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Evaluation of the Phase Training Model of Cancer Rehabilitation

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ABSTRACT

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Exercise is a well-established method of alleviating cancer-related toxicities during and following treatment in cancer survivors. Due to this clear evidence, exercise-based rehabilitation programs have begun to emerge. Of concern, specific recommendations of exercise prescription for patients at different time points on the cancer continuum have not been developed, and available guidelines are broad and unclear. The Phase Training Model of cancer rehabilitation was created to address this issue and replace our previously used method of exercise-based prescription and intervention. **Purpose:** To evaluate the effects of the Phase Training Model on cardiorespiratory endurance, muscular strength (MS), and cancer-related fatigue (CRF) in cancer survivors during the transition from each Phase and in those who have completed the entire Phase Training Model. **Methods**: A total of 152 cancer survivors' data were utilized. The Phase Training Model consists of four sequential Phases representing differing time points from treatment. The designated Phase prescribes intensity, progression, and goals unique to each. Changes in peak volume of oxygen consumption (VO_{2peak}), chest press MS, leg press MS, and CRF were observed in transitions from Phase 1 to 2, Phase 2 to 3, and Phase 3 to 4. Absolute values and percent change of

VO_{2peak} from data collected in the previous version of the program were compared to the data collected in the Phase Training Model. **Results**: VO_{2peak}, chest press MS, leg press MS, and CRF all significantly improved from Phase 1 to Phase 2, and from Phase 2 to Phase 3 ($p < 0.05$). VO_{2peak} and chest press MS significantly improved in patients transitioning from Phase 3 to 4 ($p < 0.05$). VO_{2peak} improved to a greater extent in the Phase Training Model when compared to the previous program (29.4% and 14.8%, respectively. **Conclusion:** These findings suggest the Phase Training Model provides the first clear and reproducible guidelines for exercise prescription in cancer survivors, and is more effective at improving cardiorespiratory endurance than the previous model of the program. This model of exercise-based intervention yielded significant physiological and psychological improvements in patients both during and immediately following treatment, with reduced results as time from treatment increases.

Keywords: cancer, cancer rehabilitation, oncology rehabilitation, exercise-based interventions

DEDICATED TO:

DR. CAROLE M. SCHNEIDER

You changed my life. Most importantly, you changed the lives of hundreds of thousands of cancer survivors for the better. Through your tireless work, you educated the world about the benefits of prescriptive exercise for cancer patients and helped usher in a time where oncologists no longer say "rest and relax during treatment; don't exercise". Thanks to you, that is outdated.

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CHAPTER I

INTRODUCTION

Cancer is a disease that is characterized by abnormal and uncontrolled cell growth. Currently, there are 14.5 million Americans with a history of cancer, and 1,658,370 new diagnoses are expected to be made in 2015 (American Cancer Society, 2015). The gerontological population has the greatest risk of developing cancer as 78% of cancer diagnoses affect those who are 55 years of age or older (ACS, 2015). Males have the greatest risk of developing cancer, with a slightly less than 50% chance, while females have approximately a 33% risk (ACS, 2015). About 590,000 Americans are expected to die from cancer this year. Fortunately, the 5-year survival rate for all cancers between 2004 and 2010 is now at 68%, which is substantially higher than the 49% survival rate between 1975-1977 (ACS, 2015). This increase in survival rate may be due to earlier detection, prevention, and the advanced cancer treatments now available.

Advancements in cancer treatments such as chemotherapy and radiation have increased survival rates of cancer patients, but often result in many deleterious side-effects during and following treatments. Cancer survivors can suffer from physiological toxicities affecting the following systems: cardiovascular, pulmonary, musculoskeletal, immune, gastrointestinal, hepatic, and neuroendocrine (Schneider, Dennehy, & Carter, 2003; Schneider, Dennehy, Roozeboom, & Carter, 2002). Additionally, many survivors will experience psychological decrements such as increased fatigue

(Daniell, 2004; Stone & Minton, 2008; Wu & McSweeney, 2007), increased depression (Dauchy, Dolbeault, & Reich, 2013; Gagliese, Gauthier, & Rodin, 2007; Ng, Boks, Zainal, & de Wit, 2011), and decreased quality of life (QOL) (Lee et al., 2010; Rauma, Sintonen, Räsänen, Salo, & Ilonen, 2015).

In 1971, the National Cancer Act was established to investigate the rehabilitative needs and evaluate interventions established for cancer survivors to improve diagnosis, treatment, and care delivery. From this, rehabilitation programs began to emerge for cancer survivors (Lehmann et al., 1978) and from 1971 to the late 1990's, these programs consisted of large, hospital-based multidisciplinary approaches utilizing oncologists, social workers, surgeons, physical therapists, and other healthcare professionals. This remained the only model of rehabilitation for cancer survivors until the advent of exercise only-based rehabilitative interventions (DeLisa, 2001; Schneider et al., 2002). The opportunity to move towards a single mode of intervention— exercise—instead of the numerous therapies seen with most multidisciplinary approaches stemmed from the advancements in cancer care that have occurred within the last 30 years. Advances in detection, diagnosis, and treatments have improved prognosis and lessened the need for hospital and physician-based interventions (Alfano, Ganz, Rowland, & Hahn, 2012). Exercise-based programs are a viable option of cancer rehabilitation for cancer survivors as the benefits of exercise directly attenuate the toxicities and decrements of cancer and concurrent treatments (Dittus et al., 2015; Schmitz et al., 2010; Schneider et al., 2002). It has been demonstrated throughout the literature that cancer survivors who perform physical activity before, during, and/or after treatments have significant improvements in muscular strength, maximal oxygen consumption, flexibility, and QOL, as well as

decreased levels of fatigue and depression (Herrero et al., 2006; Schneider, Hsieh, Sprod, Carter, & Hayward, 2007a). As the benefits of physical activity on cancer recovery is gaining recognition from oncologists and physicians, more cancer survivors are now being exposed to exercise-based rehabilitation services (Thorsen et al., 2011).

Exercise-based interventions should be comprehensive and address the multidimensional needs of cancer survivors during treatment and following treatment. For this reason, a "one size fits all" approach to exercise interventions will not suffice (Marcus et al., 2000), and survivors need prescriptive exercise that is specialized for each individual based on treatment status and placement on the cancer continuum. The cancer continuum commonly refers to the various points of cancer survivorship, from prevention, to detection and diagnosis, treatment, survivorship, and end of life (National Cancer Institute, 2011). Organizations and facilities that are offering exercise-based cancer rehabilitation are starting to emerge, and many of them are not located or affiliated with a hospital or medical organization. Of note, there are many different modes and intensities that are being used for physical activity-based interventions in the cancer population, and most are unstructured. To date, there is only one longstanding model of a standardized exercise intervention with guidelines for intensity, frequency, and duration for cancer survivors (Schneider et al., 2003; Schneider et al., 2002). Evidence that this program improves cardiovascular endurance, muscular endurance, and reduces fatigue has been well documented following a 6-month intervention (Schneider et al., 2002; Schneider, Hsieh, Sprod, Carter, & Hayward, 2007b; Schneider, 2013); however, further analysis of this program suggests reduced improvements with continued exercise, while physical functioning remains well below average (Brown, Lalonde, Dallow, Hayward, &

Schneider, 2012) . It was concluded that this prescriptive exercise intervention was sufficient to improve cancer survivor's physiological function at the onset, but suggests that survivors may begin to experience diminishing returns from exercise training as the program lengthens. For those working with cancer survivors, greater attention should be paid to the principles of exercise training, specifically progression and overload to ensure that these individuals continue to improve and reach apparently healthy status. To this purpose, creation of a new model of exercise-based cancer rehabilitation is needed to ensure patients continue to improve physiological and psychological functioning throughout the rehabilitation program. Revision of previous recommendations of intensity, duration, and frequency are needed and guidelines should be established for each patient based on treatment status and placement on the cancer continuum. The University of Northern Colorado Cancer Rehabilitation Institute (UNCCRI) has created a Phase Training Model to address these issues and concerns. The effectiveness of this model must be evaluated.

Statement of Purpose

The purpose of this study is to evaluate the effects of the Phase Training Model on cardiorespiratory endurance, muscular strength, and cancer-related fatigue in cancer survivors during the transition from each Phase and in those who have completed the entire Phase Training Model.

Research Hypotheses

H1 Cancer survivors transitioning from Phase 1 to Phase 2 of the Phase Training Model will significantly increase cardiovascular endurance, muscular strength, and decrease levels of fatigue.

H2 Cancer survivors transitioning from Phase 2 to Phase 3 of the Phase Training Model will significantly increase cardiovascular endurance, muscular strength, and decrease levels of fatigue.

H3 Cancer survivors transitioning from Phase 3 to Phase 4 of the Phase Training Model will increase cardiovascular endurance and muscular strength, and these improvements will yield classifications representing apparently healthy status. Values for fatigue will improve yielding a normal classification.

H4 Cancer survivors who complete the entire Phase Training Model (from entry to Phase 4) will maintain or improve values of cardiovascular endurance and muscular strength.

H5 Improvements observed in cardiovascular endurance will be greatest for those subjects who complete the Phase Training Model (from entry to Phase 4) compared with subjects who participated in the previous version of the program for an equivalent period of time.

Significance of Study

Exercise is a well-established method of alleviating cancer-related toxicities during and following treatment in cancer survivors (Brown, Huedo-Medina, et al., 2012; Murtezani et al., 2014; Schneider et al., 2007a). Specifically, exercise interventions attenuate cardiotoxicity (Arola et al., 2000; Eschenhagen et al., 2011; Richard et al., 2011), pulmonary toxicity (Camp-Sorrell, 2006; Ohe, 2002) , musculoskeletal dysfunction (Barret et al., 2014; Tisdale, 2009), and myelosuppression (Rasmussen & Arvin, 1982; Schneider et al., 2003). Due to the clear evidence that exercise plays an integral role in cancer survivorship, exercise–based cancer rehabilitation programs have begun to emerge. Of concern, most exercise programs to date have failed to properly

apply and adhere to the principles of exercise training: individuality, specificity, progression and overload (referred to as progressive overload), reversibility, and diminishing returns (Campbell, Neil, & Winters-Stone, 2012; Kenney, Wilmore, & Costill, 2015). Subsequently, these interventions violate standards that must be employed to prescribe the appropriate dosage and mode of exercise to ensure optimal and reproducible results.

The American College of Sports Medicine (ACSM) suggests cancer survivors reach at least 150 minutes of moderate physical activity or 75 minutes of vigorous activity per week (American College of Sports Medicine, 2013). However, these guidelines are very broad and are not specific enough for cancer survivors. Furthermore, it is currently unclear how to alter exercise prescriptions for patients at different time points on the cancer continuum, as well as why or when to modify exercise dosage during an intervention to elicit specific adaptations. The Phase Training Model of cancer rehabilitation was created to address these concerns and provide a clear method of exercise prescription and intervention to alleviate treatment-related toxicities. Therefore, this study is focused on evaluating the effectiveness of the Phase Training Model on physiological and psychological function in cancer survivors.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Cancer is the second leading cause of death in the United States, only succeeded by heart disease, but is now the leading cause of death in 21 US states (American Cancer Society, 2015; Siegel, Miller, & Jemal, 2015). Unfortunately, more than half a million Americans are expected to succumb to cancer, with more than 1,600 deaths attributed to the disease per day (ACS, 2015). Cancer can affect any organ or part of the body, with breast and prostate cancers representing the largest majority in males and females, respectively. However, lung and bronchus cancer are the deadliest and account for the most deaths (ACS, 2015). Although cancer is a leading cause of death in the United States, the 5-year survival rate for all cancers is improving. The survival rates for those diagnosed between 2004-2010 was 68%, which is 19% higher than the survival rates seen between 1975-1977 (ACS, 2015). This increase in survivability may be attributed to earlier detection and advancements in cancer treatments. Despite the increased prognosis, cancer survivors still suffer from debilitating treatment-related toxicities. Specifically, the side effects associated with cancer and its concurrent treatments result in serious decrements in physiological and psychological function, represented by decreased VO_{2peak}, pulmonary function, muscular strength, myelosuppression, and increased fatigue, depression, and ultimately a reduction in QOL. Due to this, establishing a

standard cancer rehabilitation program to properly address these variables is needed. Cancer rehabilitation may consist of many aspects such as: nutritional planning, social support groups, art therapy, stress management, massage, acupuncture, occupational therapy, and/or educational services (Gudbergsson et al., 2015; Silver et al., 2015). While several modes are utilized, exercise-based interventions remain a well-established, documented and effective method of rehabilitation for cancer survivors (Courneya, 2003; Schmitz et al., 2010; Schneider et al., 2002; Warburton, Nicol, & Bredin, 2006). Despite this knowledge, precise exercise prescription and standardization of exercise-based models has not been developed (Brown, Lalonde, et al., 2012; Winters-Stone, Neil, & Campbell, 2013).

Cancer Treatments

Advancements of cancer treatments is one of the primary contributing factors leading to the overall increases in survivorship. There are many treatment options available, however the most effective and common treatments include chemotherapy, radiation, and surgery. Other treatments can include, but are not limited to, hormonal treatment, immunotherapy, hyperthermia treatment, and stem cell transplants (ACS, 2015). These treatments are not as regularly used but may still be effective in the appropriate circumstance, such as when treating a specific cancer type.

Chemotherapy is one of the most effective forms of cancer treatment. It is usually administered by infusion via vein or artery allowing it to affect the entire body systemically. In other cases it might be taken orally via a pill or liquid, or it may be absorbed into the skin as a cream (Sugerman, 2013). These types of drugs attempt to kill the cancer cells directly, stop the cancer from spreading, and/or slow the rate of growth of

tumors. There are different classes of chemotherapy, each having its own unique mechanism in treating cancer. The most common classes of chemotherapy are alkylating agents, antimetabolties, antitumor antibiotics, and alkaloids (Schneider et al., 2003). Alkylating agents bind with the DNA in DNA synthesis to stop cell replication. Antimetabolites attack the cancer cells during mitosis, and will imitate normal cell nutrients in order to starve the cancer cell. Antitumor antibiotics are inserted in the strands of DNA, inhibiting the synthesis of RNA. Finally, alkaloids inhibit cell replication by interrupting the formation of chromosomes (Schneider et al., 2002). Although chemotherapy is very effective at interfering with cancerous cell growth, it is also extremely cytoxic to healthy cells, resulting in the most severe toxicities. These side-effects affect both physiological and psychological function, leading to cardiovascular, pulmonary, musculoskeletal, and immune toxicities, while increasing fatigue, depression, and reducing QOL (Carayol et al., 2013; Chap et al., 1997; Curigliano et al., 2012; Dauchy et al., 2013; Schneider et al., 2002).

Radiation therapy uses high energy x-rays, electron beams, or radioactive isotopes to damage or destroy malignant cancer cells (Schneider et al., 2003). However, like chemotherapy, it will affect normal cells surrounding the cancerous tumor. Typically, radiation is used to target small, localized tumors and is not used in metastatic cancers, where a systemic treatment is needed (Schneider et al., 2003). There are different types of radiation, with internal and external representing the two most common. External beam radiation aims the beams of energy from a source outside of the body at the target site of cancer. Internal radiation surgically places a radioactive isotope directly on or near the tumor inside of the body. Administration of radiotherapy will also

result in side effects, such as necrosis, fibrosis, ulcerations, irritations of the skin, damage to the specific organs where the radiation was administered, increased fatigue, decreased QOL, and increased depression (Schneider et al., 2003; Whelan, Levine, Julian, Kirkbride, & Skingley, 2000).

Surgery is one of the most effective methods of treatment for eliminating cancer from the body. If the tumor is small and confined to one area, it may be completely removed along with some normal surrounding tissue. If the tumor is larger and cannot be removed in its entirety, debulking, or removing part of the tumor gives adjuvant treatment a better chance at eliminating the cancer cells (Schneider et al., 2003). Besides removal of cancerous cells, surgery can be used as a diagnostic tool and a preventive measure. By obtaining a biopsy, medical staff are able to determine the tumor grade and cancer stage. If an individual does not yet have cancer but are positive for a gene or loss of a gene, such as BRCA1, they may opt to have preventive surgery and remove the entire breast to eliminate any risk of developing cancer. Surgery is very effective for localized tumors and causes few side effects beyond pain, decreased range of motion at the incision site, and lymphedema (Schneider et al., 2003).

Side Effects from Cancer Treatments

Cancer survivors experience a vast array of concurrent physiological and psychological side effects which may affect any organ or system in the body. The decrements are complex and variable between patients, even those with the same cancer diagnosis or treatment regimen. The toxicities experienced can manifest in the cardiovascular, pulmonary, musculoskeletal, and immune systems, and can lead to fatigue, depression, and reduced QOL.

Cardiovascular Toxicity

Chemotherapeutic agents can directly damage the heart and can lead to cardiac dysfunction (Schneider et al., 2003; Yeh et al., 2004). Anthracyclines such as doxorubicin have been reported to result in cardiotoxicity after repeated bouts of dose-dependent administration, which may play a role in the disruption of myofibrils and contractile proteins, cardiomyocyte apoptosis, and oxidative stress (Eschenhagen et al., 2011; Richard et al., 2011). Repeated cycles of chemotherapy may lead to cardiotoxicity months or even years after treatment, however acute cardiotoxicity can take place minutes after administration (Arola et al., 2000; Monsuez, Charniot, Vignat, & Artigou, 2010; Shakir & Rasul, 2009; Vejpongsa & Yeh, 2014). Cardiotoxicities may develop into congestive heart failure or cardiomyopathy once treatment is finished (Monsuez et al., 2010; Wood, Shapiro, & Recht, 2001). Radiation treatments may also result in similar side effects. External radiation to the thoracic region may damage the myocardium, pericardium, valves, and coronary vessels (Veinot & Edwards, 1996). Radiation may cause fibrous thickening of the pericardium, commonly resulting in pericarditis (Veinot & Edwards, 1996). Valvular heart disease is a common side effect due to the thickening of the cardiac valves (Veinot & Edwards, 1996). Additionally, patients may also experience complications such as angina, dyspnea, and in extreme cases, sudden death (Brosius, Waller, & Roberts, 1981).

Pulmonary Toxicity

Cancer survivors who are undergoing cancer treatments experience both acute and chronic pulmonary side-effects, which may develop within days or possibly years after treatment. Chemotherapy will initially damage the endothelial cells, which may result in

an inflammatory response leading to drug-induced pneumonitis and pulmonary fibrosis (Camp-Sorrell, 2006). In some instances, the interstitial pneumonitis can progress to fatal pulmonary fibrosis if it is left untreated (Ohe, 2002; Pavlakis, Bell, Millward, & Levi, 1997; Peters et al., 1993). Chemotherapy can also cause detrimental alterations to the pulmonary parenchyma, connective tissue, and alveoli (Camp-Sorrell, 2006). Radiation treatments to the thoracic area can produce comparable toxicities as well, such as pneumonitis and fibrosis. Radiation can also destroy the cell lining of the alveoli, causing inflammation. These effects will depend on the volume of the lungs that are irradiated and the radiation dose (Villani et al., 1997), and greater cumulative doses of radiation result in a higher risk of radiation pneumonitis (Mehta, 2005). In fact, it is estimated that roughly 10-20% of patients receiving chemotherapy or radiotherapy will suffer from severe pneumonitis (Mehta, 2005). This ultimately will lead to impaired diffusion of oxygen and carbon dioxide within the alveoli (Abid, Malhotra, & Perry, 2001), shortness of breath, low functional capacity, and dyspnea (Schneider et al., 2002).

Musculoskeletal Alterations and Decrements

Muscular degeneration is another common side-effect observed in cancer survivors, with approximately 50% of patients experiencing some type of muscle wasting (Tisdale, 2009). Cancer cachexia, or the involuntary loss of muscle and adipose tissue as a result of cancer and the associated treatments, results from a decrease in protein synthesis and an increase in protein degradation. The decrease in protein synthesis may be attributed to a reduced level of initiation factor 4F and elongation factor 2, while an increase in protein degradation results from increased activity of the ubiquitin-proteasome pathway and lysosomes (Tisdale, 2009). Additionally, tumor and host factors

such as proteolysis-inducing factors, tumor necrosis factor-α, pro-inflammatory cytokines, and angiotensin II may result in muscle wasting (Gordon, Green, & Goggin, 2005; Tisdale, 2009). The wasting of skeletal muscle will contribute to a decrease in muscular strength, as muscle mass is directly proportional to muscular strength (Jones, Rutherford, & Parker, 1989; Stewart, Skipworth, & Fearon, 2006). Chemotherapy treatment is the largest contributing factor that worsens the effects of cachexia and the loss of muscle mass (Barret et al., 2014; Braun et al., 2014; Jung et al., 2015; Miyamoto et al., 2015; Sjøblom et al., 2015) and contributes to the decrease in overall strength observed in cancer survivors (Kilgour et al., 2010; Merchant, Chapman, Kilbreath, Refshauge, & Krupa, 2008; Salhi et al., 2014). Radiation will also negatively alter skeletal muscle, as it may alter the sarcolemma, sarcoplasmic reticulum, and mitochondrial membrane, which will lead to altered force generation. Similarly, myofibrils and myofilaments will be damaged and become disorganized due to radiotherapy, leading to decreased force production (Schneider et al., 2003).

Immune System Toxicity

Cancer treatments negatively affect the immune system and may result in myelosuppression, or the decrease in production of immune cells in the bone marrow. Specifically, immune system toxicity can lead to leukopenia, lymphocytopenia, granulocytopenia, and thrombocytopenia (Rasmussen & Arvin, 1982; Schneider et al., 2003; Schwartz, 1968). Chemotherapy-induced neutropenia is a common side effect of myelosuppression and often results in hospitalization (Lyman, Abella, & Pettengell, 2014). Suppressed immune function is a common, treatment-related, chronic side-effect of radiation, and is associated with early death from tumor progression (Grossman et al.,

2011). The overall extent of cell death and myelosuppression will depend on the type, dose, and location of the cancer treatment (DeVita, Hellman, & Rosenberg, 1997; Kohn & Melvold, 1976). Immune system toxicity results in an increased susceptibility to infections and diseases and in rare cases, more serious diseases such as pneumonia and premature death (Schneider et al., 2002).

Fatigue

Cancer-related fatigue (CRF) is the most prevalent side-effect experienced by cancer survivors during and following treatment (Hofman et al., 2004; Hofman, Ryan, Figueroa-Moseley, Jean-Pierre, & Morrow, 2007). CRF is described as an overwhelming, draining, whole-body tiredness that is unrelated to activity or exertion, and negatively impacts overall well-being and activities of daily living. CRF is not alleviated by rest and may be augmented by sedentary behavior (Schneider et al., 2003; Wu & McSweeney, 2007). Stedman's medical dictionary further describes fatigue as a state when ATP expenditure outstrips the restorative processes of the body (Lewis, 2000). CRF may result from cardiotoxicity, pulmonary toxicity, musculoskeletal toxicity, and other physiological toxicities resulting from treatment (Schneider, 2013). Specifically, toxicities to the cardiovascular system result in decreased stroke volume and cardiac output and a subsequent reduction in oxygen delivery to body tissues. Similarly, pulmonary toxicity resulting in fibrosis decreases lung capacity and limits the amount of oxygen diffusion in the lungs. This also leads to reduced oxygen delivery to the body and ultimately increased fatigue. Cancer cachexia or other musculoskeletal toxicities increase protein catabolism, limits cross-bridge formation and muscle contraction, which contributes to reduced strength and power. This will result in increased feelings of CRF

in cancer survivors (Bower, 2014; Peterson, Repka, Dallow, Hayward, & Schneider, 2012; Schneider et al., 2003; Schneider, 2013). It has been suggested that up to 100% of all cancer survivors experience CRF to some degree (Hofman et al., 2007; Koornstra, Peters, Donofrio, van den Borne, & de Jong, 2014; Weis, 2011; Yeh et al., 2011). Some reports state that CRF is experienced in 58-94% of breast cancer survivors undergoing treatment, and 56-95% following treatment (Berger, Gerber, & Mayer, 2012; Cramp & Byron-Daniel, 2012; Escalante, Manzullo, & Valdres, 2003). The duration a patient may experience CRF will vary; it may last for months or persist for years following the completion of treatment. Fatigue can negatively affect physical functioning with up to 91% of cancer survivors receiving chemotherapy reporting difficulty performing activities of daily living such as cleaning, food preparation, and light lifting (Hofman et al., 2007). Likewise, CRF may also lead to severe deficits and lead to mental and emotional distress subsequently reducing overall QOL (Visser & Smets, 1998).

