases for both the BC and OC groups with observed for dominant hand grip strength (7.5% and 8.6%), lower body muscular endurance (30.2% and 35.7%), distance traveled in the 6MWT (14% and 21%), and balance (8.9% and 7.8%). The OC group did not show any significant increase in non-dominant hand grip strength (5.1%) however the BC group did (9.4%). One possible explanation for this is that the BC group (n=100), was exclusively female and accounted for roughly half of the study population (n=207). This means that the differences could be attributed to sex differences as opposed to cancer diagnosis. The lack of major differences in outcome measures between the BC and OC groups suggest that this type of exercise intervention is effective at increasing the physical function for all CS. However, to truly explore the differences between cancer groups, larger sample sizes are required. While the study population consisted of a wide variety of cancer diagnoses, group sizes varied drastically with BC survivors making up the overwhelming majority. This is not surprising as majority of exercise intervention studies have examined BC survivors (Turner et al., 2018a). Further research should aim to recruit greater numbers to adequately subdivide their sample into large enough groups to allow for comparisons between diagnoses.

**Age Differences in Outcome Measures**

Age has a well-documented inverse relationship with physical health and performance (Frederiksen et al., 2006; Isles et al., 2004; Simmonds, 2003; Tveter et al., 2014). That was apparent within this study population with significant differences between the ≥65 and <65 groups at both the pre and post intervention assessments for $HGST_{Dom}$, $HGST_{Non\text{-}dom}$, 30CST, 6MWT, AHR, and FFRT (tables 12 and 13). Previous literature has shown that while physical function declines with age, physical exercise can help mitigate these effects (Tveter et al., 2014). Despite these differences in scores between groups, both the <65 and ≥65 groups saw significant improvements in $HGST_{Dom}$, $HGST_{Non\text{-}dom}$, 30CST, 6MWT, AHR, and FFRT with large effect sizes. This shows that despite the differences in pre intervention physical fitness, the individualized exercise programs of the SSCRP can have a significant positive impact on the physical fitness of both older and younger CS. However, to optimize health related benefits age should be considered when designing exercise programs, especially for older adults.

**Strengths and Limitations**

While pragmatic trials do come with their limitations, they also have many benefits. They take the well-established benefits in a very controlled setting such as a RCT and help determine how to apply them effectively and efficiently in a clinical or community-based setting. In this case, the researchers established that a 12-week community-based exercise intervention can significantly increase upper body muscular strength, lower body muscular endurance, exercise capacity and balance in cancer survivors. When the population was stratified by age, sex, and cancer diagnosis these trends remained apparent. The results of this study suggest that while there is no perfect, all-encompassing recovery plan, if experienced exercise professionals tailor structured exercise plans to individuals needs and limitations, they can yield both positive physical and functional benefits.

There are many limitations that encumber the translation of the established positive benefits of regular, structured, physical activity for cancer survivors from a controlled setting to a real-world setting. Pragmatic trials such as this one, are essential in identifying these limitations to help raise the current standard of care and to make it easier for future studies to do so as well.

One limitation of this study was the heterogeneity of the study population. The ratio of females to males skewed heavily towards females (≅3:1) and this was even more apparent in the BC subgroup which was comprised entirely of females. The researchers identified two possible explanations for this disproportionate ratio. The first is that the original target population for this intervention was BC survivors who are predominantly females. Another explanation could be that male cancer survivors were not targeted for recruitment or do not have the same interest in community-based exercise programs as females do (Adams et al., 2015). This is a direct result of the study being pragmatic trial, as participants enrolled in the study based on their interest. Females have been found to be more likely to enroll in an exercise intervention (Adams et al., 2015) and the majority of exercise trials have explored women with BC (Turner et al., 2018b). This could be attributed to individual predispositions or lifestyle habits prior to their cancer experience which has been hinted at in previous literature however more research is required to substantiate this theory (Turner et al., 2018). Future studies should explore more effective ways to recruit male participants and the barriers associated with this to get a better representation of the general population.

Participants were encouraged to attend two weekly 60-minute supervised exercise sessions; regrettably program attendance was not recorded. Participants were also given a membership to the YMCA of Greater Saint John to allow them additional opportunities for exercise on their own time. The number of times participants visited the YMCA outside of the supervised exercise sessions and duration of these visits were also not monitored. The lack of adherence data means that it is unclear whether the observed improvements are a direct result of the bi-weekly supervised exercise sessions or that the improvements were only present in those who exercised outside of these sessions. Collecting adherence data would provide more complete information on the impact of a structured exercise intervention. Gathering specific information on individual compliance would add depth to future studies. The positive results seen in this study offer a foundation for further investigation.