Depression

Depression is one of the most commonly reported emotional symptoms experienced with cancer and its associated treatments. It can be defined as the pathological response to loss of normality in one's personal world as a result of cancer diagnosis, its treatments, or side effects (Haig, 1992). This disorder affects roughly 20-47% of cancer survivors (Pirl & Roth, 1999; Zabora, Brintzenhof-Szoc, Curbow, Hooker, & Piantadosi, 2001), and occurs two to three times more frequently in the cancer population than in the apparently healthy (Dauchy et al., 2013). Not only does depression cause mental suffering, but it can also lead to decreased QOL, increased sensitivity to pain, and reduced expectation of survival from cancer diagnosis (Gagliese

et al., 2007; Satin, Linden, & Phillips, 2009; Skarstein, Aass, Fosså, Skovlund, & Dahl, 2000). Although depression negatively affects cancer survivors, it still continues to be under-diagnosed and is usually left untreated (Dauchy et al., 2013).

Quality of Life

QOL is a multidimensional concept that assesses overall functional, physical, emotional, psychological, and social well-being in relation to health (Faguy, 2013). Cancer and cancer treatments have been shown to significantly reduce overall QOL in cancer survivors, and this reduction in QOL may persist long after treatment has ended (Jansen, Koch, Brenner, & Arndt, 2010; Lee et al., 2010). The physiological and psychological side effects from treatment contribute to the overall decrease in QOL. Cardiovascular and muscular toxicities such as decreased aerobic function and muscle wasting lead to a reduced ability to complete basic activities of daily living. This can lead to depression and ultimately decreased QOL. In fact, compared to the apparently healthy population, QOL is significantly lower in cancer survivors particularly in regards to mobility, breathing, and vitality (Rauma et al., 2015). Improving QOL is paramount and should be an integral goal of cancer rehabilitation programs.

Rehabilitation as a Viable Method to Attenuate Cancer-Related Toxicities

Following the identification of the severe and diverse toxicities experienced by cancer survivors, clinicians began suggesting that rehabilitation programs may be capable of attenuating these side effects. Rehabilitation is defined as “the process of restoration of skills by a person who has had an illness or injury to regain maximum self-sufficiency and function in a normal or as near normal manner as possible” (Agnes, 2003). The advent of cancer-specific rehabilitation can be traced to one event, the National Cancer

Act in 1971 (Alfano et al., 2012). This national research program funded clinical cancer research centers and other projects in the late 1970's to investigate the rehabilitative needs and evaluate interventions established for cancer survivors to improve cancer diagnosis, treatment, and care delivery. In 1978, Lehmann et al. completed the first and largest study to assess the rehabilitative needs of a sample of 805 cancer patients from four different hospitals. The purpose was to determine what type of decrements and to what extent cancer survivors experience debilitating problems, and to establish the need for rehabilitative care. Psychological problems represented the greatest percentage (52%), with generalized weakness, difficulty performing activities of daily living, ambulation, and communication representing 35%, 30%, 25%, and 7%, respectively. Following the identification of the most common side effects experienced by the subjects, the authors sought to determine if appropriate rehabilitative care was received, and if not, identify the major barriers to patients receiving rehabilitative care. The largest of these barriers included a general lack of physician referral and familiarity with the concepts of rehabilitation and financial support. To address this, the authors proposed an interdisciplinary model with both an educational and a rehabilitative component.

This type of approach to cancer rehabilitation was standard throughout the 70's, 80's, and 90's, with most programs existing in large community or university hospitals with inpatient care given by a multidisciplinary team of healthcare professionals consisting of oncologists, physicians, physiatrists, social workers, physical therapists, and other medical personnel (DeLisa, 2001; Harvey, Jellinek, & Habeck, 1982). These programs depended upon the facility and medical personnel available, and the level of coordination between services. The care was diverse, yet highly specific as success was

measured only by improvements in basic activities of daily living such as ambulation, food preparation, bathing, etc. (Harvey et al., 1982; Marciniak, Sliwa, Spill, Heinemann, & Semik, 1996; O'toole & Golden, 1991; Yoshioka, 1994). This model of cancer-specific rehabilitation is no longer prevalent and has lost relevance, which raises the question, what has changed?

The largest contributing factors to the changes in patient care revolve around improved prognosis and enhanced survivability. Improvements in detection, diagnosis, and advancements in treatment have led to vastly different side effects and patient needs. For example, the radical mastectomy and reconstructive flap procedures were common in the 80's and early 90's. Now breast conserving surgeries are the standard of care, with reductions in axillary dissection to preserve lymph node function (Alfano et al., 2012). This has led to a lessened need for specialized and advanced hospital-based rehabilitation and ultimately a diminished use of the multi-disciplinary approach to patient care.

There is now a disconnect and misunderstanding between what clinicians and healthcare providers refer to as "cancer rehabilitation." One thought is that because cancer survivors still suffer from a myriad of complex disabilities, a single or unidimensional approach cannot treat the varying limitations (Alfano et al., 2012; Silver et al., 2015). Whereas, proponents of the unidimensional approach suggest that a single method can be the cornerstone of care if the effects are profound and can affect the majority of cancer survivors. The most promising single method of rehabilitation is structured exercise. The role of exercise intervention as a complementary therapy has been well documented and unlike other methods, has the capacity to act across multiple body systems to attenuate cancer-related toxicities (Lakoski et al., 2013; Schmitz et al.,

2010; Schneider et al., 2002). Through this belief, the Rocky Mountain Cancer Rehabilitation Institute (RMCRI) was developed by Dr. Carole Schneider in 1996 to advance the quality of life of cancer patients during and following treatment through prescriptive exercise rehabilitation (Schneider et al., 2002). The name RMCRI has since been changed to "University of Northern Colorado Cancer Rehabilitation Institute" or "UNCCRI" and will hereafter be referred to as such.

Benefits of Exercise on Cancer and Treatment-Related Side Effects

Exercise has been established as a successful method for primary and secondary disease prevention in multiple clinical settings (Warburton et al., 2006) and is an essential mode of rehabilitation for the improvement of both physiological and psychological side effects in cancer survivors. In 2010 an American College of Sports Medicine (ACSM) roundtable of experts reported that the psychological and physiological challenges faced by cancer survivors can be prevented, attenuated, treated, or rehabilitated through exercise and that physical inactivity should be avoided following diagnosis (Schmitz et al., 2010). Cancer survivors who exercise on a regular basis during or after treatments experience significant increases in cardiorespiratory fitness, psychological well-being, and QOL compared to those who are inactive (Brown, Huedo-Medina, et al., 2012; Dimeo et al., 1997; Murnane, Geary, & Milne, 2012).

The cardiorespiratory system may see some of the most significant improvements due to exercise. Aerobic exercise can protect the heart against damage caused by oxidative stress, which may offset some of the cardiovascular toxicities caused by treatments. Exercise can result in improved cardiac output, stroke volume, and increased arteriovenous oxygen difference and unloading of oxygen, which may lead to an increase

in functional capacity (Kim, Kang, Smith, & Landers, 2006; Schneider et al., 2007b). In fact, a single bout of acute endurance training twenty-four hours before receiving chemotherapy preserves left ventricular systolic pressure and attenuates the chemotherapy-induced decline in left ventricular developed pressure (Wonders, Hydock, Schneider, & Hayward, 2008). Additionally, the maximum volume of oxygen consumed (VO_{2max}), which is the gold standard of the measurement of aerobic capacity, has been shown to improve between 2-40% after an aerobic exercise program in cancer survivors (Garner & Erck, 2008; Jones et al., 2011; Kim et al., 2006; Klika, Callahan, & Drum, 2009; Marulli et al., 2010; McNeely et al., 2010; Schneider et al., 2007b).

Exercise improves the pulmonary system by strengthening the respiratory and intercostal muscles and by improving cellular respiration (Zolaktaf, Ghasemi, & Sadeghi, 2013). Increases in pulmonary function are evidenced by improvements in percent of forced expiratory volume, forced vital capacity, and overall lung function during and following treatment (Marulli et al., 2010; Schneider et al., 2007b). Additionally, pulmonary rehabilitation with a mixed low-intensity cardio and strength training intervention has been demonstrated to reduce expiratory flow limitations and hyperinflation of the lungs at rest (Yoshimi et al., 2012).

Muscle wasting in cancer survivors has many contributing factors, with increased protein degradation and decreased protein synthesis being primary causes. Resistance training directly attenuates cachexia by increasing protein synthesis via the mTOR pathway, which promotes levels of insulin-like growth factor-1 and mechanical growth factors (Miyazaki & Esser, 2009; Zanchi & Lancha Jr, 2008). Clinically, strength training has been shown to significantly increase muscular strength, endurance, and

power (Kraemer & Ratamess, 2004). After a six-month exercise intervention that consisted of aerobic, resistance, and flexibility training, cancer survivors improved upper-body and lower-body endurance by 47% and 67%, respectively (Schneider et al., 2007a). In similar studies, cancer patients have increased upper-body and lower-body strength by 41% and 96%, respectively (Galvão, Taaffe, Spry, & Newton, 2007), and a combined regimen of aerobic and resistance training significantly improved leg press strength, sit-to-stand test results, and overall QOL (Herrero et al., 2006). These improvements in protein synthesis, muscle cell mass, muscular strength, and muscular endurance increases the ability to perform activities of daily living which is directly related to improvements in QOL for cancer survivors, as (Zinna & Yarasheski, 2003).

In addition to increasing cardiovascular endurance, pulmonary function, and muscular strength, immune function may also increase due to exercise. The immune system consists of many complex cells, such as natural killer cells and cytotoxic T lymphocytes, to combat diseases (Nieman et al., 1990). These cells have been known to increase by as much as 150-300% after exercise (Nieman, 1994). Clinically, a 6-month exercise intervention in breast cancer survivors found that physical activity increased lymphocyte activation of T helper cells, concluding exercise may improve immune function in cancer survivors by increased lymphocyte activation (Hutnick et al., 2005).

Exercise will not only improve physiological variables, but will also improve psychological variables such as fatigue, depression, and QOL. Fatigue is the most common side effect experienced by cancer survivors, with approximately 70-100% of the population reporting some level of fatigue (Cramp & Byron-Daniel, 2012). Exercise interventions have resulted in a 32 to 39% decrease in fatigue scores (Schneider, 2013),

and cancer survivors who are physically active have significantly reduced levels of fatigue when compared to sedentary controls (Brown, Huedo-Medina, et al., 2012; Carayol et al., 2013; Puetz & Herring, 2012). Improvements may also be seen in depression scores. Survivors who exercise during treatment as well as following treatment report decreases in depression by 43% and 25%, respectively (Schneider et al., 2007b). Perhaps most importantly, QOL is shown to increase with exercise. Cancer survivors who exercise at least three times a week experience significantly higher QOL values than those who are inactive (Blanchard et al., 2003). Similarly, it has been well documented that survivors who are undergoing treatment or have completed treatment experience significant improvements in QOL following an exercise intervention (Buffart et al., 2014; Cheema & Gaul, 2006; Courneya et al., 2005; De Backer et al., 2007; Mishra et al., 2015; Murtezani et al., 2014; Ohira, Schmitz, Ahmed, & Yee, 2006; Zeng, Huang, Cheng, Zhou, & So, 2014).

Exercise and physical activity yield significant positive effects and attenuate many toxicities affecting the physiological and psychological function of cancer survivors. Specifically, exercise can benefit the cardiovascular, pulmonary, musculoskeletal, and immune systems while concomitantly improving psychological variables such as fatigue, depression, and quality of life. With this knowledge, it becomes increasingly clear that exercise is a viable mode of cancer rehabilitation.

In Versus Out of Treatment

During treatment cancer patients experience different and more severe side effects than they do following treatment. For this reason, the effectiveness of exercise interventions are thought to differ between patients with different treatment statuses.

Likewise, the safety of exercise has been questioned for those in treatment (Watkins, 1950). For cancer survivors in treatment, the longevity of side effects will vary from person to person. Most side effects typically end once cancer treatments conclude, as healthy cells recover over time (American Cancer Society, 2015). Some side effects, such as cardiovascular toxicity, may last months or even years following the completion of treatment (Yeh et al., 2004). Additionally, some studies have observed fatigue to be prevalent in patients up to eight years following treatment (Wu & McSweeney, 2007). Although cancer survivors who have completed cancer treatments may still experience some lingering side effects, those who are still undergoing treatments experience the worst degree of physiological and psychological toxicities. There are very few studies that compare side effects experienced in patients receiving treatment against side effects experienced once treatment is completed. However, one study documented these effects. It was observed that those who were still completing treatment experienced more severe fatigue, memory loss, nausea, sleep problems, concentration difficulties, weight loss problems, and shortness of breath than those who were post treatment (Sprod et al., 2011).

Although the severity of side effects may differ depending on treatment status, exercise still remains a safe and viable option of rehabilitation both during and following treatment. Exercise has been shown to be beneficial for patients who are still undergoing chemotherapy or radiation. Breast cancer survivors who exercise show significant increases in functional ability, decreased fatigue, and decreased weight gain during cancer treatments (Schwartz, 1999; Schwartz, Mori, Gao, Nail, & King, 2001). When comparing patients who exercised during treatments to those who were sedentary, those

that exercised maintained pre-chemotherapy VO_{2max} levels, while those that were sedentary experienced a decline in VO_{2max} (Al-Majid, Wilson, Rakovski, & Coburn, 2015). Correspondingly, survivors who exercised during treatment regimens reported significantly decreased memory problems, concentration difficulties, weight loss, and shortness of breath compared to those who were not physically active (Sprod et al., 2011). Physiologically, systolic blood pressure, diastolic blood pressure, hand grip strength, upper and lower body strength, and time on treadmill have been observed to significantly improve even during treatment as a result of an exercise intervention. Likewise, improvements in psychological values such as total fatigue improve with exercise (Schneider et al., 2007b). Survivors who have completed cancer treatments experience similar results. Systolic blood pressure, diastolic blood pressure, resting heart rate, hand grip strength, overall muscular strength, flexibility, depression, QOL, and total fatigue have been observed to significantly improve following exercise (Schneider et al., 2007b; Sprod et al., 2011).

Generation of Cancer-Specific Exercise Guidelines

Exercise and physical activity has been established as a crucial part for a cancer survivor's recovery (Schmitz et al., 2010). However, standardized exercise guidelines for cancer survivors do not exist. Current ACSM guidelines for the apparently healthy adult population recommend at least 150 minutes of moderate intensity cardiorespiratory exercise per week. These recommendations can be met by completing 30-60 minutes of moderate intensity exercise five days per week, or 20-60 minutes of vigorous intensity exercise three days per week. Additionally, adults should perform resistance training for each major muscle group two to-three days per week, with the reps and sets varying

depending on each individual's goals (ACSM, 2013). The most recent ACSM cancer exercise roundtable concluded that although physical activity should be incorporated, exercise guidelines were variable and were dependent on the type of cancer. It was suggested that patients and clinicians refer to the United States Department of Health and Human Services (US DHHS) Physical Activity Guidelines (Schmitz et al., 2010).

The US DHHS Physical Activity Guidelines and the American Cancer Society recommends 150 minutes of aerobic exercise each week at a moderate intensity, or 75 minutes per week of vigorous-intensity aerobic activity (Rock et al., 2012; Tucker, Welk, & Beyler, 2011). Similar to ACSM's recommendations, they also suggest performing resistance training at a moderate or high intensity that involves all major muscle groups at least two times a week (Tucker et al., 2011). While it is generally agreed upon that maintaining and improving muscular strength and cardiovascular endurance is important during and following treatment in cancer survivors, most recommendations regarding exercise refer to age appropriate apparently healthy recommendations, with slight modifications. For example, cardiovascular recommendations for both breast and prostate cancer survivors informs the clinician to be aware of an increased potential risk for fractures, and when prescribing resistance training for prostate cancer survivors, pelvic floor exercises should be used (Schmitz et al., 2010). However, researchers have suggested that recommendations for the apparently healthy may not be applicable for cancer survivors, as they are too intense (Kuehl et al., 2015; Scharhag-Rosenberger et al., 2015). Overall these recommendations are very broad and will differ from patient to patient, which makes the establishment of cancer-specific exercise guidelines difficult.

Cancer-Specific Exercise Interventions and Cancer Rehabilitation Programs

The number of cancer survivors continues to increase every year due to advancements in diagnosis and treatment. Exercise training is a profound therapy that has the capacity to positively affect multiple systems and reduce most debilitating side effects. Organizations such as ACSM, the American Cancer Society, and the World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) have established some forms of exercise guidelines for cancer survivors that can give guidance without the support of a dedicated cancer rehabilitation program. However, rehabilitation options for cancer survivors are scarce. Surveys have addressed the level of gratification of current rehabilitative services and issues that have been unmet. The most wanted services that were reported as universally unavailable consisted of physical training, physical therapy, psychological counseling, and occupational therapy. As many as 63% of cancer survivors reported a need for at least one of these services, while 40% stated that none of their rehabilitation needs were being met (Thorsen et al., 2011). Additionally, 75-85% of cancer survivors indicated an interested in physical activity and exercise programs and guidelines (Jones & Courneya, 2002; Stevinson et al., 2009).

Following the creation of UNCCRI, other cancer rehabilitation programs are beginning to emerge in businesses and hospital settings, such as the Young Men Christian Association's gyms and in cardiac rehabilitation clinics (Dittus et al., 2015). Of note, these new programs are not specifically and judiciously structured and lack clear methodology. Most do not provide the appropriate assessment, prescription, and interventions needed to directly target the toxicities caused by cancer treatments (Schneider et al., 2002). Finally, there is still no clear method of exercise prescription for

the cancer population that takes treatment status and placement on the cancer continuum into account and supports the findings with scientifically based evidence

Cancer-Specific Exercise Prescriptions

Exercise prescription refers to specific exercise guidance prescribed for an individual that is designed for a specific purpose or purposes. In cancer rehabilitation, the exercise prescription is the design of a rehabilitative exercise program for the cancer survivor and may or may not have physician approval. Exercise prescriptions should have at least these three primary objectives (ACSM, 2013): 1) to increase physical fitness, 2) to improve health by reducing the risk factors for chronic disease, and 3) to ensure safety during exercise (Brown, Hash, & Lyons, 2001). These are especially important to a cancer survivor, as many have decreased fitness levels (Tisdale, 2009; Yeh et al., 2004) and more risk factors due to cancer and the concurrent treatments (Schneider et al., 2002; Schneider et al., 2007b). Additionally, there is an increased susceptibility for falls and/or injury in the cancer population (Stone, Lawlor, Nolan, & Kenny, 2011; Winters-Stone et al., 2011). For these reasons, inaccurate prescriptions can lead to dangerous situations and can compromise a patient's health (Brown et al., 2001)

Proper exercise prescription in cancer survivors includes two distinct components. The first essential prerequisite is detailed medical and cancer screening and comprehensive physiologic and psychologic assessment (Sasso et al., 2015; Schneider et al., 2002). The exercise prescription should be individualized according to a cancer survivor's treatment status, medical comorbidities, aerobic fitness, muscular strength and endurance fitness, and negative effects of treatments experienced at any given time (Schmitz et al., 2010).

Second, the exercise prescription should apply the principles of exercise training: individuality, specificity, progressive overload, rest/recovery, diminishing returns, and reversibility (Campbell et al., 2012; Sasso et al., 2015). The principle of individuality, which can be thought of as the customized application of training mode and intensity towards the physiological status of the patient, is the most integral, as individual response to exercise, rate of development, and program structure will differ for every patient (Brown et al., 2001). The principle of specificity states that the prescribed exercise must be specific and target the designated system(s) or pathway(s) to achieve the desired result (e.g., aerobic exercise to affect the cardiovascular system). This is particularly relevant in cancer rehabilitation, as the goal is to alleviate treatment toxicities affecting specific systems. Progressive overload alters the *frequency, intensity, time* and *type (FITT)* of exercise so that the body and targeted organ systems are overloaded beyond equilibrium. This overload results in biological stress and overcompensation, wherein the body can withstand greater future stress. Repeated bouts of overload lead to further enhancements of the system. The principle of progressive overload is of the utmost importance in the creation of appropriate exercise prescriptions. If the prescription does not result in overload, physiological adaptations will not occur, however, if the exercise dose results in chronic overload without rest, patients may experience increased fatigue, injury, and myelosuppression thereby increasing the susceptibility to illness. The principles of diminishing returns and reversibility have yet to be adhered to consistently in the cancer population. Diminishing returns refers to the thought that continued physiological improvements will begin to lessen as training continues and will cease once a patient's "genetic ceiling" has been reached. Reversibility refers to the concept that the cessation

of exercise will result in a reduction and eventual loss of the physiological adaptations achieved by exercise.

Despite knowledge of the importance of medical screening, assessment, and adherence to the principles of exercise training, implementation of current exercise guidelines into clinical practice and the successful creation of exercise prescriptions for cancer patients is challenging. Similarly, ACSM's recommendations often are unusable in the creation of exercise prescriptions due to the general lack of data and relatively broad guidance (Wolin, Schwartz, Matthews, Courneya, & Schmitz, 2012).

Due to unclear or vague guidelines regarding exercise for cancer survivors, many clinicians are left to use their past experience to progress a patient through their exercise intervention, sometimes without the creation of an appropriate exercise prescription. Of great concern, it appears that clinicians and programs are neglecting the principles of exercise and thus limiting the positive outcomes of an exercise program. Maintaining these principles ensures the most appropriate type and dosage of exercise to obtain desired results. In studies involving exercise interventions for cancer survivors, many fail to adhere to the principles of exercise training. In a recent analysis by Campbell et al., (2012), only 41% and 31% of programs adhered to the principles of progression and overload, respectively, and only 3% to the principles of diminishing returns and reversibility. Additionally, many of these studies failed to report the components of the exercise prescription being used. Thirty-four percent of the studies evaluated failed to report all components of the prescription and as a result these studies have yielded unreproducible results (Campbell et al., 2012). Although there is a plethora of research investigating exercise and cancer rehabilitation, the lack of appropriate medical screening

and assessment compounded with the failure of programs and interventions to adhere to the principles of exercise training has resulted in the absence of a clear and standardized method of cancer-specific exercise prescription.