**Conclusions**

The benefits of structured exercise programs have been well documented and so has our understanding of how to deliver it to cancer survivors in a way that is both safe and effective. More research is needed to further understand how factors such as age, sex and cancer diagnosis affect the physical and functional abilities of cancer survivors. However, the results of this study clearly highlight the importance of tailoring exercise programs to the specific needs and limitations of each individual as significant improvements were observed across a diverse population of CS with a wide range in age, cancer diagnosis, and physical fitness. This demonstrates that SSCRP is an effective cancer rehabilitation program.

As more research is conducted, our understanding of cancer, its side effects, and the role exercise can play in the recovery process continues to grow. The focus on gradually building up exercise levels emphasizes the importance of working with the patient’s needs, limitations, and preferences to turn a recovery tool into a lifelong practice.

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# Appendix A

**Stay Strong Physiotherapy Assessment Form**

Client: ____________________________________ Gender: ____________

DOB: ________________________

Family MD: ________________________________

Oncologist: _________________________________

Address: ______________________________________________________________

Phone #: _______________________

Email: ____________________________________________

Emergency Contact Name: __________________________________________________

Phone #: ________________________

Diagnosis: Exercising during treatment? Yes No

History of disease/treatments:

Chemotherapy: _________________________ Radiation: _____________________________

Hormone therapy: ___________________________________________

Symptoms resulting from treatment:

Analysis: Clinical impression:

______________________________________________________________

**Stay Strong Physiotherapy Assessment Form**

| | Initial Assessment | Discharge (Week 12) |
|---|---|---|
| **Personal Goals for Program** | 1:<br><br>2:<br><br>3: | # goals achieved? |
| **Observations** | | |
| **Activity Level** | Current vs Previous. (Sedentary, light, moderate, active) | Previous level achieved? |
| **Weight** | | |
| **Blood Pressure** | | |

| | Initial Assessment | Discharge (Week 12) |
|---|---|---|
| **Range of Motion** | ☐ Shoulder affected?<br>☐ N/A<br>☐Left ROM:______<br>☐Right ROM:______ | ☐ Shoulder affected?<br>☐ N/A<br>☐Left ROM:______<br>☐Right ROM:______ |
| **Strength** *: Hand Grip Test* | Non-dominant Hand: ☐ Left ☐ Right<br>Trial 1: _______ kgs<br>Trial 2: _______ kgs<br>Trial 3: _______ kgs<br><br>Average: _______kgs | Non-dominant Hand: ☐ Left ☐ Right<br>Trial 1: _______ kgs<br>Trial 2: _______ kgs<br>Trial 3: _______ kgs<br><br>Average: _______kgs |
| **Strength** *Lower Body: Sit to Stand Test* | Time: ________ seconds | Time: ________ seconds |
| **Neuropathy** | ☐ Hands (☐ none /☐ mild/ ☐ moderate/ ☐ severe)<br>☐ Feet (☐ none /☐ mild/ ☐ moderate/ ☐ severe) | ☐ Hands (☐ none /☐ mild/ ☐ moderate/ ☐ severe)<br>☐ Feet (☐ none /☐ mild/ ☐ moderate/ ☐ severe) |
| **Endurance** *Six Minute Walk Test (6MWT)* | Distance: ________ metres<br><br>Heart Rate following test:_______ | Distance: ________ metres<br><br>Heart Rate following test: ________ |
| **Balance** *Forward Reach* | Reach: ________cms | Reach: ________cms |
| **Flexibility** *Fingertips to Floor Test* | Distance from fingertips to floor: __________ cms | Distance from fingertips to floor: __________ cms |

## Appendix B

Table 16: Wilcoxon Signed Rank Test results for all variables

| | n= | $Median_{Post}$ | $Median_{Pre}$ | Z | P | r |
|---|---|---|---|---|---|---|
| Weight (kg) | 75 | 81.19 | 81.19 | -2.639 | 0.008 | 0.305 |
| RHR (bpm) | 75 | 76 | 75 | -1.762 | 0.078 | 0.203 |
| $HGST_{Dom}$ ($kg_{relative}$) | 75 | 0.3215 | 0.3596 | -4.805 | 0.000 | 0.555 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 75 | 0.2887 | 0.3180 | -4.177 | 0.000 | 0.482 |
| 30CST (repetitions) | 75 | 13 | 17 | -7.394 | 0.000 | 0.854 |
| 6MWT (m) | 75 | 536 | 580 | -7.318 | 0.000 | 0.845 |
| AHR (bpm) | 75 | 110 | 121 | -6.214 | 0.000 | 0.718 |
| FFRT (cm) | 75 | 33 | 36 | -5.472 | 0.000 | 0.632 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at $p=0.05$ and corrected to $p=0.00625$ for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 17: Pre-intervention Mann Whitney U results – male/female

| | n= m/f | $Median_{male}$ | $Median_{Female}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 20/55 | 89.58 | 78.02 | -2.546 | 0.010 | 337.5 | 0.307 |
| RHR (bpm) | 20/55 | 77 | 75 | -0.030 | 0.979 | 547.5 | 0.497 |
| $HGST_{Dom}$ ($kg_{relative}$) | 20/55 | 0.4406 | 0.3010 | -3.187 | <0.001 | 252.0 | 0.229 |
| $HGST_{Non-dom}$ ($kg_{relative}$) | 20/55 | 0.4406 | 0.2632 | -4.157 | <0.001 | 203.0 | 0.185 |
| 30CST (repetitions) | 20/55 | 13.5 | 12 | -0.709 | 0.483 | 491.0 | 0.446 |
| 6MWT (m) | 20/55 | 547.5 | 530 | -0.078 | 0.941 | 543.5 | 0.494 |
| AHR (bpm) | 20/55 | 108 | 113 | -1.426 | 0.156 | 431.0 | 0.392 |
| FFRT (cm) | 20/55 | 34.5 | 32 | -1.965 | 0.049 | 386.5 | 0.351 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non-dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 18: Post-intervention Mann Whitney U results – male/female

| | n= m/f | $Median_{male}$ | $Median_{Female}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 20/55 | 88.09 | 77.11 | -2.714 | 0.006 | 323.5 | 0.294 |
| RHR (bpm) | 20/55 | 71 | 76 | -0.330 | 0.746 | 522.5 | 0.475 |
| $HGST_{Dom}$ ($kg_{relative}$) | 20/55 | 0.4715 | 0.3254 | -3.187 | <0.001 | 284.0 | 0.258 |
| $HGST_{Non-dom}$ ($kg_{relative}$) | 20/55 | 0.4506 | 0.2870 | -3.822 | <0.001 | 231.0 | 0.210 |
| 30CST (repetitions) | 20/55 | 18 | 17 | -0.456 | 0.653 | 512.0 | 0.465 |
| 6MWT (m) | 20/55 | 619 | 576 | -1.534 | 0.126 | 422.0 | 0.384 |
| AHR (bpm) | 20/55 | 129.5 | 121 | -0.144 | 0.889 | 538.0 | 0.489 |
| FFRT (cm) | 20/55 | 36.5 | 36 | -0.577 | 0.569 | 502.0 | 0.456 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non-dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 19: Pre-intervention Mann Whitney U results – <65/>65

| | $N_{<65}$ | $Median_{>65}$ | $Median_{\geq 65}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 43/32 | 81.10 | 83.91 | -0.745 | 0.460 | 618.5 | 0.449 |
| RHR (bpm) | 43/32 | 76 | 74.5 | -0.488 | 0.630 | 642.5 | 0.467 |
| $HGST_{Dom}$ ($kg_{relative}$) | 43/32 | 0.3967 | 0.2732 | -3.567 | <0.001 | 355.0 | 0.258 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 43/32 | 0.3501 | 0.2513 | -3.760 | <0.001 | 337.0 | 0.245 |
| 30CST (repetitions) | 43/32 | 14 | 10 | -3.739 | <0.001 | 340.0 | 0.247 |
| 6MWT (m) | 43/32 | 577 | 455 | -4.989 | <0.001 | 222.5 | 0.162 |
| AHR (bpm) | 43/32 | 117 | 103 | -3.542 | <0.001 | 357.5 | 0.260 |
| FFRT (cm) | 43/32 | 135 | 29.5 | -2.627 | 0.008 | 443.5 | 0.322 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 20: Post-intervention Mann Whitney U results - <65/>65