The University of Northern Colorado Cancer Rehabilitation Institute's program has been the only rehabilitation model to date, that has consistently and from its inception complied with the first essential component of exercise prescription. Entry into the program begins with physician referral, cancer and medical screening, and assessment of initial physiologic and psychologic values. The exercise prescription is then created with a focus on the patient's treatment status, medical information, and assessment results. In UNCCRI's earliest model, patients were divided based on if they were currently in or following treatment, and changes to the exercise prescription were determined by the changes in treatment status. Only the principle of progression is mentioned in this model, however the application is unclear, as the rate of progression during the exercise intervention is based on the aforementioned criteria and is only referred to as "slow". Recommended starting intensities were suggested based on health status. Those who were sedentary or in poor health began exercise at an intensity of 30%-40% heart rate reserve (HRR), while those who were active or in moderate health began at 50%-60% HRR (Schneider et al., 2003; Schneider et al., 2002). Regardless of the lack of recognition and adherence to the principles of exercise training, this program has yielded the largest dataset and greatest amount of literature demonstrating the model's effectiveness at attenuating treatment-related side effects in cancer survivors (Hydock et al., 2012; Schneider et al., 2003; Schneider et al., 2002; Schneider et al., 2007a, 2007b; Schneider, 2013; Sprod et al., 2011; Sprod, Hsieh, Hayward, & Schneider, 2010;

Wonders et al., 2008). The violation of the principles of exercise do not appear to affect this model's effectiveness during the first 3-to-6 months of the exercise intervention. However, long-term analysis of this program's results have demonstrated a decline and plateau in improvements observed in measures of cardiovascular endurance and muscular endurance. In fact, after an initial 13% and 32% improvement in cardiovascular and muscular endurance, respectively, following 3-or-6 months of the program, both variables proceeded to plateau or decrease by reassessment at 21 months. This final reassessment represented the end of the rehabilitation intervention, however the majority of patients still fell into the poor or well below average classifications of cardiovascular endurance. It was suggested that the exercise prescription and intervention failed to properly utilize the principle of progressive overload to ensure continual progression throughout the intervention (Brown, Lalonde, et al., 2012). To address this issue, UNCCRI redesigned the process of exercise prescription to ensure all components are met and the principles of exercise training are prominent and adhered to throughout.

Creation of the Phase Training Model of Cancer Rehabilitation

To date, there exists no standardized model of exercise-based cancer rehabilitation and no program has effectively maintained all essential components of exercise prescription in the cancer population (Campbell et al., 2012; Sasso et al., 2015; Schmitz et al., 2010). Specifically regarding the exercise prescription there are no consistent or set guidelines on what intensity a cancer survivor should be exercising at in relation to placement on the cancer continuum and in regards to diagnosis, treatment status, or assessment results. There are however, suggestions on exercise training based off intensity classifications. Low exercise intensities have ranged from 25-50% HRR,

moderate intensities from 35-66% HRR, vigorous intensities from 58-85% HRR, and near-maximal intensities $\geq$ 90% HRR (Heinrich et al., 2015; Kuehl et al., 2015; Scharhag-Rosenberger et al., 2015; Schneider et al., 2003). However, there are no guidelines on when cancer survivors should perform each intensity classification or what data would guide the clinician to alter the prescription. The proposed Phase Training Model establishes set exercise guidelines and intensities in relation to placement on the cancer continuum, status of treatment, medical information, and data collected from an initial assessment. This model is divided into distinct sections which represent patients who differ based on the aforementioned criteria.

CHAPTER III

METHODOLOGY

Subjects

Data obtained from patients participating in the UNCCRI cancer rehabilitation program between the years 2012-2016, and following implementation of the Phase Training Model were used. Participants were male and female cancer survivors over 18 years of age who were undergoing or had completed surgical intervention, chemotherapy, radiation therapy, immunotherapy, hormonal therapy, stem cell, gene, or bone marrow transplantation, and/or other types of unconventional treatment. Safety of the participants was ensured throughout all data collection, exercise testing, and exercise training. All cancer survivors were cleared to participate in an exercise program through a referral completed by each individual's oncologist or physician, and a detailed medical and cancer history for each participant was faxed with each referral. Prior to any data collection, all participants were informed that they were volunteers and can terminate their involvement in the program at any time. An informed consent (see Appendix A) was provided. Each subject, following a thorough explanation of the program, signed the consent form and agreed to participation. All protocols used for the study were approved by the University of Northern Colorado's (UNC) Institutional Review Board (see Appendix B). All data collected and all exercise testing and training took place at UNCCRI on the University of Northern Colorado's campus in Greeley, Colorado.

Experimental Design

The purpose of this study was to evaluate the effects of the UNCCRI Phase Training Model on cardiorespiratory endurance, muscular strength, and cancer-related fatigue in cancer survivors during the transition from each Phase and in those who have completed the entire UNCCRI Phase Training Model.

All participants' data were obtained from initial assessments and subsequent reassessments while participating in the Phase Training Model. The Phase Training Model of cancer rehabilitation utilizes a four Phase approach with assessments of physiological and psychological variables conducted at each assessment. Participants performed initial assessments upon entering the program and completed reassessments every 12 weeks until four reassessments had been completed. Each reassessment marked the completion of that specific Phase and subsequent entry into the next. The order of initial assessments and reassessments is graphically represented in Figure 1.

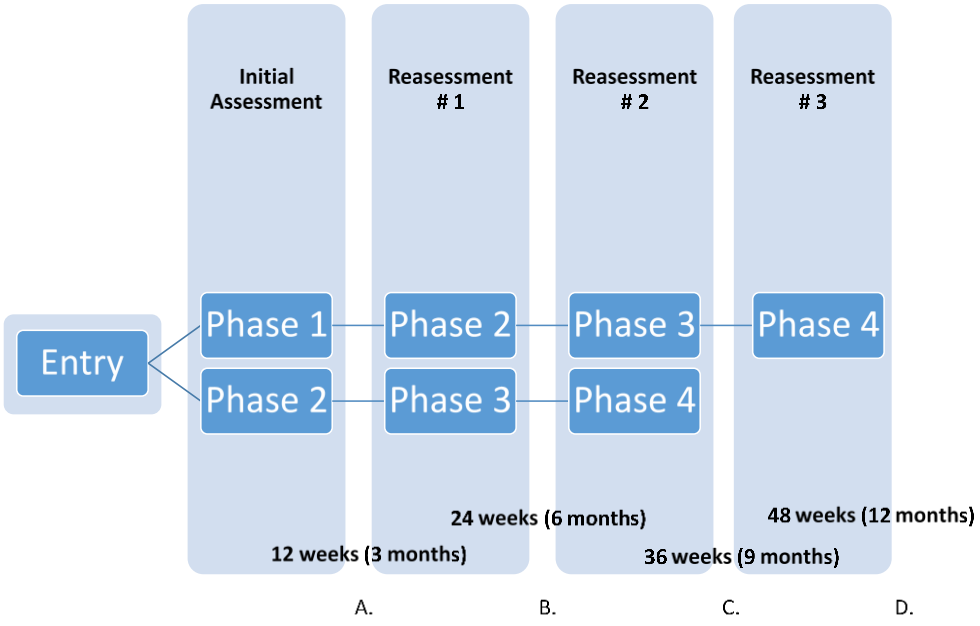

Figure 1. Initial assessments and the corresponding reassessments

Entry into the program depended on the patients' treatment statuses (allowing entry as Phase 1 or Phase 2), and thus altered the length of program completion. Phases 1 through 3 were considered "true cancer rehabilitation", and the program was marked as completed once the patient had entered Phase 4. However, continued reassessment took place as patients continue the Phase Training Model in Phase 4 and was referred to as personal training. Patients who entered the program as Phase 1 completed the program in 36 weeks, while those who entered as Phase 2 completed the program in 24 weeks. The points, A, B, C, and D in Figure 1 represent specific time points of data collection in the Phase Training Model. Each point represents the entry and subsequent transition from one Phase to the next.

A. **Phase 1 to Phase 2**: Patients entering the program as Phase 1. This marks the entry into and completion of Phase 1. Subsequently this marks the entry into Phase 2.

   Phase 2 to Phase 3: Patients entering the program as Phase 2. This marks the entry into and completion of Phase 2. Subsequently this marks the entry into Phase 3.

B. **Phase 2 to Phase 3**: Patients have completed the first reassessment marking completion of Phase 2 and the subsequent transition into Phase 3.

   Phase 3 to Phase 4: Patients have completed the first reassessment marking completion of Phase 3 and the subsequent transition into Phase 4. The program has been completed.

C. **Phase 3 to Phase 4**: Patients have completed the second reassessment marking completion of Phase 3 and the subsequent transition in Phase 4. The program has been completed.

D. **Phase 4 to Phase 4**: Patients have completed the second reassessment and are still in Phase 4.

All procedures, assessments, and measurements were conducted by trained Cancer Exercise Specialists (CES) and were overseen by the UNCCRI Clinical Coordinator.

Preliminary Paperwork and Patient Screening

Following participant referral and signing of the informed consent, each participant was asked to complete questionnaires evaluating psychological functioning, lifestyle, behavior, and medical information. The questionnaires included: a Lifestyle/Activity Evaluation (Appendix C), a Medical History (Appendix D), the Revised Piper Fatigue Scale (Appendix E), the Beck Depression Inventory (Appendix F), and the Ferrans and Powers Quality of Life Index Version III (Appendix G). All questionnaires were completed prior to assessment.

Lifestyle/ Activity Evaluation: This questionnaire evaluated the participants' personal lifestyle choices regarding smoking, drinking, sleep, physical activity, and diet. *Medical History:* Participants' medical information was obtained via this self-reported worksheet detailing present medical history, family medical history, medications, allergies, and cancer diagnosis. If needed, further medical information was requested from the participants' oncologist or primary care physician.

The Revised Piper Fatigue Scale: Fatigue was measured via the Piper Fatigue Inventory, which evaluates total cancer-related fatigue, as well as subscales of fatigue

such as affective, behavior, cognitive, mood, and sensory. These individual subscales comprise 22 points with the average score representing total fatigue. The scale ranges from 0 to 10. A score of 0 indicates that the participant shows no sign of fatigue, a score from 1 to 3 indicates mild fatigue, 4 to 6 indicates moderate fatigue, and a score of ≥7 indicates severe fatigue (Piper et al, 1998).

Beck Depression Inventory: This inventory is a valid and reliable (Vodermaier, Linden, & Siu, 2009) 21 question index that assessed symptoms such as, but not limited to hopelessness, feelings of being punished, weight loss, and guilt. Higher scores indicate greater depression with 0 indicating no depression and >40 indicating extreme depression.

Ferrans and Powers Quality of Life Index Version III: This 66-question questionnaire is designed to evaluate social, psychological, family, and health satisfaction as well as total QOL. Higher scores indicate greater satisfaction in QOL (Ferrans & Powers, 1985).

Prior to the initial assessment and each subsequent reassessment, a detailed medical and cancer screening was recorded on the Client Summary form (see Appendix H). The Client Summary listed all pertinent cancer information, treatments, surgeries, medications, current health status, and personal patient goals.

Phase Training Model: Assessment Protocols

Initial assessments occurred prior to the creation of the exercise prescription and exercise intervention. Reassessments occurred after each 12-week exercise intervention and every 12 weeks until four consecutive reassessments had been completed. Each assessment included the measurement of vitals, body composition, functional

assessments, balance, pulmonary function, cardiovascular endurance, muscular strength and endurance, and flexibility and range of motion (ROM). The results from the assessment protocols were recorded on the Data Collection Sheet for the corresponding Phase (see Appendices I-K).

Vital Measurements

Prior to any exercise testing and throughout all physical activity, participants' heart rate, oxygen saturation (SPO_2), and blood pressure were assessed via a heart rate monitor with chest strap (Polar, Inc. Lake Success, NY), pulse oximeter, and sphygmomanometer and stethoscope, respectively.

Body Composition

Body fat was first assessed via the three-site skinfold (SKF) test (Jackson & Pollock, 1978; Jackson, Pollock, & Ward, 1979) by using skinfold calipers. The three-site SKF locations for men were: the chest, abdomen, and thigh. The three-site SKF location for women were: the tricep, supraliliac, and thigh. Two measurements, in a rotational order, were taken; a third was taken at any site that differed by more than 2 millimeters. Waist-to-hip ratios were measured. A tape measure was utilized to measure the narrowest and the widest part of the lower thoracic region to obtain a waist and hip measurement, respectively. Body fat was also taken using a bioelectrical impedance machine (InBody 770, Cerritos, CA.). The InBody 770 machine involved the subject standing on a scale platform for no longer than one minute while holding a sensor in each hand.

Functional Assessments

The anatomical plumb line and the National Academy of Sports Medicine (NASM) overhead squat assessment were used to assess any functional deviations. For the anatomical plumb line test, the participant was instructed to stand as straight as possible against a door frame or any straight vertical line against a wall. The participant was then viewed anteriorly, posteriorly, and from the sagittal plane. From each view, any irregularities in posture or stance, such as shoulder elevation or depression were documented.

For the NASM squat test, the participant was asked to squat between one to five seconds while holding his or her arms above the head. This was repeated two to three times, as the participant was viewed from the anterior, sagittal, and posterior planes. Any deficiencies from a normal squat, such as a rounded back, were noted.

Balance

A Bertec BalanceCheck Screener™ (Bertec) (Bertec Corporation, Columbus, OH.) was used to assess balance. Height was obtained before the balance assessment using an InBody Stadiometer (InBody, Cerritos, CA.). The Bertec used a series of tests to assess the subject's ability to maintain balance while standing on a stable surface and an unstable surface. The subject stood as still as possible with feet placed so that the medial malleolus of each ankle lined up with a designated line on the Bertec force plate. The first test required the subject to stand as still as possible with his or her eyes open; the second test required the eyes to be closed. Two similar tests were administered with the participant standing on an unstable, foam surface. A limits of stability test was also performed, in which the subject moved dynamically, as far as possible, towards the front,

back, left, and right with movement occurring from the subtalar joint of the ankle. The subject returned to the center position before completing each direction. Scores were recorded at the conclusion of all the tests.

Pulmonary Assessment

Participants' pulmonary function was evaluated using a spirometer (Spirolab III MIR, Rome, Italy). Before the test was conducted, participants were given nose plugs to wear and were instructed to place a disposable mouthpiece in the spirometer. The participant was instructed to form a tight seal on the mouthpiece and blow into the spirometer as forcefully and for as long as possible. Prior to the test, the participant was asked to take a couple of deep breaths in and out before giving a final effort. This test was performed twice, and if there was variance greater than 5% between the two tests, a third test was administered. The highest values of force vital capacity (FVC) and forced expiratory volume (FEV1) were recorded.

Cardiovascular Endurance Assessment

Cardiovascular endurance was evaluated using the cancer-specific UNCCRI Treadmill Protocol which yields VO_{2peak} values. This protocol was found to be the most accurate and appropriate for the cancer population (Shackelford, 2015). The goal of this test was for the participant to reach self-perceived maximal exertion or fatigue. The highest measurement of oxygen consumption was calculated. This protocol consists of one minute stages, which increase speed and/or incline at the conclusion of every stage. During the test, heart rate (HR) and oxygen saturation (SPO_2) was collected at the end of every minute. Blood pressure (BP) was recorded at the end of every three minutes, as well as the participant's rating of perceived exertion (RPE) on the modified Borg Scale.

This RPE scale consists of numbers 0-10 which correlates to the perceived intensity of the test. A RPE of 0 correlates with the intensity of a stroll in the park, and a RPE of 10 signifies the patient has reached his or her maximal effort and cannot continue. The use of handrails was discouraged, but was allowed if deemed necessary. Handrail usage must stay consistent throughout the test. Termination criteria of the test were: participant reached volitional fatigue or asked to stop for any reason, failure to increase systolic BP or HR with increased intensity, fluctuation of more than 10 mmHg from resting measures in diastolic BP, or oxygen saturation drops below 80 on the pulse oximeter. Once the testing ended, each subject completed a cool-down period, where all of the aforementioned variables were measured in the same manner as during the test. Final treadmill time, BP, HR, and RPE was recorded. Peak volume of oxygen consumption was estimated using ACSM's walking and running equations, which have been found to be valid in determining VO_{2peak} (Shackelford, 2015).

Muscular Strength Assessment

Muscular strength was assessed via the estimated one-repetition maximum protocol (EST 1-RM) using the Brzycki equation. This test used Cybex Eagle resistance machines (Cybex Inc., Medway, MA.), and specifically utilized the following machines: chest press, lat pulldown, seated row, shoulder press, leg press, leg curl, and leg extension. The goal of this test was to have the participant lift as much weight as possible between one and ten repetitions. RPE values were asked at the end of every set. The test was performed in six steps. (1) Before the participant began the test, the CES demonstrated how to perform each machine correctly with proper form, and adjusted the machine to ensure a proper fit for each participant. (2) The participant was then asked to

perform a warm-up set, which consisted of five repetitions at a low intensity. (3) After the warm-up set, the weight was increased accordingly to elicit muscular failure or fatigue between 1 and 10 repetitions. (4) The participant then attempted to lift the weight deemed appropriate to elicit failure between 1 to 10 repetitions. (5) If the weight appeared to be too light to elicit failure between 1 to 10 repetitions, the set was stopped immediately and the weight increased. If the weight was too heavy for even one full repetition, the weight was reduced accordingly. (6) Finally, after a 2 to 3 minute rest, steps 4 and 5 may have been repeated up to two times per machine to elicit a weight that resulted in muscular fatigue between 1 and 10 reps. The EST 1-RM values, as kilograms (kgs) lifted, were recorded for each machine. The leg and chest press values were then divided by the patient's body weight, both in kgs, to yield a strength-to-weight ratio for each machine.

Handgrip strength was measured using a handgrip dynamometer (Takei Scientific Instruments Co., LTD., Niigata City, Japan). The handgrip size was adjusted accordingly for every individual. The participant was asked to hold the dynamometer by his or her side with the dial facing away from the body. They were then instructed to squeeze the dynamometer as hard as possible until told to stop (about two to five seconds) without moving or swaying the arm. This was done three times for each hand, alternating hands between each attempt. The highest values for each hand were recorded.

Muscular Endurance Assessment

Muscular endurance of the core and lower body were measured via the plank test and the chair squat test, respectively. The plank test required the patient to begin in a prone position on his or her hands and knees. They were then instructed to transition

from the hands to the forearms, and to extend the legs so they were on their toes. They were instructed to hold their hips in a neutral spine for as long as possible, or up to a maximum of 60 seconds. The final time was recorded in seconds.

To administer the chair squat test, a chair was positioned against a wall directly behind the patient. The patient was instructed to cross his or her arms across the chest and to squat down into the chair so that the buttocks briefly touched the seat of the chair. As soon as they touched the chair they were instructed to return to the standing position. The participant continued to do this until physical exhaustion was achieved, the cadence of movement slowed, or the maximum time of 60 seconds was reached.

Flexibility and Range of Motion Assessment

The modified sit-and-reach (SR) test, back scratch test, and reaching tests were used to assess flexibility and range of motion. For the modified SR test, the participant was instructed to sit on the floor with his or her shoulders, head, and hips against a wall. The legs were extended in front of them, with their feet flat against a 12-inch SR box. The participant then extended his or her arms out, with one on top of the other. The end of the arm of the SR box was positioned so it was at the end of the participant's fingertips. The participant was instructed to bend forward at the hips and slide the fingertips along the arm of the SR box until no further extension was possible. The value was recorded in centimeters. This procedure was conducted two additional times, and the highest value recorded.

The back scratch test required the patient to reach up and behind their back with the dominant hand, palm facing the back. They were asked to reach the other arm down and behind the back as far as possible, with the palm facing away from the back. Both

wrists were kept as straight as possible. The distance between each middle finger was used as landmarks and the distance in centimeters recorded. If the fingertips touched without overlapping, the score was recorded as zero centimeters. If they did not touch, the score was recorded as a negative value in centimeters, and if they overlapped it was recorded as a positive value in centimeters.

For the reaching tests, the participant was asked to reach as far as possible with both arms in the anterior plane, and then the sagittal plane. Arms were kept as straight as possible. The highest score in each plane (anterior: 1 to 4; sagittal: 1 to 8) was recorded.

Phase Training Model: Exercise Prescription

Exercise prescription took place following the assessment and was created using the Client Overview document (see Appendix L). The Client Overview indicated the Phase the participant is stratified into, the starting target intensity of both the aerobic and resistance training components of the program, and the rate of progressive overload prescribed during the 12 weeks for each subject. The participant screening, which was recorded on the Client Summary, and the data collected from each assessment protocol, which was recorded on the Data Collection Sheet, were used together to create the exercise prescription for each participant. Specifically, the treatment status (during versus following) and the types of treatment received dictated the Phase the client entered the program in. If the subject was currently undergoing chemotherapy and/or radiation therapy, he or she was placed in Phase 1. If treatment had ended at entry into the program or if the subject underwent surgical intervention and/or other treatments (hormonal, immune, etc.), he or she was placed in Phase 2. The assessment results and specifically the classifications achieved by the participant during each assessment were

utilized to begin the process of selecting the appropriate target intensity of the intervention. For example, if the subject performed very poorly on the UNCCRI Treadmill Protocol and yielded a classification of low in cardiovascular function when compared to other cancer survivors, this indicated a prescription at the lowest end of the Phase recommendations for HRR was needed. Likewise, if a subject performed well on the EST 1-RM protocol and achieved a strength-to-weight ratio that indicated an above average ranking, the resistance training intensities at the higher end of the range recommended by the Phase were prescribed. The Client Summary further assisted the prescription of intensity as the principle of individualization and specificity were utilized in relation to each patient's specific goals and desired outcomes from the program. If a participant's goal consisted of being able to walk or jog a 5-K race at the conclusion of 12 weeks, and if the medical history indicated this would not jeopardize the patient's immune function, then a steeper progression of intensity during the aerobic intervention was prescribed. Similarly, if a participant's goals included competing in a weight lifting competition as part of the local Senior Games, a prescription utilizing more assertive progressive overload was included during resistance training. The Client Overview ensured that both essential components of exercise prescription were included, assessment results and adherence to the principles of exercise training.

The Phase Training Model: Exercise Intervention

Each exercise intervention session took place at UNCCRI. Physiological data were recorded by UNCCRI CES's. The Phase Training Model assured that the five basic principles of exercise were being met. The main principles included progressive overload, individuality, specificity, diminishing returns, and reversibility. The intensity

of the exercise intervention was dictated by the exercise prescription and was dependent upon treatment status, assessment results, and ascribed Phase. A graphic representation of the Phase Training Model is shown in Figure 2. One-on-one training occurred in the first three Phases, with the option also being available in Phase 4. For all one-on-one sessions, a whole body exercise intervention was utilized. The frequency of training was prescribed as three sessions per week for 12 weeks. The duration of each exercise session was 60 minutes with 20 minutes designated for cardiovascular exercise, 30 minutes for resistance exercise, 10 minutes for flexibility training, and with balance exercises incorporated throughout the entire session. The following modes were utilized for the aerobic portion of the exercise session: treadmill, cycle ergometer, NuStep, Aquaciser (underwater treadmill), outdoor walking or jogging. In regards to resistance exercise, each session targeted the following muscle groups: chest (pectoralis major and minor), back (rhomboids and latissimus dorsi), lower body (quadriceps and hamstrings), and core (trunk stabilizers and pelvic floor), and utilized three sets of 10 repetitions of each exercise. Other muscle groups may have been included (deltoids, biceps, triceps, adductors, etc.) within the 30 minutes of strength training. Modes of resistance training included: Cybex® resistance machines, therabands, dumbbells, medicine balls, body weight, and resistance tubing. The flexibility portion utilized stretches targeting all muscle groups that were used during the exercise session. Additional equipment that aids in the stretching portion included: rope pulleys, range of motion wheels, and ropes. For the addition of balance, the following equipment was used: ski poles, stability balls, Bosu balls, Ballast balls, dyna disks, wobble boards, and foam pads. Prior to the start of each exercise session, resting HR, BP, and SPO_2 were measured and current health was

assessed via discussion with the participant. A heart rate monitor was worn throughout the entire session by the participant. At the conclusion of every session, HR, BP, and SPO_2 were measured to ensure values were near resting measures and the participant was safe to leave the facility.

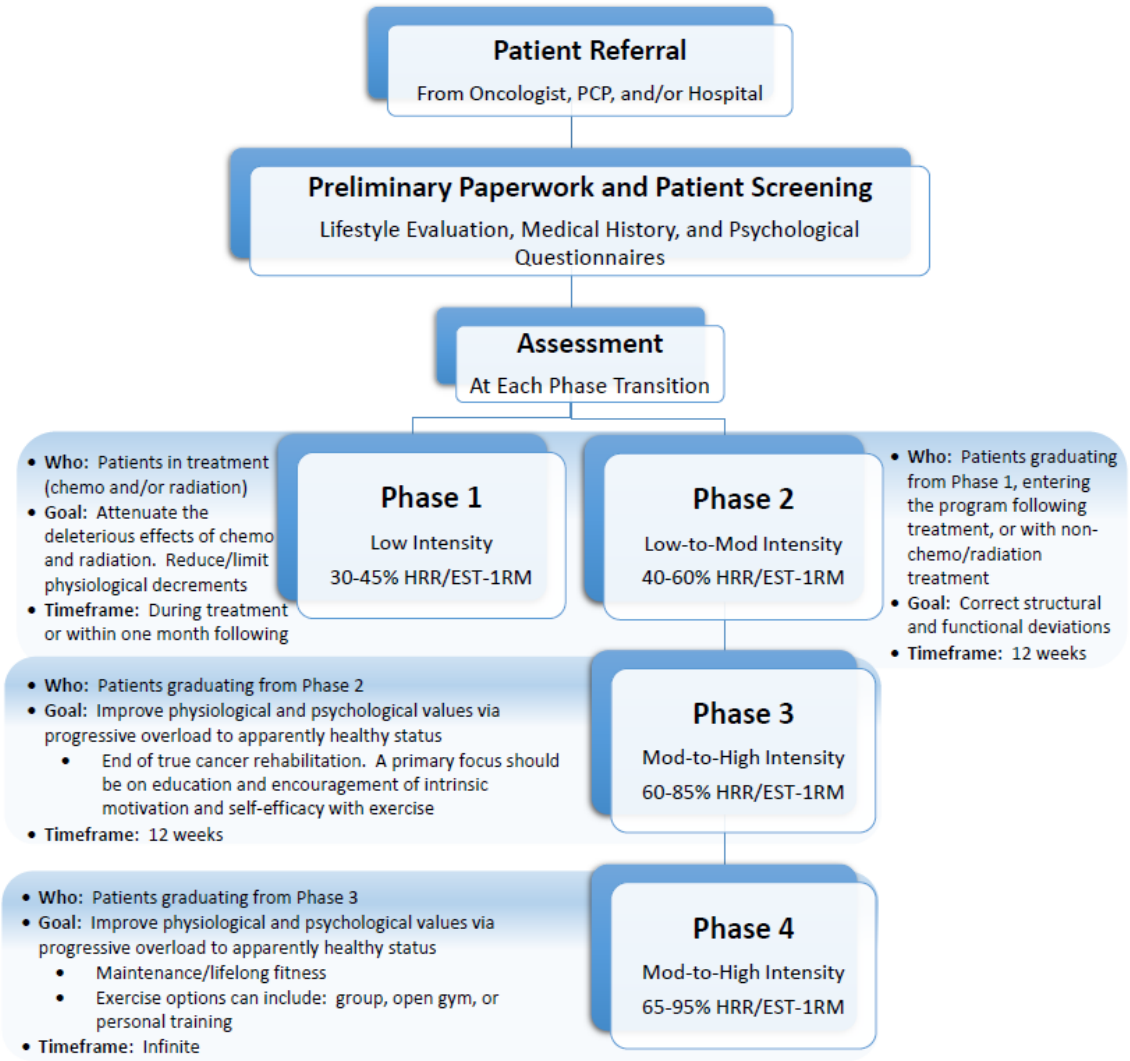

Figure 2. Phase Training Model of Cancer Rehabilitation

Phase 1 was developed for cancer survivors who are still receiving chemotherapy or radiation treatments. Due to side effects being more prevalent while in treatment as opposed to out of treatment (Sprod et al., 2011), the goal of this Phase was to maintain or

slightly increase a cancer survivor's physiological and psychological values. Phase 1 was specifically designed to adhere to the principles of individuality and specificity. Decrements below baseline should not have occurred, as this Phase was designed to attenuate the toxicities from cancer treatment. The starting intensity was categorized as low (Kuehl et al., 2015; Schneider et al., 2003) with intensity ranging between 30-45% HRR and EST 1-RM. This intensity was determined by reviewing over 100 exercise logbooks from clients that were currently undergoing treatment. The mean training intensity was well tolerated among patients and varied between 30-45% HRR, which corresponds with intensities for those in poor health (Schneider et al., 2003). Participants remained in this Phase for the duration of his or her cancer treatment or for 12 weeks, if treatment concluded prior to the entry into the next Phase. Of note, usage of any aquatic exercises was prohibited during this Phase due to skin irritation resulting from treatment.

Phase 2 was designed for cancer survivors who have moved from Phase 1 to Phase 2, or for any survivor who had undergone cancer treatment that was not categorized as chemotherapy or radiation therapy. Other forms of treatment included hormonal altering or blocking therapy, immunotherapy, or stem cell transplants. Side effects from a survivor undergoing chemotherapy or radiation differ from the side effects experienced during other forms of treatment which are generally less severe (Collins et al., 2011). Due to this, the starting intensity of Phase 2 was prescribed as low-to-moderate (Kuehl et al., 2015); and ranged between 40%-60% HRR and EST 1-RM. The intensity was determined by reviewing over 100 exercise logbooks for those who had just completed cancer treatments. This intensity range was closely related to intensities previously reported for the active, cancer patient (Schneider et al., 2002). The goal of

Phase 2 was to build a foundational base using corrective and functional training with a focus on developing and stabilizing the core, pelvic floor, shoulder girdle, or any other joints or muscles affected by surgery and/or hormonal treatments, and the lasting effects from chemotherapy or radiotherapy. Stabilizer muscles such as the core, pelvic floor, and shoulder girdle are prominently affected by cancer and its treatments (Collins et al., 2011; Swenson et al., 2002). Strengthening these components of the body will assist with activities of daily living and general movement patterns. Phase 2 was designed to continue adherence to the principles of individuality and specificity, and to begin incorporating progressive overload based on assessment results and treatment deficits. Typically, a client remained in this Phase for 12 weeks.

Phase 3 was intended for cancer survivors who have completed Phase 2, and was the transitional Phase from cancer rehabilitation to apparently healthy exercise. As Phase 3 represented the last Phase considered cancer rehabilitation, a major goal was to educate participants with the skills necessary to implement and maintain an exercise program on their own. Participants should have transitioned from Phase 3 with the ability to perform exercises with self-efficacy and knowledge to avoid injury and create progression. This goal existed to support the principles of diminishing returns and reversibility. Phase 3 also aimed to improve physiological and psychological values beyond baselines and to incorporate the principle of progressive overload to the highest extent. Improvements have occurred in cardiovascular fitness, muscular strength and endurance, pulmonary function, flexibility, and balance. Psychological improvements should have been visible via QOL, depression, and fatigue scores. At completion, cancer survivors should have achieved classification near or at apparently healthy status. This type of training was

classified as moderate-to-high, as intensities ranged between 60-85% HRR and EST 1-RM. This range has been deemed appropriate for vigorous exercise (Kuehl et al., 2015; Scharhag-Rosenberger et al., 2015) and overload. A cancer survivor remained in this Phase for 12 weeks.

Phase 4 was designed for cancer survivors who have completed Phase 3, and there was no time limit for this Phase. Cancer survivors in this Phase had successfully completed the prior three Phases, and were deemed close or at apparently healthy status. Phase 4 was not considered cancer rehabilitation as it was meant to assist patients for the rest of their lives in maintaining physical activity and healthy function. Unlike the other three Phases, additional alternatives to one-on-one training were available. Patients may have chosen to participate in group fitness classes or attend an open gym schedule at UNCCRI. The goal of this Phase was to maintain improvements in both physiological and psychological values gained during the past Phases or continue progressive overload based on the patient's personal goals. The type of training was classified as moderate-to-near-maximal, as the range of intensities was 65-95% HRR and EST 1-RM. This intensity range was appropriate for cancer survivors who are or close to apparently healthy status (Kuehl et al., 2015; Scharhag-Rosenberger et al., 2015).

Statistical Analysis

Individual paired-sample t-tests were utilized to examine if significant differences occurred in cardiovascular endurance, muscular strength, and fatigue during each Phase transition. The following dependent variables were measured: VO_{2peak}, EST 1-RM of the leg press, EST 1-RM of the chest press, strength-to-weight ratio for the leg press, strength-to-weight ratio for the chest press, and fatigue. The following Phase transitions

(assessment and reassessment) were evaluated: Phase 1 to Phase 2, Phase 2 to Phase 3, and Phase 3 to Phase 4. Because several paired t-tests were utilized, a Bonferroni adjustment was used to reduce the chance of committing type I error. Statistical analyses will be performed using the Statistical Package for the Social Sciences software package (SPSS, Chicago, IL.). Significance levels were set at $p < 0.05$.

CHAPTER IV

RESULTS

The purpose of this study was to evaluate the effects of the Phase Training Model on cardiorespiratory endurance, muscular strength, and cancer-related fatigue in cancer survivors during the transition from each Phase and in those who have completed the entire Phase Training Model.

Participant Characteristics

Table 1 displays the demographic characteristics of the participants. A total of 152 cancer survivors' data were utilized to assess the Phase Training Model. The study consisted of 58 males and 94 females, where the mean age was 62 ± 12 years of age and the mean weight was 80 ± 21 (kgs). Table 2 depicts the total number of assessments and Phase transitions that occurred among the participants. Of these, 87.7% of the assessments represented standard Phase transitions from one Phase to the subsequent Phase, whereas 12.3% were non-standard transitions in which the individual remained in the same Phase for an additional 12 weeks. Non-standard Phase transitions occurred from Phase 1 to Phase 1 during continued chemotherapy and/or radiation treatment, from Phase 2 to Phase 2 when there existed lasting functional and postural deviations that required additional time to attenuate, and from Phase 3 to Phase 3 due to a participant that required further education and motivation to learn proper form, exercise creation, and generate the self-efficacy needed to establish an exercise intervention. Tables 3, 4, and 5

display the cancer types, treatment demographics, and cancer stages, respectively. Cancer types included: Breast (36%), liquid (12%), prostate (11%), lung (11%), head and neck (7%), gynecological (5%), colorectal (4%), and other cancer types (14%). Of the participants, 13% had surgery only, 9% had chemotherapy only, 3% had radiation only, 26% had surgery and chemotherapy only, 18% had surgery and radiation only, 3% had chemotherapy and radiation only, 27% had surgery, chemotherapy, and radiation, and 1% had no treatment. For those who had completed treatment, the average time post treatment was 10 months. Of the participants, 24%, 26%, 24%, and 14% were diagnosed as stage 1, 2, 3, or 4, respectively; stage was unknown or was not staged in 12% of the participants.

Mean attendance of all subjects participating in the program was 80% and average retention was approximately 58% between each Phase Transition until program completion. Retention for those who began in and completed Phase 1 was 54%. For those who entered the program as Phase 2, retention was 65%. Finally, retention for those who completed Phase 3 and completed the program into Phase 4 was 54%. Of the 152 program participants, 33 completed the entire Phase program from entry through Phase 4.

Table 1

Participant Characteristics

Participant Characteristics	**N = 152**
Age (years)	62 ± 12
Male, n (%)	58 (38)
Female, n (%)	94 (62)
Height (centimeters)	168 ± 10
Weight (kilograms)	80 ± 21

Table 2

Assessments and Phase Transitions

Phase Transitions	**N (%)**
Total Assessments	292
Phase 1 to Phase 2	43 (14.7)
Phase 2 to Phase 3	126 (43.2)
Phase 3 to Phase 4	68 (23.3)
Phase 4 to Phase 4	19 (6.5)
Phase 1 to Phase 1*	16 (5.5)
Phase 2 to Phase 2*	13 (4.5)
Phase 3 to Phase 3*	7 (2.4)

*Denotes a non-standard Phase transition

Table 3

Cancer Types

Cancer Types	**N (%)**
Breast	55 (36)
Liquid	19 (12)
Prostate	16 (11)
Lung	16 (11)
Head and Neck	10 (7)
Gynecological	8 (5)
Colorectal	7 (4)
Other	21 (14)

Table 4

Treatment Demographics

Treatment Demographics	**N (%)**
Surgery only	20 (13)
Chemotherapy only	14 (9)
Radiation Only	5 (3)
Surgery and Chemotherapy Only	40 (26)
Surgery and Radiation Only	27 (18)
Chemotherapy and Radiation Only	5 (3)
Surgery, Chemotherapy, and Radiation	39 (27)
No treatment	2 (1)
Average Months Since Treatment	10

Table 5

Cancer Stage

Cancer Stage	**N (%)**
I	37 (24)
II	39 (26)
III	37 (24)
IV	21 (14)
Unknown/not staged	18 (12)

Changes in Peak Volume of Oxygen Consumption, Muscular Strength, and Fatigue in Phase Transitions

Table 6 depicts absolute values (pre-to-post) for all Phase transitions for VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$), leg press muscular strength (MS) (kgs lifted), chest press MS (kgs lifted), leg press strength-to-weight ratio (SWR), chest press SWR, and fatigue. Figure 3 depicts mean percent change in VO_{2peak} and fatigue in each Phase transition. Figures 4 and 5 depict mean percent changes in lower and upper body strength, respectively.

Phase 1 to 2 Transition

Significant improvements were observed in VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) (19.9 ± 7.5 to 22.5 ± 8.0; $p < 0.001$), leg press MS (kgs) (82 ± 34 to 88 ± 44; $p < 0.05$), chest press MS (kgs) (27 ± 16 to 32 ± 19; $p < 0.001$), leg press SWR (0.98 ± 0.5 to 1.11 ± 0.5; $p < 0.05$), chest press SWR (0.35 ± 0.2 to 0.38 ± 0.2; $p < 0.05$), and fatigue (5.0 ± 2.5 to 3.6 ± 2.0; $p < 0.05$). Percent change for each variable was as follows: VO_{2peak} (12.5%), leg press MS (7.5%), chest press MS (16.2%), leg press SWR (9.6%), chest press SWR (8.1%), and fatigue (-27.3%).

Phase 2 to 3 Transition

Significant improvements were observed in VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) (21.1 ± 7.0 to 24.3 ± 8.4; $p < 0.001$), leg press MS (kgs) (83 ± 32 to 96 ± 42; $p < 0.001$), chest press MS (kgs) (30 ± 18 to 36 ± 19; $p < 0.001$), leg press SWR (1.02 ± 0.3 to 1.18 ± 0.4; $p < 0.001$), chest press SWR (0.36 ± 0.2 to 0.45± 0.2; $p < 0.001$), and fatigue (4.2 ± 2.3 to 3.0 ± 2.2; $p < 0.001$). Percent change for each variable was as follows: VO_{2peak} (15%), leg press MS (15.7%), chest press MS (23%), leg press SWR (15.7%), chest press SWR (24.7%), and fatigue (-26.8%).

Phase 3 to 4 Transition

Significant improvements were observed in VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) (24.3 ± 7.0 to 25.5 ± 7.1; $p < 0.05$), chest press MS (kgs) (37 ± 18 to 40 ± 20; $p < 0.05$), and chest press SWR (0.46 ± 0.2 to 0.49 ± 0.2; $p < 0.05$). Non-significant improvements ($p > 0.05$) were observed in leg press MS (kgs) (101 ± 47 to 105 ± 41) and fatigue (3.4 ± 2.1 to 3.1 ± 2.2). A non-significant decrease in leg press SWR was observed (1.29 ± 0.4 to 1.28 ± 0.4). Percent change for each variable was as follows: VO_{2peak} (5%), leg press MS (3.6%), chest press MS (7.6%), leg press SWR (-0.1%), chest press SWR (7.6%), and fatigue (-8%).

Phase 4 to 4 Transition

Non-significant improvements were observed in leg press MS (kgs) (97 ± 44 to 98 ± 37), chest press MS (kgs) (32 ± 17 to 34 ± 15), leg press SWR (1.16 ± 0.4 to 1.22 ± 0.4), and fatigue (2.8 ± 2.1 to 2.2 ± 2.0). A non-significant decrease ($p > 0.05$) in chest SWR (0.44 ± 0.2 to 0.43 ± 0.2) and VO_{2peak} (25.6 ± 6.8 to 24.6 ± 6.1) was observed. Percent change for each variable was as follows: VO_{2peak} (-3.6%), leg press MS (1.4%), chest press MS (4%), leg press SWR (5.3%), chest press SWR (-2.4%), and fatigue (-21.9%).

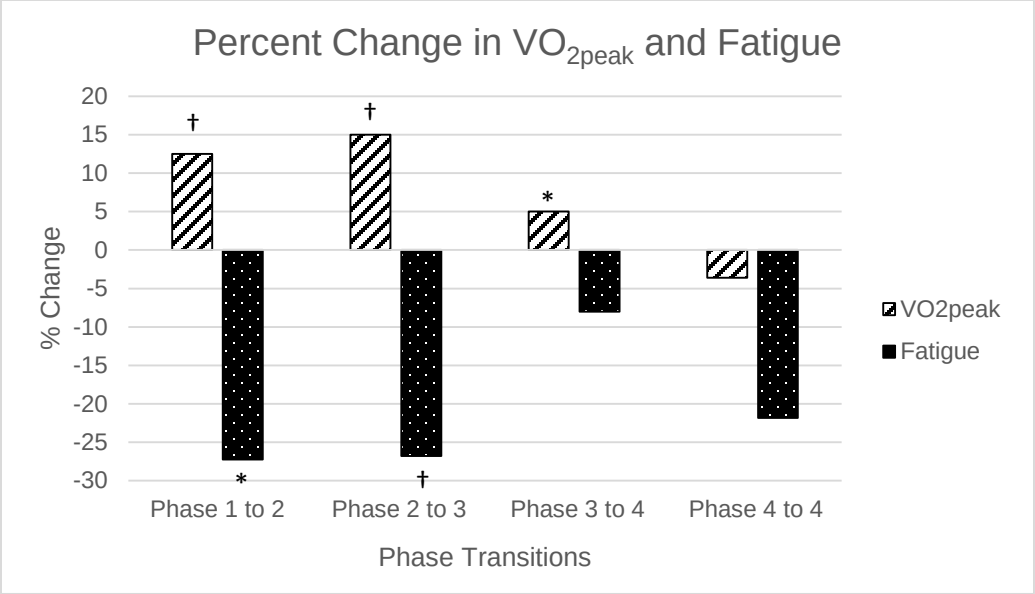

Figure 3. Mean percent change in VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) and fatigue. *p < 0.05; †p < 0.001

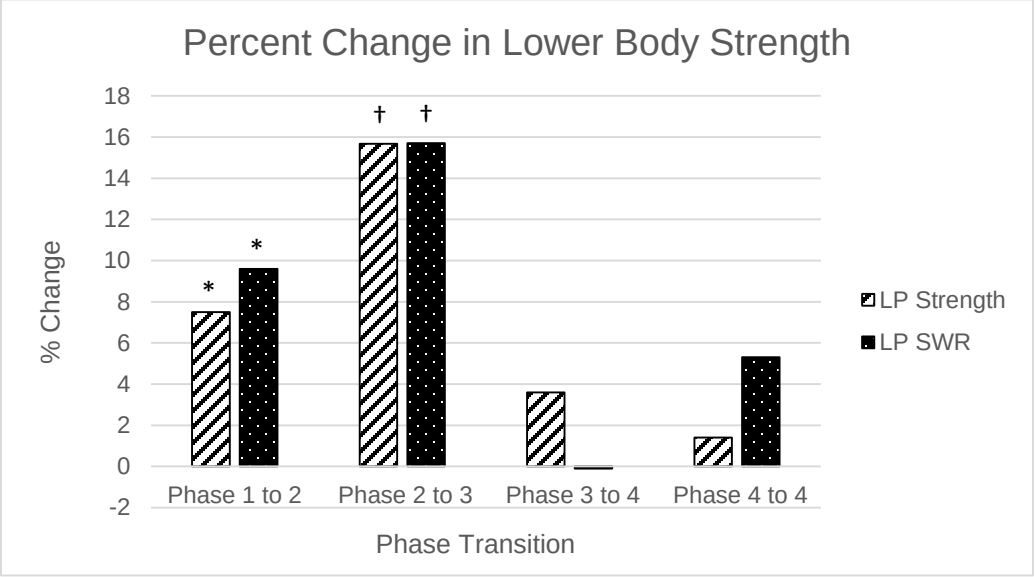

Figure 4. Mean percent change in lower body strength. LP, leg press; SWR, strength-to-weight ratio; *p < 0.05; †p < 0.001

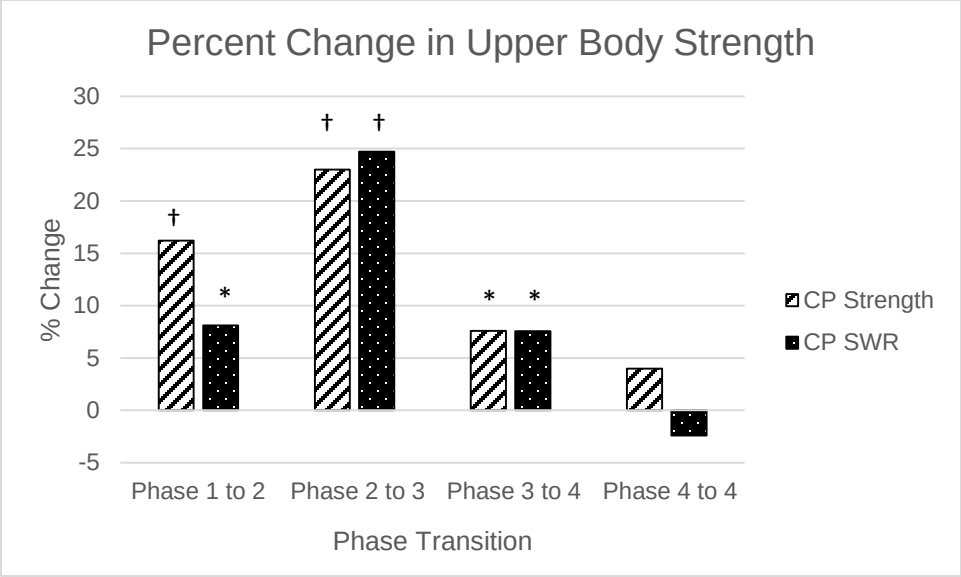

Figure 5. Mean percent change in upper body strength. CP, chest press; SWR, strength-to-weight ratio *$p < 0.05$; †$p < 0.001$

Table 6

Improvements in Physiological Values and Fatigue

Phase Transition	Phase 1 to 2		Phase 2 to 3		Phase 3 to 4		Phase 4 to 4	
N	43		126		68		19	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
VO_{2peak}	19.9 ± 7.5	22.5 ± 8.0†	21.1 ± 7.0	24.3 ± 8.4†	24.3 ± 7.0	25.5 ± 7.1*	25.6 ± 6.8	24.6 ± 6.1
Leg press MS	82 ± 34	88 ± 44*	83 ± 32	96 ± 42†	101 ±47	105 ± 41	97 ± 44	98 ± 37
Chest Press MS	27 ± 16	32 ± 19†	30 ± 18	36 ± 19†	37 ± 18	40 ± 20*	32 ± 17	34 ± 15
Leg Press SWR	0.98 ± 0.5	1.11 ± 0.5*	1.02 ± 0.3	1.18 ± 0.4†	1.29 ± 0.4	1.28 ± 0.4	1.16 ± 0.4	1.22 ± 0.4
Chest Press SWR	0.35 ± 0.2	0.38 ± 0.2*	0.36 ± 0.2	0.45 ± 0.2†	0.46 ± 0.2	0.49 ± 0.2*	0.44 ± 0.2	0.43 ± 0.2
Fatigue	5.0 ± 2.5	3.6 ± 2.0*	4.2 ± 2.3	3.0 ± 2.2†	3.4 ± 2.1	3.1 ± 2.2	2.8 ± 2.1	2.2 ± 2.0

Note. N = number of participants, VO_{2peak} = peak volume of oxygen consumption ($mL \cdot kg^{-1} \cdot min^{-1}$); MS = muscular strength (kgs lifted); SWR = Strength-to-weight ratio; * denotes a p value < 0.05 between pre and post values; † denotes a p value < 0.001.