| | n= <65/>65 | $Median_{<65}$ | $Median_{\geq 65}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 43/32 | 81.19 | 81.42 | -0.611 | 0.545 | 631.0 | 0.459 |
| RHR (bpm) | 43/32 | 76 | 72.5 | -0.054 | 0.960 | 683.0 | 0.496 |
| $HGST_{Dom}$ ($kg_{relative}$) | 43/32 | 0.4079 | 0.2964 | -3.674 | <0.001 | 345.0 | 0.251 |
| $HGST_{Non-dom}$ ($kg_{relative}$) | 43/32 | 0.3679 | 0.2808 | -3.299 | <0.001 | 380.0 | 0.276 |
| 30CST (repetitions) | 43/32 | 20 | 15 | -3.693 | <0.001 | 344.0 | 0.250 |
| 6MWT (m) | 43/32 | 690 | 520 | -5.567 | <0.001 | 168.5 | 0.122 |
| AHR (bpm) | 43/32 | 135 | 113 | -3.821 | <0.001 | 331.5 | 0.241 |
| FFRT (cm) | 43/32 | 38 | 33 | -3.045 | 0.002 | 404.5 | 0.294 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non-dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 21: Pre-intervention Mann Whitney U results – BC/OC

| | n= BC/OC | $Median_{BC}$ | $Median_{OC}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 40/35 | 77.88 | 86.18 | -1.566 | 0.121 | 553.5 | 0.395 |
| RHR (bpm) | 40/35 | 76 | 75 | -0.590 | 0.559 | 644.5 | 0.460 |
| $HGST_{Dom}$ ($kg_{relative}$) | 40/35 | 0.3073 | 0.3630 | -1.497 | 0.136 | 559.0 | 0.399 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 40/35 | 0.2648 | 0.3292 | -2.156 | 0.031 | 497.0 | 0.355 |
| 30CST (repetitions) | 40/35 | 13 | 12 | -1.246 | 0.215 | 583.0 | 0.416 |
| 6MWT (m) | 40/35 | 555 | 515 | -1.594 | 0.122 | 550.0 | 0.393 |
| AHR (bpm) | 40/35 | 115 | 105 | -2.306 | 0.021 | 483.0 | 0.345 |
| FFRT (cm) | 40/35 | 33 | 32 | -0.341 | 0.737 | 668.0 | 0.477 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.

Table 22: Post-intervention Mann Whitney U results – BC/OC

| | n= BC/OC | $Median_{BC}$ | $Median_{OC}$ | Z | P | U | r |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 40/35 | 77.33 | 85.09 | -1.827 | 0068 | 528.0 | 0.377 |
| RHR (bpm) | 40/35 | 76 | 74 | -0.622 | 0.538 | 641.5 | 0.458 |
| $HGST_{Dom}$ ($kg_{relative}$) | 40/35 | 0.3151 | 0.3792 | -1.731 | 0.084 | 537.0 | 0.384 |
| $HGST_{Non\text{-}dom}$ ($kg_{relative}$) | 40/35 | 0.2866 | 0.3362 | -1.795 | 0.073 | 531.0 | 0.379 |
| 30CST (repetitions) | 40/35 | 17 | 17 | -0.537 | 0.595 | 649.5 | 0.464 |
| 6MWT (m) | 40/35 | 580.5 | 578 | -0.207 | 0.839 | 680.5 | 0.486 |
| AHR (bpm) | 40/35 | 123 | 120 | -1.307 | 0.193 | 577.0 | 0.412 |
| FFRT (cm) | 40/35 | 36 | 36 | -0.272 | 0.789 | 647.5 | 0.463 |

*Note.* RHR = resting heart rate, $HGST_{dom}$ = hand grip strength test for dominant hand, $HGST_{non\text{-}dom}$ = hand grip strength test for non-dominant hand, 30CST = 30-second sit to stand test, 6MWT = six-minute walk test, AHR = average heart rate after the 6MWT, and FFRT = forward functional reach test. Significance level was set at p=0.05 and corrected to p=0.00625 for 8 comparisons. An effect size (r) of 0.1 indicates a small effect, 0.3 indicates a moderate effect, and 0.5 or greater indicates a large effect.