Changes in Patients Who Completed the Entire Phase Training Model (Entry to Phase 4)

Changes in VO_{2peak} for patients who completed the entire Phase Model are depicted in Figure 6. Mean initial VO_{2peak} values at the initial assessment was 18.9 $mL \cdot kg^{-1} \cdot min^{-1}$. At the first reassessment, VO_{2peak} increased to 21.7 $mL \cdot kg^{-1} \cdot min^{-1}$ (+15.2%). At the second reassessment, VO_{2peak} increased to 22.5 $mL \cdot kg^{-1} \cdot min^{-1}$ (+3.7%). At the third reassessment, VO_{2peak} increased to 24.4 $mL \cdot kg^{-1} \cdot min^{-1}$ (+8.4%). For comparison, Figure 7 depicts mean changes in VO_{2peak} for patients who completed three reassessments in the previous program. Mean percent improvements for chest press and leg press were 79.7% and 50.3%, respectively. Fatigue decreased by -29.4% from entry to program completion.

Comparison of Patients Who Completed the Entire Phase Training Model to the Previous Program

Percent changes in VO_{2peak} in the previous cancer rehabilitation program compared to the Phase Model are depicted in Figure 8. At three months post initial assessment, VO_{2peak} improved by 12.1% and 15.2% for the previous program and Phase Model, respectively. At six months post the initial assessment, VO_{2peak} improved by 3.5% and 3.7% for the previous program and the Phase Model, respectively. At nine months post initial assessment, VO_{2peak} decreased by -1.1% for the older model, while VO_{2peak} increased by 8.4% for the Phase Model.

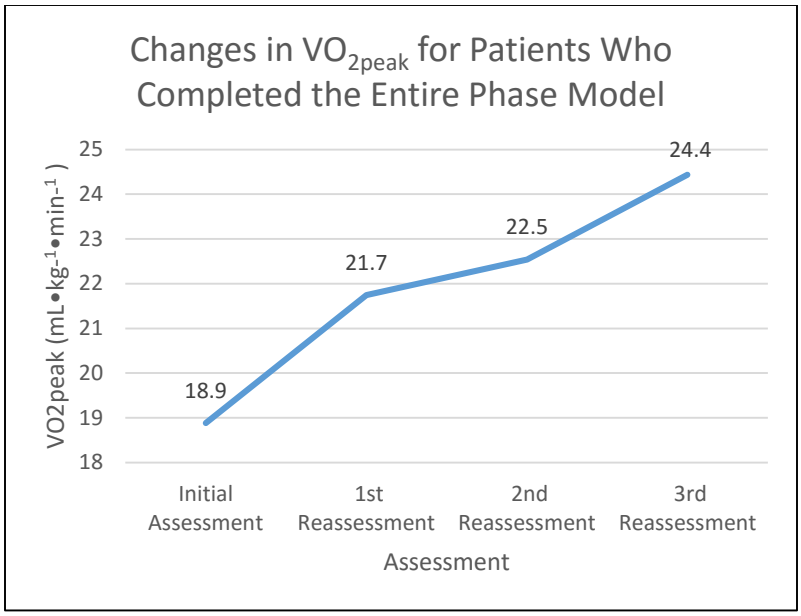

Figure 6. Mean changes in VO_{2peak} for patients who completed the entire Phase Model.

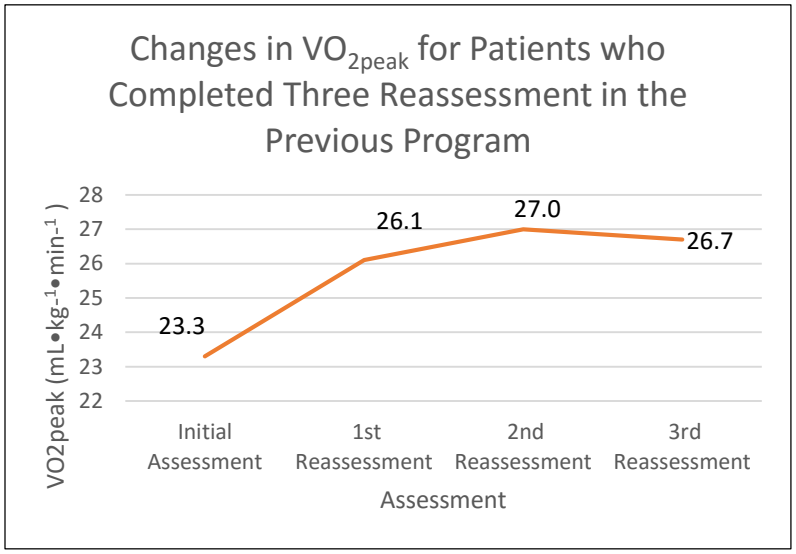

Figure 7. Mean changes in VO_{2peak} for patients who completed three reassessments in the previous program.

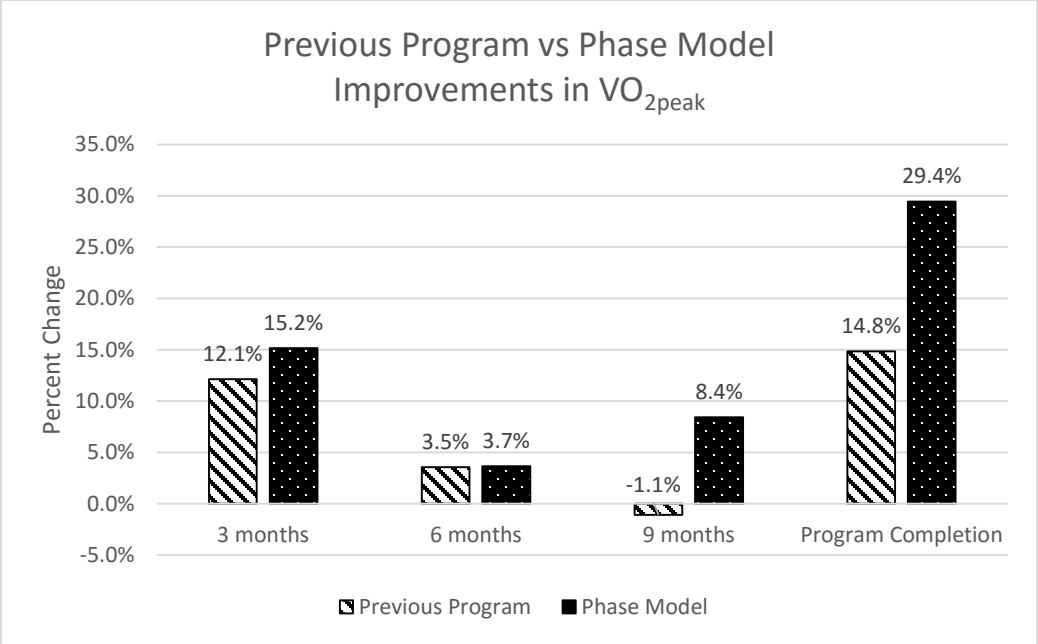

Figure 8. Mean percent change in VO_{2peak}: previous program vs. Phase Training Model.

CHAPTER V

MANUSCRIPT

Abstract

Brown, J.M., Shackelford, D.Y.K., & Hayward, R. (2016). Evaluation of the Phase Training Model of Cancer Rehabilitation. *Journal of Clinical Oncology*.

Exercise is a well-established method of alleviating cancer-related toxicities during and following treatment in cancer survivors. Due to this clear evidence, exercise-based rehabilitation programs have begun to emerge. Of concern, specific recommendations of exercise prescription for patients at different time points on the cancer continuum have not been developed, and available guidelines are broad and unclear. The Phase Training Model of cancer rehabilitation was created to address this issue. **Purpose:** To evaluate the effects of the Phase Training Model on cardiorespiratory endurance, muscular strength (MS), and cancer-related fatigue (CRF) in cancer survivors during the transition from each Phase and in those who have completed the entire Phase Training Model. **Methods**: A total of 152 cancer survivors' data were utilized. The Phase Training Model consists of four sequential Phases representing differing time points from treatment. The designated Phase prescribes intensity, progression, and goals unique to each. Changes in peak volume of oxygen consumption

(VO_{2peak}), chest press MS, leg press MS, and CRF were observed from transitions from Phase 1 to 2, Phase 2 to 3, and Phase 3 to 4. **Results**: VO_{2peak}, chest press MS, leg press MS, and CRF all significantly improved from Phase 1 to Phase 2, and from Phase 2 to Phase 3 ($p < 0.05$). VO_{2peak} and chest press MS significantly improved in patients transitioning from Phase 3 to 4 ($p < 0.05$). **Conclusion:** These findings suggest the Phase Training Model provides the first clear and reproducible guidelines for exercise prescription in cancer survivors. This exercise-based intervention yielded significant physiological and psychological improvements in patients both during and immediately following treatment, with reduced results as time from treatment increases.

Keywords: cancer, cancer rehabilitation, oncology rehabilitation, exercise-based interventions

Introduction

Advancements in cancer treatments such as chemotherapy and radiation have increased survival rates, but often result in many deleterious side-effects during and following treatments. Cancer survivors can suffer from physiological toxicities affecting the following systems: cardiovascular, pulmonary, musculoskeletal, immune, gastrointestinal, hepatic, and neuroendocrine (Schneider et al., 2003; Schneider et al., 2002). Additionally, many survivors will experience psychological decrements such as increased fatigue (Daniell, 2004; Stone & Minton, 2008; Wu & McSweeney, 2007), increased depression (Dauchy et al., 2013; Gagliese et al., 2007; Ng et al., 2011), and decreased quality of life (QOL) (Lee et al., 2010; Rauma et al., 2015). Advances in detection, diagnosis, and treatments have improved prognosis and lessened the need for hospital and physician-based interventions (Alfano et al., 2012). Exercise-based

programs are a viable option of cancer rehabilitation for cancer survivors as the benefits of exercise directly attenuate the toxicities and decrements of cancer and concurrent treatments (Dittus et al., 2015; Schmitz et al., 2010; Schneider et al., 2002).

Exercise-based interventions should be comprehensive and address the multidimensional needs of cancer survivors during treatment and following treatment. For this reason, a "one size fits all" approach to exercise interventions will not suffice (Marcus et al., 2000), and survivors need prescriptive exercise that is specialized for each individual based on treatment status and placement on the cancer continuum. There are many different modes and intensities that are being used for physical activity-based interventions in the cancer population, and most are unstructured. However, most exercise programs to date have failed to properly apply and adhere to the principles of exercise training: individuality, specificity, progression and overload (referred to as progressive overload), reversibility, and diminishing returns (Campbell et al., 2012; Kenney et al., 2015). Furthermore, it is currently unclear how to alter exercise prescriptions for patients at different time points on the cancer continuum, as well as why or when to modify exercise dosage during an intervention to elicit specific adaptations.

To date, there is only one longstanding model of a standardized exercise intervention with guidelines for intensity, frequency, and duration for cancer survivors (Schneider et al., 2003; Schneider et al., 2002). However, further analysis of this program suggests reduced improvements with continued exercise, while physical functioning remains well below average (Brown, Lalonde, et al., 2012). It was concluded that this prescriptive exercise intervention was sufficient to improve cancer survivor's physiological function at the onset, but suggested that survivors may begin to experience

diminishing returns from exercise training as the program lengthened. For those working with cancer survivors, greater attention should be paid to the principles of exercise training, specifically progression and overload to ensure that these individuals continue to improve and reach apparently healthy status. The University of Northern Colorado Cancer Rehabilitation Institute (UNCCRI) Phase Training Model of cancer rehabilitation was created to address these concerns and provide a clear method of exercise prescription and intervention to alleviate treatment-related toxicities. Therefore, the purpose of this study was to evaluate the effectiveness of the Phase Training Model on cardiovascular endurance, muscular strength, and fatigue.

Methods

Subjects

Data were obtained from patients participating in the UNCCRI cancer rehabilitation program between the years 2012-2016. Participants were male and female cancer survivors over 18 years of age who were undergoing or had completed surgical intervention, chemotherapy, radiation therapy, immunotherapy, hormonal therapy, and/or other types of unconventional treatment. All cancer survivors were cleared to participate in an exercise program through a referral completed by his/her oncologist or physician, and a detailed medical and cancer history for each participant accompanied each referral. All protocols used for the study were approved by the University of Northern Colorado's (UNC) Institutional Review Board, and an Informed Consent was signed by all participants.

Experimental Design

All participants' data were obtained from initial assessments and subsequent reassessments. The Phase Training Model of cancer rehabilitation utilized a four Phase approach with assessments of physiological and psychological variables conducted at each assessment. Participants performed initial assessments upon entering the program and completed reassessments every 12 weeks until four reassessments had been completed. Each reassessment marked the completion of the Phase and subsequent entry into the next. Entry into the program depended on the patients' treatments statuses (allowing entry as Phase 1 or Phase 2), and thus altered the length of program completion. Phases 1 through 3 are considered "true cancer rehabilitation", and the program was marked as completed once the patient had entered Phase 4. However, continued reassessments took place as patients continue the Phase Training Model in Phase 4 and was referred to as personal training. Patients who entered the program as Phase 1 completed the program in 36 weeks, while those who entered as Phase 2 completed the program in 24 weeks. All procedures, assessments, and measurements were conducted by trained Cancer Exercise Specialists (CES) and overseen by the UNCCRI Clinical Coordinator.

Preliminary Paperwork and Patient Screening

Following participant referral and signing of the informed consent (Appendix A), each subject was asked to complete questionnaires evaluating psychological functioning, lifestyle, behavior, and medical information. The questionnaires included a Medical History (Appendix D) and the Revised Piper Fatigue Scale (Appendix E). All questionnaires were completed prior to assessment.

Lifestyle/ activity evaluation. This questionnaire evaluated the participants' personal lifestyle choices regarding smoking, drinking, sleep, physical activity, and diet.

Medical history. Participants' medical information was obtained via a self-reported worksheet detailing present medical history, family medical history, medications, allergies, and cancer diagnosis. For accuracy, medical information was also requested from the participants' oncologist or primary care physician at the time of referral.

Revised Piper Fatigue Scale. Fatigue was measured via the Piper Fatigue Inventory, which evaluates total cancer-related fatigue, as well as subscales of fatigue such as affective, behavior, cognitive, mood, and sensory. These individual subscales comprise 22 points with the average score representing total fatigue. The scale ranges from 0 to 10. A score of 0 indicates that the participant shows no sign of fatigue, a score from 1 to 3 indicates mild fatigue, 4 to 6 indicates moderate fatigue, and a score of ≥ 7 indicates severe fatigue (Piper et al, 1998).

Prior to the initial assessment and each subsequent reassessment, a detailed medical and cancer screening was recorded on the Client Summary form (see Appendix H). The Client Summary listed all pertinent cancer information, treatments, surgeries, medications, current health status, and personal patient goals.

Phase Training Model:
Assessment Protocols

Initial assessments occurred prior to the creation of the exercise prescription and exercise intervention. Reassessments occurred after each 12-week exercise intervention and every 12 weeks until four consecutive reassessments had been completed. Each assessment included the measurement of vitals, body composition, functional

assessments, balance, pulmonary function, cardiovascular endurance, muscular strength and endurance, and flexibility and range of motion (ROM). Results from the assessment protocols were recorded on the Data Collection Sheet for the corresponding Phase (see Appendices I-K).

Vital measurements. Prior to any exercise testing and throughout all physical activity, participants' heart rate, oxygen saturation (SPO_2), and blood pressure were assessed via a heart rate monitor with chest strap (Polar, Inc. Lake Success, NY), pulse oximeter, and sphygmomanometer and stethoscope, respectively.

Cardiovascular endurance assessment. Cardiovascular endurance was evaluated using the cancer-specific UNCCRI Treadmill Protocol which yields VO_{2peak} values. This test was found to be the most accurate and appropriate protocol for the cancer population (Shackelford, 2015). The goal of this test was for the participant to reach self-perceived maximal exertion or fatigue. The highest measurement of oxygen consumption was calculated. This protocol consisted of one minute stages, which increase speed and/or incline at the conclusion of every stage. During the test, heart rate (HR) and oxygen saturation (SPO_2) were collected at the end of every minute. Blood pressure (BP) was recorded at the end of every three minutes, as well as the participant's rating of perceived exertion (RPE) on the modified Borg Scale. This RPE scale consisted of numbers 0-10 which correlates to the perceived intensity of the test. A RPE of 0 correlated with the intensity of a stroll in the park, and a RPE of 10 signifies the patient has reached his or her maximal effort and cannot continue. The use of handrails was discouraged, but was allowed if deemed necessary. Handrail usage stayed consistent throughout the test for each subject. Termination criteria of the test was: participant

reached volitional fatigue or asked to stop for any reason, failure to increase systolic BP or HR with increased intensity, fluctuation of more than 10 mmHg from resting measures of diastolic BP, or an oxygen saturation that dropped below 80%. Once the protocol ended, each subject completed a cool-down period, where all of the aforementioned variables were measured in the same manner as during the test. Final treadmill time, BP, HR, and RPE were recorded. Peak volume of oxygen consumption was estimated using ACSM's walking and running equations, which have been found to be valid in determining VO_{2peak} in cancer survivors (Shackelford, 2015).

Muscular strength assessment. Muscular strength was assessed via the estimated one-repetition maximum protocol (EST 1-RM) using the Brzycki equation (Brzycki, 1993). This test used Cybex Eagle resistance machines (Cybex Inc., Medway, MA.) and specifically utilized the following machines: chest press, lat pulldown, seated row, shoulder press, leg press, leg curl, and leg extension. The goal of this test was to have the participant lift as much weight as possible between one and ten repetitions. RPE values were asked at the end of every set. The test was performed in six steps. (1) Before the participant began the test, the CES demonstrated how to perform each machine correctly with proper form, and adjusted the machine to ensure a proper fit for each participant. (2) The participant was then asked to perform a warm-up set, which consisted of five repetitions at a low intensity. (3) After the warm-up set, the weight was increased accordingly to elicit muscular failure or fatigue between 1 and 10 repetitions. (4) The participant then attempted to lift the weight deemed appropriate to elicit failure between 1 to 10 repetitions. (5) If the weight appeared to be too light to elicit failure between 1 to 10 repetitions, the set was stopped immediately and the weight increased. If

the weight was too heavy for one full repetition, the weight was reduced accordingly. (6) Finally, after a 2 to 3 minute rest, steps 4 and 5 may have been repeated up to two times per machine to elicit a weight that resulted in muscular fatigue between 1 and 10 repetitions. The EST 1-RM values, as kgs lifted, were recorded for each machine. Leg and chest press values were then divided by the patient's body weight, both in kgs, to yield a strength-to-weight ratio for each machine.

Phase Training Model:
Exercise Prescription

Exercise prescription took place following the assessment and was created using the Client Overview document (see Appendix L). The Client Overview indicated the Phase the participant was stratified into, the starting target intensity of both the aerobic and resistance training components of the program, and the rate of progressive overload prescribed during the 12 weeks for each subject. The participant screening, which was recorded on the Client Summary, and the data collected from each assessment protocol, which was recorded on the Data Collection Sheet, were used together to create the exercise prescription for each participant. Specifically, the treatment status (during versus following) and the types of treatment received dictated the Phase the participant entered the program. If the subject was currently undergoing chemotherapy and/or radiation therapy, he or she was placed in Phase 1. If treatment had ended prior to entry into the program or if the subject underwent surgical intervention and/or other treatments (hormonal, immune, etc.), he or she was placed in Phase 2. The assessment results and specifically the classifications achieved by the participant during each assessment were utilized to begin the process of selecting the appropriate target intensity of the intervention. For example, if the subject performed very poorly on the UNCCRI

Treadmill Protocol and yielded a classification of low in cardiovascular function when compared to other cancer survivors, this indicated a prescription at the lowest end of the Phase recommendations for HRR was needed. Likewise, if a subject performed well on the EST 1-RM protocol and achieved a strength-to-weight ratio that indicated an above average ranking, the resistance training intensities at the higher end of the range recommended by the Phase were prescribed. The Client Summary further assisted the prescription of intensity as the principle of individualization and specificity were utilized in relation to each patient's specific goals and desired outcomes from the program. If a participant's goal consisted of being able to walk or jog a 5-K race at the conclusion of 12 weeks, and if the medical history indicated this would not jeopardize the patient's immune function, then a steeper progression of intensity during the aerobic intervention was prescribed. Similarly, if a participant's goals included competing in a weight lifting competition as part of the local Senior Games, a prescription utilizing more assertive progressive overload was included during resistance training. The Client Overview ensured that both essential components of exercise prescription were included, assessment results and adherence to the principles of exercise training.

The Phase Training Model:
Exercise Intervention

Each exercise intervention session took place at UNCCRI. Physiological data were recorded by UNCCRI CES's. The Phase Training Model assured that the five basic principles of exercise were being met. The main principles included progressive overload, individuality, specificity, diminishing returns, and reversibility. The intensity of the exercise intervention was dictated by the exercise prescription and was dependent upon treatment status, assessment results, and ascribed Phase. A graphic representation

of the Phase Training Model can be seen in Figure 9. One-on-one training occurred in the first three Phases, with the option also being available in Phase 4. For all one-on-one sessions, a whole body exercise intervention was utilized. The frequency of training was prescribed as three sessions per week for 12 weeks. The duration of each exercise session was 60 minutes with 20 minutes designated for cardiovascular exercise, 30 minutes for resistance exercise, 10 minutes for flexibility training, and balance exercises incorporated throughout the entire session. The following modes were utilized for the aerobic portion of the exercise session: treadmill, cycle ergometer, NuStep, Aquaciser (underwater treadmill), outdoor walking or jogging. In regards to resistance exercise, each session targeted the following muscle groups: chest (pectoralis major and minor), back (rhomboids and latissimus dorsi), lower body (quadriceps and hamstrings), and core (trunk stabilizers and pelvic floor), and utilized three sets of 10 repetitions of each exercise. Other muscle groups may have been included (deltoids, biceps, triceps, adductors, etc.) within the 30 minutes of strength training. Modes of resistance training included: Cybex® resistance machines, therabands, dumbbells, medicine balls, body weight, and resistance tubing.

The flexibility portion utilized stretches targeting all muscle groups that were used during the exercise session. Additional equipment that aids in the stretching portion included: rope pulleys, range of motion wheels, and ropes. For the addition of balance, the following equipment was used: ski poles, stability balls, Bosu balls, Ballast balls, dyna disks, wobble boards, and foam pads. Prior to the start of each exercise session, resting HR, BP, and SPO_2 were measured and current health was assessed via discussion with the participant. A heart rate monitor was worn throughout the entire session by the

participant. At the conclusion of every session, HR, BP, and SPO_2 were measured to ensure values were near resting measures and the participant was safe to leave the facility.

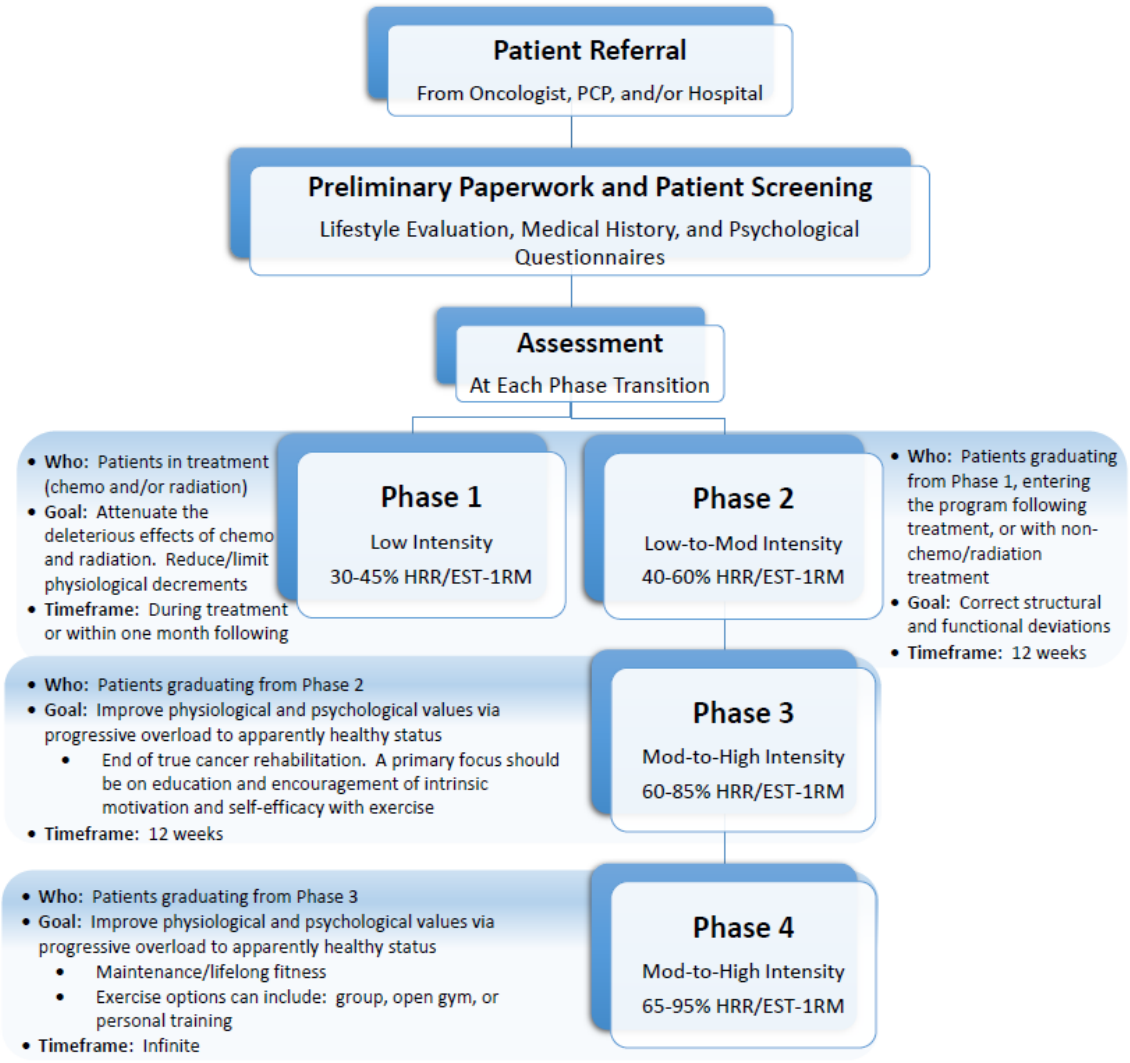

Figure 9. Phase Training Model of Cancer Rehabilitation

Phase 1 was designed for cancer survivors who are still receiving chemotherapy or radiation treatments. Due to side effects being more prevalent while in treatment as opposed to out of treatment (Sprod et al., 2011), the goal of this Phase was to maintain or slightly increase a cancer survivor's physiological and psychological values. Phase 1 was

specifically designed to adhere to the principles of individuality and specificity. Decrements below baseline should not have occurred, as this Phase was designed to attenuate the toxicities from cancer treatment. The starting intensity was categorized as low (Kuehl et al., 2015; Schneider et al., 2003) with starting intensity ranging between 30-45% HRR and EST 1-RM. This intensity was determined by reviewing over 100 exercise logbooks from clients that were currently undergoing treatment. The mean training intensity was well tolerated among patients and varied between 30-45% HRR, which corresponded with intensities for those in poor health (Schneider et al., 2003). Participants remained in this Phase for the duration of his or her cancer treatment or for 12 weeks, if treatment concluded prior to the entry into the next Phase. Of note, usage of any aquatic exercises was prohibited during this Phase due to skin irritation resulting from treatment.

Phase 2 was designed for cancer survivors who have moved from Phase 1 to Phase 2, or for any survivor who had undergone cancer treatment that was not categorized as chemotherapy or radiation therapy. Other forms of treatment included hormonal altering or blocking therapy, immunotherapy, or stem cell transplants. Side effects from a survivor undergoing chemotherapy or radiation differ from the side effects experienced during other forms of treatment which are generally less severe (Collins et al., 2011). Due to this, the starting intensity of Phase 2 was prescribed as low-to-moderate (Kuehl et al., 2015); and ranged between 40%-60% HRR and EST 1-RM. The intensity was determined by reviewing over 100 exercise logbooks for those who had just completed cancer treatments. This intensity range was closely related to intensities previously reported for the active, cancer patient (Schneider et al., 2002). The goal of

Phase 2 was to build a foundational base using corrective and functional training with a focus on developing and stabilizing the core, pelvic floor, shoulder girdle, or any other joints or muscles affected by surgery and/or hormonal treatments, and to alleviate the lasting effects from chemotherapy or radiotherapy. Stabilizer muscles such as the core, pelvic floor, and shoulder girdle are prominently affected by cancer and its treatments (Collins et al., 2011; Swenson et al., 2002). Strengthening these components of the body will assist with activities of daily living and general movement patterns. Phase 2 was designed to continue adherence to the principles of individuality and specificity, and to begin incorporating progressive overload based on assessment results and treatment deficits. Typically, a client remained in this Phase for 12 weeks.

Phase 3 was intended for cancer survivors who have completed Phase 2, and was the transitional Phase from cancer rehabilitation to apparently healthy exercise. As Phase 3 represented the last Phase considered cancer rehabilitation, a major goal was to educate participants with the skills necessary to implement and maintain an exercise program on their own. Participants should have transitioned from Phase 3 with the ability to perform exercises with self-efficacy and knowledge to avoid injury and create progression. This goal existed to support the principles of diminishing returns and reversibility. Phase 3 also aimed to improve physiological and psychological values beyond baselines and to incorporate the principle of progressive overload to the highest extent. Improvements should have occurred in cardiovascular fitness, muscular strength and endurance, pulmonary function, flexibility, and balance. Psychological improvements should have been visible via QOL, depression, and fatigue scores. At completion, cancer survivors should have achieved classification near or at apparently healthy status. This type of

training was classified as moderate-to-high, as starting intensities ranged between 60-85% HRR and EST 1-RM. This range has been deemed appropriate for vigorous exercise (Kuehl et al., 2015; Scharhag-Rosenberger et al., 2015) and overload. A cancer survivor remained in this Phase for 12 weeks.

Phase 4 was designed for cancer survivors who have completed Phase 3, and there was no time limit for this Phase. Cancer survivors in this Phase had successfully completed the prior three Phases, and were deemed close or at apparently healthy status. Phase 4 was not considered cancer rehabilitation as it was meant to assist patients for the rest of their lives in maintaining physical activity and healthy function. Unlike the other three Phases, additional alternatives to one-on-one training were available. Patients may have chosen to participate in group fitness classes or attend an open gym schedule at UNCCRI. The goal of this Phase was to maintain improvements in both physiological and psychological values gained during the past Phases or continue progressive overload based on the patient's personal goals. The type of training was classified as moderate-to-near-maximal, as the range starting of intensities was 65-95% HRR and EST 1-RM. This intensity range was appropriate for cancer survivors who are or close to apparently healthy status (Kuehl et al., 2015; Scharhag-Rosenberger et al., 2015).

Statistical Analysis

Individual paired-sample t-tests were utilized to examine if significant differences occurred in cardiovascular endurance, muscular strength, and fatigue during each Phase transition. The following dependent variables were assessed: VO_{2peak}, EST 1-RM of the leg press, EST 1-RM of the chest press, strength-to-weight ratio for the leg press, strength-to-weight ratio for the chest press, and fatigue. The following Phase transitions

(assessment and reassessment) were evaluated: Phase 1 to Phase 2, Phase 2 to Phase 3, and Phase 3 to Phase 4. Because several paired t-tests were utilized, a Bonferroni adjustment was used to reduce the chance of committing type I error. Statistical analyses were performed using the Statistical Package for the Social Sciences software package (SPSS, Chicago, IL.). Significance levels were set at $p < 0.05$.

Results

The purpose of this study was to evaluate the effects of the Phase Training Model on cardiorespiratory endurance, muscular strength, and cancer-related fatigue in cancer survivors during the transition from each Phase and in those who have completed the entire Phase Training Model.

Participant Characteristics

Table 7 displays the demographic characteristics of the participants. A total of 152 cancer survivors were included in this study. The study consisted of 58 males and 94 females, where the mean age was 62 ± 12 years of age and the mean weight was 80 ± 21 kgs. Table 8 depicts the total number of assessments and Phase transitions that occurred among the participants. Of these, 87.7% of the assessments represented standard Phase transitions from one Phase to the subsequent Phase, whereas 12.3% were non-standard transitions in which the individual remained in the same Phase for an additional 12 weeks. Non-standard Phase transitions occurred from Phase 1 to Phase 1 during continued chemotherapy and/or radiation treatment, from Phase 2 to Phase 2 when there existed lasting functional and postural deviations that required additional time to attenuate, and from Phase 3 to Phase 3 due to a participant that required further education and motivation to learn proper form, exercise creation, and generate the self-efficacy

needed to establish an exercise intervention. Tables 9, 10, and 11 display the cancer types, treatment demographics, and cancer stages, respectively. Cancer types included: Breast (36%), liquid (12%), prostate (11%), lung (11%), head and neck (7%), gynecological (5%), colorectal (4%), and other cancer types (14%). Of the participants, 13% had surgery only, 9% had chemotherapy only, 3% had radiation only, 26% had surgery and chemotherapy only, 18% had surgery and radiation only, 3% had chemotherapy and radiation only, 27% had surgery, chemotherapy, and radiation, and 1% had no treatment. For those who had completed treatment, the average time post treatment was 10 months. Of the participants, 24%, 26%, 24%, and 14% were diagnosed as stage 1, 2, 3, or 4, respectively; 12% of the stages were either unknown or were not staged.

Mean attendance of all subjects participating in the program was 80% and average retention was approximately 58% between each Phase Transition until program completion. The retention for those who began in and completed Phase 1 was 54%. For those who entered the program as Phase 2, the retention was 65%. Finally, retention for those who completed Phase 3 and completed the program into Phase 4 was 54%. Of the 152 program participants, 33 completed the entire Phase program from entry to Phase 4.

Table 7

Participant Characteristics

Participant Characteristics	**N = 152**
Age (years)	62 ± 12
Male, n (%)	58 (38)
Female, n (%)	94 (62)
Height (centimeters)	168 ± 10
Weight (kilograms)	80 ± 21

Table 8

Assessments and Phase Transitions

Phase Transitions	**N (%)**
Total Assessments	292
Phase 1 to Phase 2	43 (14.7)
Phase 2 to Phase 3	126 (43.2)
Phase 3 to Phase 4	68 (23.3)
Phase 4 to Phase 4	19 (6.5)
Phase 1 to Phase 1*	16 (5.5)
Phase 2 to Phase 2*	13 (4.5)
Phase 3 to Phase 3*	7 (2.4)

*Denotes a non-standard Phase Transition

Table 9

Cancer Types

Cancer Types	**N (%)**
Breast	55 (36)
Liquid	19 (12)
Prostate	16 (11)
Lung	16 (11)
Head and Neck	10 (7)
Gynecological	8 (5)
Colorectal	7 (4)
Other	21 (14)

Table 10

Treatment Demographics

Treatment Demographics	**N (%)**
Surgery only	20 (13)
Chemotherapy only	14 (9)
Radiation Only	5 (3)
Surgery and Chemotherapy Only	40 (26)
Surgery and Radiation Only	27 (18)
Chemotherapy and Radiation Only	5 (3)
Surgery, Chemotherapy, and Radiation	39 (27)
No treatment	2 (1)
Average Months Since Treatment	10

Table 11

Cancer Stage

Cancer Stage	**N (%)**
I	37 (24)
II	39 (26)
III	37 (24)
IV	21 (14)
Unknown/not staged	18 (12)

Changes in Peak Volume of Oxygen Consumption, Muscular Strength, and Fatigue in Phase Transitions

Table 12 depicts absolute values (pre-to-post) for all Phase transitions for VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$), leg press muscular strength (MS) (kgs lifted), chest press MS, leg press strength-to-weight ratio (SWR), chest press SWR, and fatigue. Figure 10 depicts mean percent change in VO_{2peak} and fatigue. Figure 11 and 12 depicts mean percent changes in lower body and upper body strength, respectively.

Phase 1 to 2 transition. Significant improvements were observed in VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) (19.9 ± 7.5 to 22.5 ± 8.0; $p < 0.001$), leg press MS (kgs) (82 ± 34 to 88 ± 44; $p < 0.05$), chest press MS (kgs) (27 ± 16 to 32 ± 19; $p < 0.001$), leg press SWR (0.98 ± 0.5 to 1.11 ± 0.5; $p < 0.05$), chest press SWR (0.35 ± 0.2 to 0.38 ± 0.2; $p < 0.05$), and fatigue (5.0 ± 2.5 to 3.6 ± 2.0; $p < 0.05$). Percent change for each variable was as follows: VO_{2peak} (12.5%), leg press MS (7.5%), chest press MS (16.2%), leg press SWR (9.6%), chest press SWR (8.1%), and fatigue (-27.3%).

Phase 2 to 3 transition. Significant improvements were observed in VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) (21.1 ± 7.0 to 24.3 ± 8.4; $p < 0.001$), leg press MS (kgs) (83 ± 32 to 96 ± 42; $p < 0.001$), chest press MS (kgs) (30 ± 18 to 36 ± 19; $p < 0.001$), leg press SWR (1.02 ± 0.3 to 1.18 ± 0.4; $p < 0.001$), chest press SWR (0.36 ± 0.2 to 0.45± 0.2; $p < 0.001$), and fatigue (4.2 ± 2.3 to 3.0 ± 2.2; $p < 0.001$). Percent change for each variable was as follows: VO_{2peak} (15%), leg press MS (15.7%), chest press MS (23%), leg press SWR (15.7%), chest press SWR (24.7%), and fatigue (-26.8%).

Phase 3 to 4 transition. Significant improvements were observed in VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) (24.3 ± 7.0 to 25.5 ± 7.1; $p < 0.05$), chest press MS (kgs) (37 ± 18 to 40

± 20; $p < 0.05$), and chest press SWR (0.46 ± 0.2 to 0.49 ± 0.2; $p < 0.05$). Non-significant improvements ($p > 0.05$) were observed in leg press MS (kgs) (101 ± 47 to 105 ± 41) and fatigue (3.4 ± 2.1 to 3.1 ± 2.2). A non-significant decrease in leg press SWR was observed (1.29 ± 0.4 to 1.28 ± 0.4). Percent change for each variable was as follows: VO_{2peak} (5%), leg press MS (3.6%), chest press MS (7.6%), leg press SWR (-0.1%), chest press SWR (7.6%), and fatigue (-8%).

Phase 4 to 4 transition. Non-significant improvements were observed in leg press MS (kgs) (97 ± 44 to 98 ± 37), chest press MS (kgs) (32 ± 17 to 34 ± 15), leg press SWR (1.16 ± 0.4 to 1.22 ± 0.4), and fatigue (2.8 ± 2.1 to 2.2 ± 2.0). A non-significant decrease ($p > 0.05$) in chest SWR (0.44 ± 0.2 to 0.43 ± 0.2) and VO_{2peak} (25.6 ± 6.8 to 24.6 ± 6.1) was observed. Percent change for each variable was as follows: VO_{2peak} (-3.6%), leg press MS (1.4%), chest press MS (4%), leg press SWR (5.3%), chest press SWR (-2.4%), and fatigue (-21.9%).

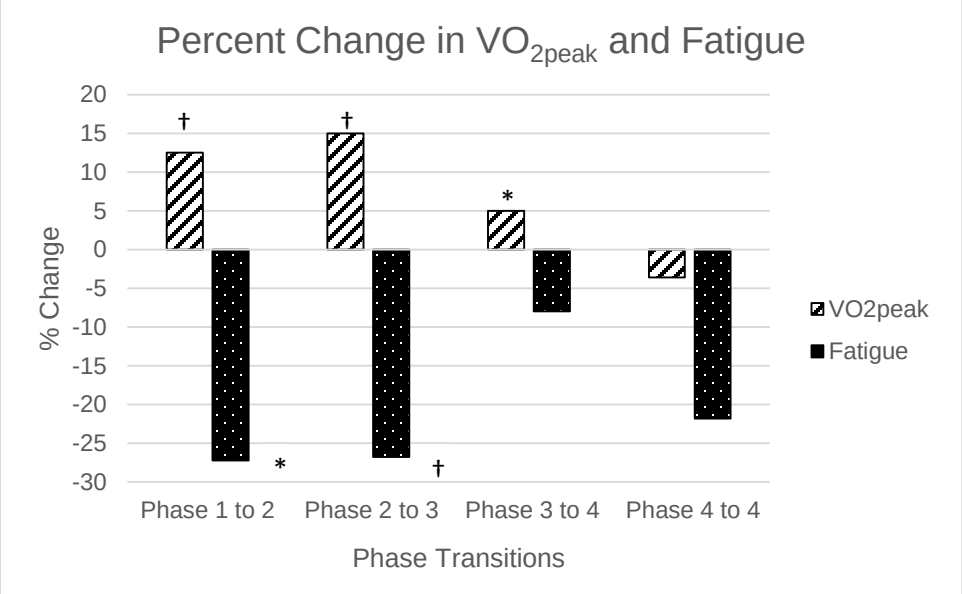

Figure 10. Mean percent change in VO_{2peak} and fatigue. *$p < 0.05$; †$p < 0.001$

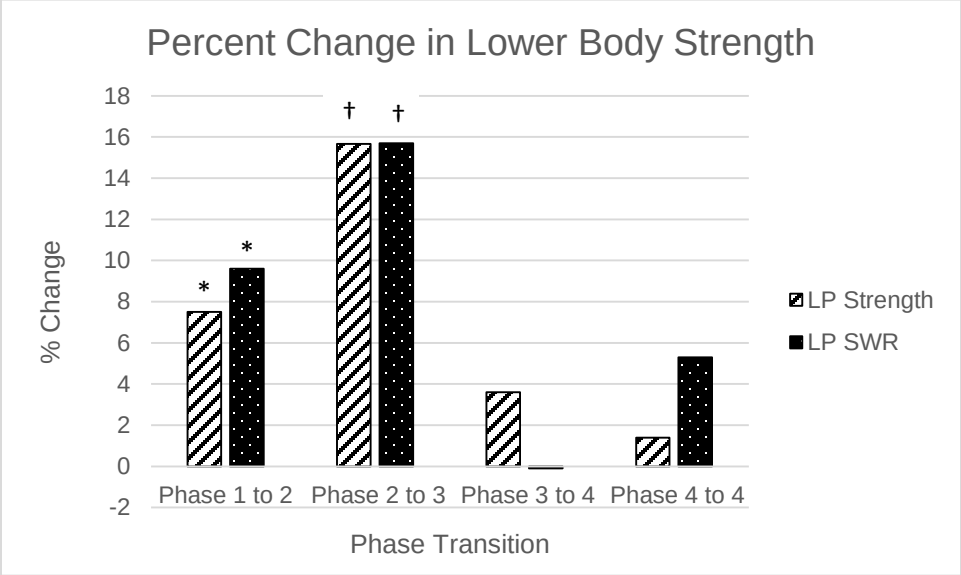

Figure 11. Mean percent change in lower body strength. LP, leg press; SWR, strength-to-weight ratio; *p < 0.05; †p < 0.001

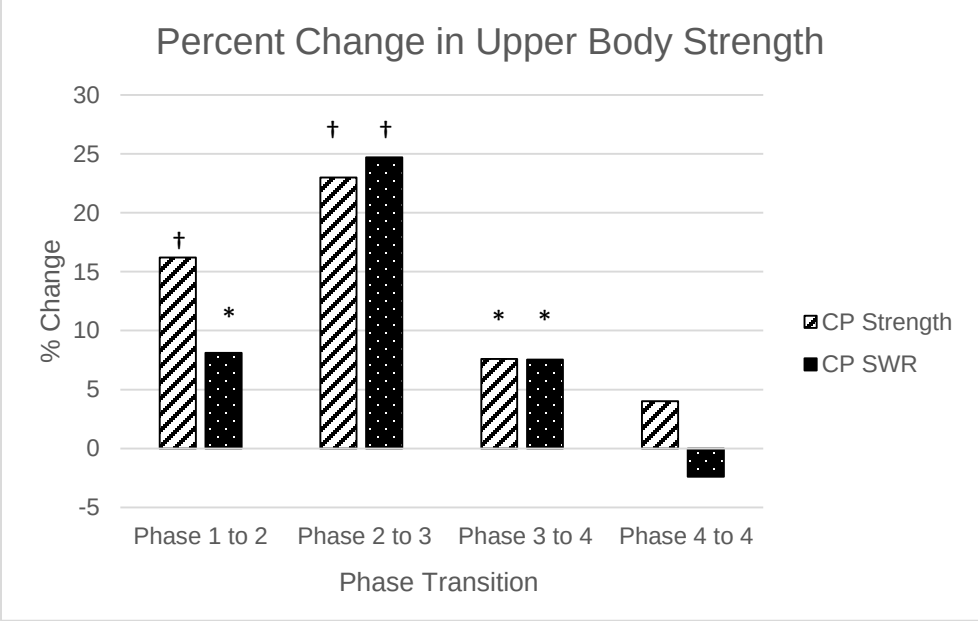

Figure 12. Mean percent change in upper body strength. CP, chest press; SWR, strength-to-weight ratio; *p < 0.05; †p < 0.001

Table 12

Improvements in Physiological Values and Fatigue

Phase Transition	Phase 1 to 2		Phase 2 to 3		Phase 3 to 4		Phase 4 to 4	
N	43		126		68		19	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
VO_{2peak}	19.9 ± 7.5	22.5 ± 8.0†	21.1 ± 7.0	24.3 ± 8.4†	24.3 ± 7.0	25.5 ± 7.1*	25.6 ± 6.8	24.6 ± 6.1
Leg press MS	82 ± 34	88 ± 44*	83 ± 32	96 ± 42†	101 ±47	105 ± 41	97 ± 44	98 ± 37
Chest Press MS	27 ± 16	32 ± 19†	30 ± 18	36 ± 19†	37 ± 18	40 ± 20*	32 ± 17	34 ± 15
Leg Press SWR	0.98 ± 0.5	1.11 ± 0.5*	1.02 ± 0.3	1.18 ± 0.4†	1.29 ± 0.4	1.28 ± 0.4	1.16 ± 0.4	1.22 ± 0.4
Chest Press SWR	0.35 ± 0.2	0.38 ± 0.2*	0.36 ± 0.2	0.45 ± 0.2†	0.46 ± 0.2	0.49 ± 0.2*	0.44 ± 0.2	0.43 ± 0.2
Fatigue	5.0 ± 2.5	3.6 ± 2.0*	4.2 ± 2.3	3.0 ± 2.2†	3.4 ± 2.1	3.1 ± 2.2	2.8 ± 2.1	2.2 ± 2.0

Note. N = number of participants, VO_{2peak} = peak volume of oxygen consumption ($mL \cdot kg^{-1} \cdot min^{-1}$); MS = muscular strength (kgs lifted); SWR = Strength-to-weight ratio; * denotes a p value < 0.05 between pre and post values; † denotes a p value < 0.001.

Changes in Patients Who Completed the Entire Phase Training Model (Entry to Phase 4)

Changes in VO_{2peak} for patients who completed the entire Phase Model are depicted in Figure 13. Mean initial VO_{2peak} values at the initial assessment was 18.9 mL•kg-^{1}•min-^{1}. At the first reassessment, VO_{2peak} increased to 21.7 mL•kg-^{1}•min-^{1} (+15.2%). At the second reassessment, VO_{2peak} increased to 22.5 mL•kg-^{1}•min-^{1} (+3.7%). At the third reassessment, VO_{2peak} increased to 24.4 mL•kg-^{1}•min-^{1} (+8.4%). Mean percent improvements for chest press and leg press were 79.7% and 50.3%, respectively. Fatigue decreased by -29.4% from entry to program completion.

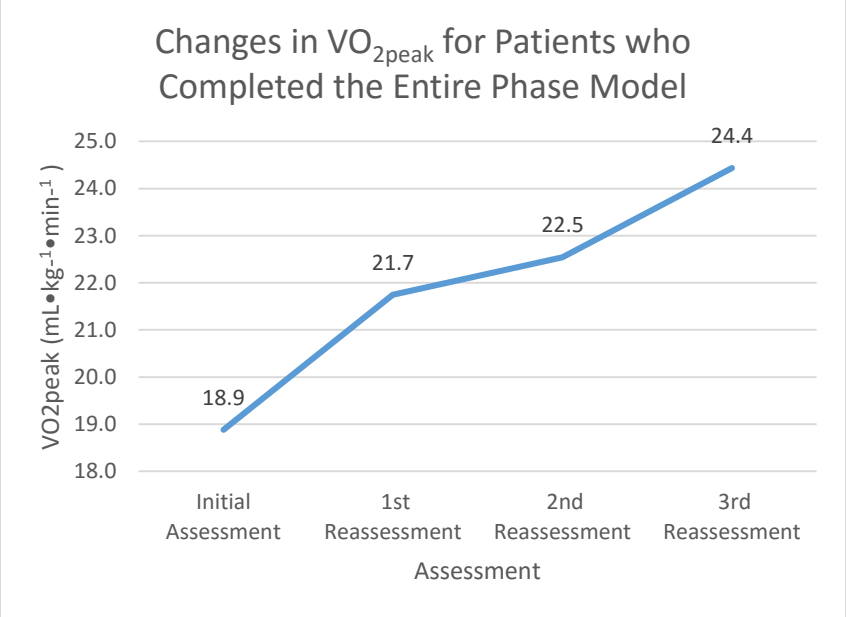

Figure 13. Mean changes in VO_{2peak} for patients who completed the entire Phase Model.

Discussion

The Phase Training model of cancer rehabilitation elicited improvements in cardiovascular endurance, muscular strength, and/or fatigue during all Phase transitions. The majority of significant improvements occurred during the transition from Phase 1 to Phase 2 and from Phase 2 to Phase 3, although each specific Phase resulted in improvements for most variables. For the patients who achieved Phase 4 and completed the rehabilitation program, cardiovascular endurance, muscular strength, and fatigue improved during each Phase transition, eliminating the plateau in progression that had been observed in our previous model (Brown, Lalonde, et al., 2012). These improvements resulted from the detailed and individualized method of exercise prescription and progression utilized in the Phase Training model.

Phase 1

Participants who completed Phase 1 experienced significant improvements in all variables after the 12-week intervention. The goal of Phase 1 was to maintain or offset any negative side effects caused by treatment with low intensity, prescriptive exercise. However, the low intensities set for this Phase not only reduced the decline in function caused by treatment, it significantly improved function. Participants who completed Phase 1 improved upper (16%) and lower (8%) body muscular strength, cardiovascular endurance (13%), and fatigue (-27%). Similar improvements in upper body strength (Adamsen et al., 2009; Jarden, Baadsgaard, Hovgaard, Boesen, & Adamsen, 2009) and lower body strength (Adamsen et al., 2009; Battaglini et al., 2007) have been observed in patients undergoing treatment previously. Strength training increases protein synthesis, increases muscle mass, and may offset cancer-related cachexia. This may explain why

survivors in Phase 1 not only maintained strength levels, but significantly improved beyond baseline measurements. Additionally, aerobic exercise has demonstrated cardioprotective effects which may explain the improvements observed in cardiovascular function (Chicco, Schneider, & Hayward, 2006; Scott et al., 2011). Cancer-related fatigue decreased by 27% in the patients transitioning from Phase 1 and this reduction is similar to previously observed results (Puetz & Herring, 2012; Schneider et al., 2007b). Contrary to the belief that fatigue levels may be heightened for those exercising while undergoing treatment, this study shows that when exercising at appropriate intensities, fatigue levels can be significantly reduced.

The improvements observed in Phase 1 exceeded expectations, as the exercise prescription dictated a low intensity (30-45% HRR) and a small progression for cardiovascular endurance and muscular strength of 5% and 15%, respectively. Modest improvements were anticipated as the majority of patients underwent all major treatment types and specifically due to the known toxicities associated with chemotherapy. Similar results have been observed in a demographically comparable group of breast cancer survivors undergoing treatment following a 12-week high intensity (60-100% of VO_{2peak}) aerobic exercise intervention (Hornsby et al., 2014). The exercise intensity prescribed in The Phase Training model for patients in Phase 1 was low due to the J-shaped curvilinear relationship between the risk of infection and increasing exercise workloads, where vigorous or heavy intensity exercise may result in a higher than normal risk of infection (Nieman, 1994). While the moderate-to-high intensity exercise utilized by Hornsby et al. (2014) yielded significant aerobic improvements, we demonstrate that similar benefits

occur using a lower intensity. This lower intensity may preserve immune function and reduce the risk of adverse effects in patients undergoing treatment.

Phase 2

Energy levels have been observed to increase once treatment has been completed (Courneya & Friedenreich, 1997). Due to this, exercise tolerance for an individual who has completed treatment will increase and may enhance the positive effects of exercise (Pinto, Trunzo, Reiss, & Shiu, 2002). The intensity prescribed for Phase 2 is higher than that of Phase 1 and represents a low-to-moderate range (40-60% HRR/EST-1RM) dependent on the patient's improvements from the previous Phase and/or lingering treatment side-effects. Additionally, patients in Phase 2 were prescribed up to a 20% progression for cardiovascular improvements and between 30 to 50% for strength. In conjunction with the increased emphasis on the principle of progressive overload, Phase 2 also prescribes correctional exercises with the goal of attenuating functional and postural deviations that may be present in patients following treatment or surgical intervention. This prescription and rate of progressive overload allowed the patients to achieve greater improvements in fatigue, cardiovascular endurance, and muscular strength than in Phase 1.

Levels of cancer-related fatigue significantly decreased in patients transitioning from Phase 2 to Phase 3 by 27%. This reduction resulted in the improvement of fatigue classification from "moderate" to "mild." It has been considered that greater improvements in fatigue will be observed in patients with a longer duration between treatment completion and exercise program initiation. Specifically, fatigue improvements are thought to be greater in those post treatment compared to those in

treatment (Puetz & Herring, 2012). Our findings show that significant declines in fatigue are possible immediately following treatment even with treatment completion averaging only 10 months. Interestingly, these improvements in fatigue, for many patients, were additive to the large, almost identical, significant improvements previously observed in Phase 1, suggesting that exercise attenuates cancer-related fatigue to the greatest extent during treatment and immediately following.

Cardiovascular endurance significantly increased by 15% in the transition from Phase 2 to Phase 3, which is slightly greater than improvements seen previously in earlier versions of our program (Brown, Lalonde, et al., 2012; Schneider et al., 2007b). In a study by Dittus et al. (2015), a similar Phase 2-based, 12-week exercise program with 20 minutes of cardiovascular exercise prescribed at 70 to 85% HRmax in patients following treatment, resulted in a 7.5% non-significant improvement in VO_{2peak}. This smaller improvement may have been due to utilizing a group model of four to six patients versus an individualized, one-on-one model or due to the subject demographics. This study consisted of mainly female breast cancer survivors, with an average time of 2.36 years post treatment. The subjects may not accurately represent the diverse cancer and treatment types represented in the cancer population immediately following treatment, and thus experience reduced side effects limiting exercise-based improvements.

Muscular strength improved significantly in subjects completing Phase 2 by an average of 20%. Similar improvements in strength have been observed in several other studies in cancer survivors not undergoing treatment (Schneider et al., 2007b), many of which utilized higher intensities (Dittus et al., 2015; Schneider et al., 2007b). In fact, following a moderate-to-high intensity resistance training intervention in breast cancer

survivors following treatment (average time from treatment of 56.5 months), average muscular strength improved significantly by 16%. Of note, the authors stated that strength only improved in those subjects who attended 50% or more of the prescribed exercise sessions and that withdrawal from the program occurred primarily in those closest to treatment (approximately 43 months since treatment) (Winters-Stone et al., 2013).

A correlation may exist between exercise intensity, time from treatment, and attendance. The intensities prescribed in Phase 2 are low-to-moderate and were capable of eliciting similar improvements in strength as the higher intensity intervention used by Winters-Stone et al. (2013). Specifically, as the average time from treatment in our study was 10 months and represents a common time point in the cancer population immediately following treatment, a lower than vigorous intensity may be desirable if it enhances exercise attendance for those closest to treatment. To further this thought, although the preservation of immune function is of less concern in those following treatment as opposed to those in treatment, and a higher intensity may not negatively affect health, increased exercise intensity may reduce attendance rates and adherence (Cox, Burke, Gorely, Beilin, & Puddey, 2003). In fact, in a study of sedentary adults randomly assigned to a moderate intensity or vigorous intensity exercise intervention, adherence was significantly greater in the moderate intensity group (Perri et al., 2002). The low-to-moderate intensity of Phase 2 resulted in significantly improved physiological and psychological values in cancer survivors immediately following treatment, while maintaining an average attendance rate of 80%. This suggests that the intensity and

progression prescribed in Phase 2 not only improves function, but may positively affect program attendance and adherence.

Phase 3 and Phase 4

Patients who transitioned from Phase 3 to 4 significantly improved cardiovascular endurance and upper body strength by 5% and 8%, respectively. Fatigue was reduced by -8% and lower body strength improved by 4%, but both were not significant. The transition from Phase 3 marks the end of true cancer rehabilitation in the Phase Training model and while many patients remain in the program for Phase 4 training, it is rarely individualized as most opt for a group model of exercise intervention.

Following the completion of Phase 3, 65% of the participants improved to the "good" or above classifications for strength-to-weight ratio for the leg press. In fact, 53% of the subjects scored in the "excellent" or "superior" classification for lower body strength when compared to the apparently healthy norms. Forty-three percent of the patients improved to the "good" or above classification for strength-to-weight ratio for the chest press, and although this is lower than lower body strength improvements, it should be noted that 36% of our patients are breast cancer survivors and that improvement in this variable was still significant. Perhaps of greatest importance, 59% of the cancer survivors in this study improved in cardiovascular endurance, as measured by $VO_{2peak,}$ to a classification and percentile deemed "fit" (Blair et al., 1989; Farrell, Braun, Barlow, Cheng, & Blair, 2002). It has been demonstrated that sedentary men who were unfit at the initial examination, but who became fit at reassessment, had a 44% reduction in risk of mortality when compared to similar unfit men who did not improve. Specifically, for each minute increase in treadmill time, there is a corresponding 8%

decrease in the risk of mortality (Blair, et al., 1989). Improvement by one minute increments using the UNCCRI Treadmill protocol generates an increase in calculated VO_{2peak}. The Phase Training model yielded significant improvements in VO_{2peak} during the transition from Phases 1, 2, and 3. Notably, these consistent improvements in VO_{2peak} at each Phase transition can represent a reduction in all-cause mortality from entry to completion of the program. Considering the complex treatment-related toxicities experienced by most cancer survivors, this continual decrease in risk of mortality at each reassessment may improve prognosis and reduce risk of recurrence. Improvements in fatigue were minimal, but this may be expected as time from treatment is increased and as exercise exposure increases, the severity of perceived fatigue will also decrease (Schwartz et al., 2001).

Across all parameters, the amount of improvement was reduced in Phases 3 and 4, when compared to the large improvements observed in Phases 1 and 2. Although improvements were observed in all variables, only upper body strength and cardiovascular endurance improved significantly in Phase 3. Upper and lower body strength improved slightly in Phase 4, while VO_{2peak} remained relatively the same. Fatigue continued to be reduced through all Phase transitions and was the lowest for those in Phase 4. For some individuals this reduction in improvements may be due to the principle of diminishing returns, particularly in those who yielded classifications above excellent. For others, there may have been an unforeseen reduction in the ability to maintain adherence to the principle of overload as the frequency and duration of exercise sessions were capped in this study. Phase 3 was designed to adhere to the principle of progressive overload, as the intensity prescribed in Phase 3 represents a vigorous or high

intensity. ACSM recommends a frequency of 5 to 7 days per week at a moderate intensity (40-59% HRR) for 30 to 60 minutes each day. Additionally, if the exercise intensity is vigorous (60-89% HRR), the recommended frequency is 3 to 5 days per week, for 20 to 60 minutes each day. Phase 3 adheres to the lower end of the latter recommendation. The program prescribes exercise for three, 60 minute sessions per week (combined aerobic and resistance training) at a vigorous intensity of 60-85% HRR/EST 1-RM. This level of progressive overload may be sufficient to elicit change in some individuals in Phase 3, but as one adapts to the stress of the exercise (and the side-effects from cancer treatments continue to lessen), the fitness level increases, and greater volume is needed to elicit further results. The volume of exercise refers to the product of frequency, intensity, and duration (American College of Sports Medicine, 2013). The intensity prescribed in Phase 3 already represents a vigorous intensity, therefore to increase progressive overload, the frequency and duration must be enhanced. Unfortunately, the ability to increase session length or add additional sessions is limited by program infrastructure and by cost to the patient. Therefore, volume must be increased via frequency and/or duration outside of the program, by the patients themselves.

The United States Department of Health and Human Services (USDHHS) recommends a minimum of 150 minutes of moderate intensity exercise or 75 minutes of vigorous exercise per week to obtain health benefits (U.S. Department of Health and Human Services, 2008). Phase 3 prescribes about 150 minutes per week of vigorous exercise to meet this guideline, however it is stated that at least twice this amount (USDHHS), and up to five times (Sattelmair et al., 2011), is needed for additional

benefits. In a recent study of our Phase 3 and 4 program participants documenting their daily physical activity patterns, it was revealed that 78% of their time was spent in sedentary behavior, 20% spent in light physical activity, and only 2% spent doing moderate-to-vigorous exercise. It was concluded that the vigorous exercise occurred only during the prescribed exercise sessions, and that the participants remained largely sedentary the remainder of the week (Coronado et al., 2016). Because the majority of the participants transitioning from Phase 3 represent "good" or "fit" classifications for strength and aerobic capacity, an increased frequency and/or duration must be incorporated by the individual outside of the program to continue to elicit results. Although the education and generation of self-efficacy and intrinsic motivation is already an established goal of Phase 3, these results suggest an imperative need to begin this process immediately at the start of Phase 3 and during Phase 4. To accomplish this, individuals working with cancer survivors in an exercise-based rehabilitation program must prescribe exercise "homework" for their patients and it must be followed by the patient outside of the established rehabilitation program to ensure continued improvements. As stated previously, higher intensity exercise results in reduced attendance and adherence. Therefore, while clinicians can attempt to increase intensity further to ensure progressive overload during the intervention without relying on added frequency or duration, it may limit attendance and ultimately result in the completion of less exercise over time (Perri et al., 2002).

A Need for Phases 3 and 4?

The improvements observed in Phases 3 and 4 were less than those observed in the earlier Phases. This may be due to the principle of diminishing returns and the

continued physical improvements observed as time from treatment grows. Specifically, for most patients who have experienced improvement in the previous Phases, increased progressive overload in the form of increased frequency or duration outside of the established program may be needed. Some clinicians may suggest there is no need for an established intervention at this time point and propose the removal of Phases 3 and/or 4. To negate this thought, it has been well-documented that home-based or homework assigned exercise interventions have significantly lower attendance and adherence rates when compared to supervised interventions. Specifically, Winters-Stone et al. (2013) documented that the home-based portion of a resistance training exercise program resulted in an attendance rate of only 27% versus 82% in the supervised sessions. Similarly, another study examined whether six months of supervised exercise resulted in greater long-term retention and adherence when compared to a regular, home-based intervention in older, sedentary women. It was found that exercise adherence was significantly higher in the supervised group and that energy expenditure was higher (Cox et al., 2003). Although it may be tempting to limit the prescriptive, individualized exercise intervention to Phases 1 and 2, for some individuals the intensity of Phase 3 alone may generate enough stress to elicit improvements, and for others, adoption of additional exercise at home may be more manageable in conjunction with regularly scheduled exercise sessions.

In recognition of the principle of individuality, not all patients completed a standard transition from one Phase to the next. Twelve percent of our subjects reassessed into the same Phase following the 12-week intervention, representing a non-standard transition. The majority of these, about 16 (5.5%) patients remained in Phase 1 due to

continued treatment status. Thirteen (4.5%) patients experienced functional and postural deviations as a result of surgical intervention and treatments that required additional time to address, causing them to remain in Phase 2. Only seven subjects (2.4%) remained in Phase 3 due to the fact that they required further education to reach the targeted level of self-efficacy to progress to Phase 4. The Phase Training model ensures individuality is maintained even when standard Phase transitions are not justified.

The prescribed intensity and rate of progression of Phase 1 was appropriate for those in treatment and was well-tolerated. This addresses concerns that patients during treatment may not be able or willing to participant in an exercise-based rehabilitation program, and negates the thought that these patients only be prescribed in-patient physical therapy (Dittus et al., 2015). Our results suggest that not only is our model safe, but that it is capable of eliciting significant physiological and psychological improvements despite the limiting side effects of treatment. We suggest that the exercise prescription utilized in Phase 1 become the standard intervention for patients undergoing treatment.

Conclusion

To date, this is the only study to establish a structured model of cancer rehabilitation and to evaluate its effectiveness over a longitudinal timeframe in patients at different time points on the cancer continuum. Research is lacking on exercise interventions lasting longer than three months, specifically with consistent reassessment of physiological and psychological data. The information gained from these long-term interventions is needed to determine the effectiveness of exercise-based rehabilitation on patient prognosis, rates of recurrence, and total healthcare costs.

Currently, there are a limited number of exercise-based programs being offered for cancer survivors despite the evidence that exercise rehabilitation improves functional capacity (Brown, Huedo-Medina, et al., 2012; Dittus et al., 2015; Schmitz et al., 2010; Schneider et al., 2007a; Winters-Stone et al., 2013), may lessen the likelihood of cancer recurrence, and decreases mortality (Blair et al., 1989). The majority of these programs are paid for out of pocket by the patients due to lack of insurance reimbursement and general inadequacy of support from the medical community. Of concern, from our experience, is that the personal financial burden of these programs directly contribute to patient attrition and may limit the benefits gained from a long-term intervention.

This study included participants of both genders, all major cancer types, varying treatment plans, and statuses both during, immediately following and following treatment. Most studies suffer from an overwhelmingly biased patient demographic (e.g. all males, only breast cancer survivors, only during treatment, non-clinically relevant time from diagnosis, etc.). Our subject demographics represents a well-rounded view of the cancer population and for a longer duration of intervention than any other studies.

Up to this point, specific recommendations regarding mode, intensity, frequency, and duration of exercise for cancer survivors has been lacking. As a result, clinicians in general have failed to adhere to the principles of exercise training which guide appropriate exercise prescription for cancer patients. Data from this study provide the first clear and reproducible evidence in support of the Phase Training Model for cancer survivors. This model outlines guidelines for exercise prescription in the cancer population and it consistently yields significant physiological and psychological improvements in cancer survivors both during and following treatment. Based on this

evidence, it is recommended that the Phase Training Model become the standard for exercise-based cancer rehabilitation programs.

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APPENDIX A

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH

INFORMED CONSENT

[FOR PARTICIPATION IN RESEARCH AT UNCCRI]

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ **DATE** _____

PROJECT TITLE : Exercise Interventions to Attenuate the Negative Side-Effects of Cancer Treatments

University of Northern Colorado Cancer Rehabilitation Institute

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jessica.brown@unco.edu

The University of Northern Colorado Cancer Rehabilitation Institute (UNCCRI) and the School of Sport and Exercise Science support the practice of protection of human subjects participating in research. The following information is provided for you to decide whether you wish to participate in either the standard UNCCRI program or if recruited, specific research investigations. You should be aware that even if you agree to participate, you are free to withdraw at any time without affecting opportunities for participation in other programs offered by this department.

This program is involved with the assessment of your body composition, pulmonary function, cardiovascular endurance, muscular strength and endurance, range of motion and flexibility. Skinfold calipers will be used to measure body composition (body fat percentage). The pulmonary function test will be measured through maximum exhalation into a sterile mouthpiece. Measuring oxygen consumption on a motor-driven treadmill will assess your cardiorespiratory capacity. Assessment of muscular strength and endurance will occur through the use of weights, dumbbells, a handgrip dynamometer, and other established tests. Flexibility and range of motion will be measured by the modified sit-and-reach test and the reaching test. Baseline measurements such as: heart rate, blood pressure, height, weight, and circumference measurements will be taken for risk stratification and safety during your participation. Forms to be completed for the program include cancer history, medical history, lifestyle/activity questionnaire, and psychological tests such as depression scales, quality of life, fatigue and cognitive functioning. Blood may be drawn with your permission at various time points during your participation. Once all of the tests are completed, the results will be analyzed and an exercise prescription will be written. You may then have the option of participating in a three month exercise intervention based on your testing results. The expected benefits associated with your participation in this program include information regarding your level of physical fitness and recommended fitness and lifestyle changes necessary to improve your quality of life and health.

Please Initial _____

If you are recruited, and agree to participate in a specific research investigation, additional exercise, psychological, and/or cognitive tests may be administered. Your optional three month exercise intervention may also differ, but the expected benefits should still include improved quality of life and health. All participants at UNCCRI will be under the direction of the UNCCRI Director and Clinical Coordinator but other persons will be associated or assist with the data collection. Your participation is solicited, although strictly voluntary. The obtained data may be used in reports or publications but your identity will not be associated with such reports. We at UNCCRI take mental distress that may accompany health issues seriously and will attempt to support you with counseling referrals and information on local cancer support groups if this is an issue. Our staff is required to report evidence of clear and imminent danger.

This research should not result in physical injury, however, some soreness may occur and some of the fitness tests can be uncomfortable. Additionally, with the blood draws you may feel temporary discomfort. The duration of the discomfort is short. Please give your consent with full knowledge of the nature and purpose of the procedures, the benefits that you may expect, and the discomforts and/or risks which may be encountered. We appreciate your assistance.

Participation is voluntary. You may decide not to participate in this study and if you begin participation, you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference if requested. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910.

_____ _____

Signature of Subject Agreeing to Participate — Date

By signing this consent you certify you are at least 18 years of age.

_____ _____

Signature of Researcher — Date

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

DATE:	March 28, 2016
TO:	Reid Hayward, PhD
FROM:	University of Northern Colorado (UNCO) IRB
PROJECT TITLE:	[573297-4] Exercise Interventions to Attenuate the Negative Side-Effects of Cancer Treatments
SUBMISSION TYPE:	Continuing Review/Progress Report
ACTION:	APPROVED
APPROVAL DATE:	March 26, 2016
EXPIRATION DATE:	March 26, 2017
REVIEW TYPE:	Expedited Review

Thank you for your submission of Continuing Review/Progress Report materials for this project. The University of Northern Colorado (UNCO) IRB has APPROVED your submission. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on applicable federal regulations.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of March 26, 2017.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

APPENDIX C

LIFESTYLE/ACTIVITY EVALUATION

LIFESTYLE/ACTIVITY
[EVALUATION]

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

SMOKING
1. Have you ever smoked cigarettes, cigars, or a pipe?
2. Do you currently smoke? Amount per day/week
3. At what age did you start smoking?
4. When did you quit smoking?

DRINKING
1. During the past month, on how many days did you drink alcoholic beverages?
2. During the past month, what are the most drinks consumed on one occasion?

DIET
1. Are you pleased with your current weight?
2. What would you like to weigh?
3. What is the most you ever weighed as an adult?
4. What is the least you ever weighed as an adult?
5. What weight loss methods have you tried?

EXERCISE
1. Do you exercise on a regular basis?
2. What exercises do you participate in regularly?
3. On average, how many days/week do you exercise?
4. How many minutes do you spend exercising at one time?
5. Would you consider your exercise to be light moderate vigorous
6. Which of the following best describes your occupation:
   - O Inactive (desk job)
   - O Light work (housework, light carpentry)
   - O Heavy work (heavy carpentry, lifting)
7. What physical activities are the most enjoyable to you?
8. What types of facilities/equipment are available for your use?
9. What recreational activities (boating, camping) do you participate in?
10. What recreational activities do you enjoy?
11. Has your physical activity changed in the past year?

SLEEP
1. During the past week, what was your average amount of sleep per night on the week nights? (Sunday-Thursday)
2. What was your average amount of sleep on the weekend nights? (Friday-Saturday)
3. Would you classify your sleep as restful or restless?
4. Do you awake often during the night?
5. Do you regularly take sleep aids?

DAILY ACTIVITY ANALYSIS
1. Do you have difficulty performing any of the following?

   - O Opening jars/turning door knobs
   - O Routine yard work
   - O Carrying groceries/laundry
   - O Driving
   - O Putting groceries/dishes away
   - O Making a bed
   - O Removing laundry from washer/dryer
   - O Lifting children
   - O Clasping any articles of clothing
   - O Other

2. If you answered yes to any of the above,

   a. Did the difficulty begin before or after your treatment for cancer?
      - O Before
      - O After

   b. If known, explain the cause of the difficulty.

Reviewed By

APPENDIX D

MEDICAL HISTORY

MEDICAL HISTORY

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

SECTION I : GENERAL INFORMATION

Age _____ Primary Care Physician _____

Date of Last Completed Physical _____ Oncologist _____

SECTION II : PRESENT MEDICAL HISTORY

Check ALL spaces below which apply to you. If checked, please include explanation and date of occurrence.

		EXPLANATION & DATES
	Rheumatic fever/heart murmur	
	High blood pressure	
	Chest discomfort	
	Heart abnormalities (racing, skipping beats)	
	Abnormal ECG	
	Heart problems	
	Coughing up blood	
	Stomach or intestinal problems	
	Anemia	
	Stroke	
	Sleeping problems	
	Migraine or recurrent headaches	
	Dizziness or fainting spells	
	Leg pain after walking short distances	
	Back/neck pain/injuries	
	Foot/ankle problems	
	Knee/hip problems	
	Lymphedema	
	High cholesterol	
	Diabetes	
	Thyroid problems	
	Lung disease	
	Respiratory problems/asthma	
	Chronic or recurrent cough	
	Disease of arteries	
	Varicose veins	
	Increased anxiety/depression	
	Recurrent fatigue	
	Arthritis	
	Swollen/stiff/painful joints	
	Epilepsy	
	Vision/hearing problems	

PRESENT MEDICAL HISTORY CONT'D

Operations (starting with the most recent)

1.	Date
2.	Date
3.	Date
4.	Date

Hospitalizations (reason)

SECTION III : FAMILY MEDICAL HISTORY

	High blood pressure	Family member(s):	
	Heart attacks	Family member(s):	
	Heart surgery	Family member(s):	
	High cholesterol	Family member(s):	
	Stroke	Family member(s):	
	Diabetes	Family member(s):	
	Obesity	Family member(s):	
	Early death	Family member(s):	
	Cancer	Type:	Family member:
		Type:	Family member:
	Other familial illnesses (list)		

SECTION IV : MEDICATIONS

List all current medications:

Medication	Dosage	Date Started
1.		
2.		
3.		
4.		
5.		
6.		

Drug Allergies

Reviewed By Date

APPENDIX E

REVISED PIPER FATIGUE SCALE

REVISED PIPER FATIGUE SCALE

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

SECTION I

For each of the following questions, circle the number that best describes the fatigue you are experiencing now. Please make every effort to answer each question to the best of your ability.

1. How long have you been feeling fatigued? (check one response only)
   - ☐ Minutes
   - ☐ Hours
   - ☐ Days
   - ☐ Weeks
   - ☐ Months
   - ☐ Other (please describe) _____

2. To what degree is the fatigue you are feeling now causing you distress

   No Distress — A great deal of distress

   0 1 2 3 4 5 6 7 8 9 10

3. To what degree is the fatigue you are feeling now interfering with your ability to complete work or school activities?

   None — A great deal

   0 1 2 3 4 5 6 7 8 9 10

4. To what degree is the fatigue you are feeling now interfering with your ability to visit or socialize with your friends?

   None — A great deal

   0 1 2 3 4 5 6 7 8 9 10

5. To what degree is the fatigue you are feeling now interfering with your ability to engage in sexual activity?

   None — A great deal

   0 1 2 3 4 5 6 7 8 9 10

6. Overall, how much is the fatigue, which you are experiencing now, interfering with your ability to engage in the kind of activities you enjoy doing?

   None — A great deal

   0 1 2 3 4 5 6 7 8 9 10

7. How would you describe the degree of intensity or severity of the fatigue which you are experiencing now?

   Mild — Severe

   0 1 2 3 4 5 6 7 8 9 10

SECTION II

To what degree would you describe the fatigue which you are experiencing now as being:

8. Pleasant — Unpleasant

   0 1 2 3 4 5 6 7 8 9 10

9. Agreeable — Disagreeable

   0 1 2 3 4 5 6 7 8 9 10

CONTINUED ON NEXT PAGE

10. Protective — Destructive
0 1 2 3 4 5 6 7 8 9 10

11. Positive — Negative
0 1 2 3 4 5 6 7 8 9 10

12. Normal — Abnormal
0 1 2 3 4 5 6 7 8 9 10

13. To What degree are you now feeling
Strong — Weak
0 1 2 3 4 5 6 7 8 9 10

14. To what degree are you now feeling
Awake — Sleepy
0 1 2 3 4 5 6 7 8 9 10

15. To what degree are you now feeling
Lively — Listless
0 1 2 3 4 5 6 7 8 9 10

16. To what degree are you now feeling
Refreshed — Tired
0 1 2 3 4 5 6 7 8 9 10

17. To what degree are you now feeling
Energetic — Unenergetic
0 1 2 3 4 5 6 7 8 9 10

18. To what degree are you now feeling
Patient — Impatient
0 1 2 3 4 5 6 7 8 9 10

19. To what degree are you now feeling
Relaxed — Tense
0 1 2 3 4 5 6 7 8 9 10

20. To what degree are you now feeling
Exhilarated — Depressed
0 1 2 3 4 5 6 7 8 9 10

21. To what degree are you now feeling
Able to concentrate — Unable to concentrate
0 1 2 3 4 5 6 7 8 9 10

22. To what degree are you now feeling
Able to remember — Unable to remember
0 1 2 3 4 5 6 7 8 9 10

23. To what degree are you now feeling:
Able to think clearly — Unable to think clearly
0 1 2 3 4 5 6 7 8 9 10

CONTINUED ON NEXT PAGE

24. Overall, what do you believe is the most directly contributing to or causing your fatigue?

25. Overall, the best thing you have found to relieve your fatigue is:

26. Is there anything else you would like to add that would describe your fatigue better to us?

27. Are you experiencing any other symptoms right now? If YES, please describe:

APPENDIX F

BECK DEPRESSION INVENTORY

BECK INVENTORY

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

For each of the following, please choose the answer that best describes how you are with that area of your life.
Please mark your answer by circling the number. There are no right or wrong answers.

1. 0 I do not feel sad.
   1 I feel sad.
   2 I am sad all of the time and I can't snap out of it.
   3 I am so sad or unhappy that I can't stand it.

2. 0 I am not particularly discouraged about the future.
   1 I feel discouraged about the future.
   2 I feel I have nothing to look forward to.
   3 I feel that the future is hopeless and that things cannot improve.

3. 0 I do not feel like a failure.
   1 I feel I have failed more than the average person.
   2 As I look back on my life, all I can see is a lot of failures.
   3 I feel I am a complete failure as a person.

4. 0 I get as much satisfaction out of things as I used to.
   1 I don't enjoy things the way I used to.
   2 I don't get real satisfaction out of anything anymore.
   3 I am dissatisfied or bored with everything.

5. 0 I don't feel particularly guilty.
   1 I feel guilty a good part of the time.
   2 I feel quite guilty most of the time.
   2 I feel guilty all of the time.

6. 0 I don't feel I am being punished.
   1 I feel I may be punished.
   2 I expect to be punished.
   3 I feel I am being punished.

7. 0 I don't feel disappointed in myself.
   1 I am disappointed in myself.
   2 I am disgusted with myself.
   4 I hate myself.

8. 0 I don't feel I am any worse than anybody else.
   1 I am critical of myself for my weaknesses or mistakes.
   2 I blame myself all of the time for my faults.
   3 I blame myself for everything bad that happens.

9. 0 I don't have any thoughts of killing myself.
   1 I have thoughts of killing myself, but I would not carry them out.
   2 I would like to kill myself.
   4 I would kill myself if I had the chance.

10. 0 I don't cry any more than usual.
    1 I cry more now than I used to.
    2 I cry all the time now.
    3 I used to be able to cry, but now I can't even though I want to.

11. 0 I am no more irritated by things than I ever am.
    1 I am slightly more irritated now than usual.
    2 I am quite annoyed or irritated a good deal of the time.
    4 I feel irritated all the time now.

12. 0 I have not lost interest in other people.
    1 I am less interested in other people than I used to be.
    2 I have lost most of my interest in other people.
    3 I have lost all of my interest in other people.

13. 0 I make decisions about as well as I ever could.
    1 I put off making decisions more than I used to.
    2 I have greater difficulty in making decisions than before.
    3 I can't make decisions at all anymore.

14. 0 I don't feel that I look any worse than I used to.
    1 I am worried that I am looking old or unattractive.
    2 I feel that there are permanent changes in my appearance that make me look unattractive.
    3 I believe that I look ugly.

15. 0 I can work about as well as before.
    1 It takes an extra effort to get started at doing something.
    2 I have to push myself very hard to do anything.
    3 I can't do any work at all.

CONTINUED ON NEXT PAGE

16. 0 I can sleep as well as usual.
    1 I don't sleep as well as I used to.
    2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
    3 I wake up several hours earlier than I used to and cannot get back to sleep.

17. 0 I don't get more tired than usual.
    1 I get tired more easily than I used to.
    2 I get tired from doing almost anything.
    3 I am too tired to do anything.

18. 0 My appetite is not worse than usual.
    1 My appetite is not as good as it used to be.
    2 My appetite is much worse now.
    3 I have no appetite at all anymore.

19. 0 I haven't lost much weight, if any, lately.
    1 I have lost more than five pounds.
    2 I have lost more than ten pounds.
    3 I have lost more than fifteen pounds.

20. 0 I am no more worried about my health than usual.
    1 I am worried about physical problems such as aches and pains, or upset stomach or constipation.
    2 I am very worried about physical problems and it is hard to think of much else.
    3 I am so worried about my physical problems that I cannot think about anything else.

21. 0 I have not noticed any recent change in my interest in sex.
    1 I am less interested in sex than I used to be.
    2 I am much less interested in sex now.
    3 I have lost interest in sex completely.

APPENDIX G

FERRANS AND POWERS QUALITY OF LIFE INDEX VERSION III

Ferrans and Powers

QUALITY OF LIFE INDEX

[CANCER VERSION - III]

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ **DATE** _____

PART 1

For each of the following, please choose the answer that best describes how **satisfied** you are with that area of your life. Please mark your answer by circling the number. There are no right or wrong answers.

1 **Very Dissatisfied**
2 **Moderately Dissatisfied**
3 **Slightly Dissatisfied**
4 **Slightly Satisfied**
5 **Moderately Satisfied**
6 **Very Satisfied**

HOW ***SATISFIED*** ARE YOU WITH:

1. Your health?	1	2	3	4	5	6
2. Your health care?	1	2	3	4	5	6
3. The amount of pain that you have?	1	2	3	4	5	6
4. The amount of energy you have for everyday activities?	1	2	3	4	5	6
5. Your ability to take care of yourself without help?	1	2	3	4	5	6
6. The amount of control you have over your life?	1	2	3	4	5	6
7. Your chances of living as long as you would like?	1	2	3	4	5	6
8. Your family's health?	1	2	3	4	5	6
9. Your children?	1	2	3	4	5	6
10. Your family's happiness?	1	2	3	4	5	6
11. Your sex life?	1	2	3	4	5	6
12. Your spouse, lover, or partner?	1	2	3	4	5	6
13. Your friends?	1	2	3	4	5	6
14. The emotional support you get from your family?	1	2	3	4	5	6
15. The emotional support you get from people other than your family?	1	2	3	4	5	6

HOW ***SATISFIED*** ARE YOU WITH:

16. Your ability to take care of family responsibilities?	1	2	3	4	5	6
17. How useful you are to others?	1	2	3	4	5	6
18. The amount of worries in your life?	1	2	3	4	5	6
19. Your neighborhood?	1	2	3	4	5	6
20. Your home, apartment, or place where you live?	1	2	3	4	5	6
21. Your job (if employed)?	1	2	3	4	5	6
22. Not having a job (if unemployed, retired, or disabled)	1	2	3	4	5	6
23. Your education?	1	2	3	4	5	6
24. How well you can take care of your financial needs?	1	2	3	4	5	6
25. The things you do for fun?	1	2	3	4	5	6
26. Your chances for a happy future?	1	2	3	4	5	6
27. Your peace of mind?	1	2	3	4	5	6

28.	Your faith in God?	1	2	3	4	5	6
29.	Your achievement of personal goals?	1	2	3	4	5	6
30.	Your happiness in general?	1	2	3	4	5	6
31.	Your life in general?	1	2	3	4	5	6
32.	Your personal appearance?	1	2	3	4	5	6
33.	Yourself in general?	1	2	3	4	5	6

PART 2

For each of the following, please choose the answer that best describes how **important** that area of your life is to you. Please mark your answer by circling the number. There are no right or wrong answers.

HOW ***IMPORTANT*** TO YOU IS:

1.	Your health?	1	2	3	4	5	6
2.	Your health care?	1	2	3	4	5	6
3.	Having no pain?	1	2	3	4	5	6
4.	Having enough energy for everyday activities?	1	2	3	4	5	6
5.	Taking care of yourself without help?	1	2	3	4	5	6
6.	Having control over your life?	1	2	3	4	5	6
7.	Living as long as you would like?	1	2	3	4	5	6
8.	Your family's health?	1	2	3	4	5	6
9.	Your children?	1	2	3	4	5	6
10.	Your family's happiness?	1	2	3	4	5	6
11.	Your sex life?	1	2	3	4	5	6
12.	Your spouse, lover, or partner?	1	2	3	4	5	6
13.	Your friends?	1	2	3	4	5	6
14.	The emotional support you get from your family?	1	2	3	4	5	6
15.	The emotional support you get from people other than your family?	1	2	3	4	5	6

HOW ***IMPORTANT*** TO YOU IS:

16.	Taking care of family responsibilities?	1	2	3	4	5	6
17.	Being useful to others?	1	2	3	4	5	6
18.	Having no worries?	1	2	3	4	5	6
19.	Your neighborhood?	1	2	3	4	5	6
20.	Your home, apartment, or place where you live?	1	2	3	4	5	6
21.	Your job (if employed)?	1	2	3	4	5	6
22.	Having a job (if unemployed, retired, or disabled)?	1	2	3	4	5	6
23.	Your education?	1	2	3	4	5	6
24.	Being able to take care of your financial needs?	1	2	3	4	5	6
25.	Doing things for fun?	1	2	3	4	5	6
26.	Having a happy future?	1	2	3	4	5	6
27.	Peace of mind?	1	2	3	4	5	6
28.	Your faith in God?	1	2	3	4	5	6
29.	Achieving your personal goals?	1	2	3	4	5	6
30.	Your happiness in general?	1	2	3	4	5	6
31.	Being satisfied with life?	1	2	3	4	5	6
32.	Your personal appearance?	1	2	3	4	5	6
33.	Are you to yourself?	1	2	3	4	5	6

APPENDIX H

CLIENT SUMMARY

CLIENT SUMMARY

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

SECTION I : GENERAL INFORMATION

Referral Source _____ Primary Care Physician _____

Date of Assessment _____ DOB _____ Age _____

Cancer Type _____ Cancer Stage _____ Date of Diagnosis _____

Height _____ Weight _____ Blood Pressure _____

SECTION II : TREATMENTS

	DATE OF TREATMENT / NA	TYPE / NAME / OTHER INFORMATION
Surgery		
Radiation		
Chemotherapy		
Other Treatment		

Complications from treatments? _____

SECTION III : ADDITIONAL MEDICAL CONCERNS

_____

_____

SECTION IV : DISEASE CONCERNS

	Y	N	MEDICATION	EXPLANATION
High Blood Pressure				
High Cholesterol				
Diabetes/ Glucose				
Smoking				
Physically Active				
Weight				
Other				
Family History			Males: CAD/Heart Attack <55	
			Females: CAD/Heart Attack <65	

SECTION V : MEDICATIONS

NAME	REASON FOR MEDICATION	SIDE EFFECTS

SECTION VI : PHYSICAL ACTIVITY

Current Physical Activity Level

Past Physical Activity Level

Short Term Goals

Long Term Goals

Assessors' Names

Assessors' Signatures

Clinical Coordinator's Signature

APPENDIX I

PHASE 1 ASSESSMENT DATA COLLECTION SHEET

PHASE 1
[DATA COLLECTION SHEET]

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

☐ INITIAL ASSESSMENT ☐ REASSESSMENT # _____ ☐ STUDY _____
NAME OF STUDY

Date of Birth _____ Age _____

Subject # _____ ☐ Male ☐ Female

START TIME:

1) Initial BP	mmHg
2) Initial HR (RHR)	bpm
Method used	
3) Initial SpO_2	%
4) Height	inches (without shoes)
5) Weight	pounds (without shoes)

COMPLETION TIME:

13) Final BP	mmHg
14) Final HR (RHR)	bpm
15) Final SpO_2	%

☐ REMOVED Heart Rate Monitor

6) Body Composition

A) Body Fat Percent (Skinfolds)

Jackson and Pollock (1980). *Abdominal fold is vertical*

MALE

	Chest	Abdomen	Thigh
1.			
2.			
3.			
Average			

Sum of skinfolds (SKF) _____

Witness _____

Men % Body Fat

$D_b = 1.109380 - 0.0008267\ (SKF) + 0.0000016\ (SKF)^2 - 0.0002574\ (age)$

Male 18-59: $(4.95 / D_b) - 4.50$

Male 60-90: $(4.97 / D_b) - 4.52$

Body Fat = _____ %

FEMALE

	Triceps	Suprailiac	Thigh
1.			
2.			
3.			
Average			

Sum of skinfolds (SKF) _____

Witness _____

Women % Body Fat

$D_b = 1.0994921 - 0.0009929\ (SKF) + 0.0000023\ (SKF)^2 - 0.0001392\ (age)$

Female 18-59: $(4.96 / D_b) - 4.51$

Female 60-90: $(5.02 / D_b) - 4.57$

Body Fat = _____ %

B) Circumference Measurements (in inches)

Forearm - 3" up from styloid process of ulna (wrist bone)
OR _____" up from styloid process of ulna **L** **R**

Upper Arm - 5" up from olecranon process (point of elbow)
OR _____" up from olecranon process **L** **R**

Lower Leg - 5" up from lateral malleolus (ankle bone)
OR _____" up from lateral malleolus **L** **R**

Thigh - 5" up from superior ridge of patella (knee cap)
OR _____" up from superior ridge of patella **L** **R**

Waist - narrowest part of torso

Hip - widest part of torso

Waist-to-Hip Ratio

7) InBody Percent Body Fat

8) Balance (Bertec Balance Screener) **OR** (Unipedal Stance Test):
Client stands with malleolus on the medial-lateral line, at a comfortable width apart, symmetric around the center line.

BERTEC BALANCE SCREENER

	CLINICAL SCORES		LOS (%)
Hard Surface	Eyes Open	%	Front
	Eyes Closed	%	Back
			Left
Foam Pad Surface	Eyes Open	%	Right
	Eyes Closed	%	

LOS %

UNIPEDAL STANCE TEST

Circle best time in each category. Dominant Leg (circle one): **L** **R**

	TRIAL 1 (SECONDS)	TRIAL 2 (SECONDS)	TRIAL 3 (SECONDS)
Eyes Open			
Eyes Closed			

9) Pulmonary Function: Record measured liters, not predicted liters.

Attempt 1: FVC liters % predicted FEV1 liters % predicted

Attempt 2: FVC liters % predicted FEV1 liters % predicted

% var between FVC trials (If greater than 5%, repeat the test)

Attempt 3: FVC liters % predicted FEV1 liters % predicted

10) Cardiovascular Endurance: Perform a VO_{2peak} test using the UNCCRI protocol. Estimated HR MAX

UNCCRI CANCER TREADMILL PROTOCOL WORKSHEET

Stage	Speed	Grade	Time	BP	HR	RPE	SpO_2
0	1.0mph	0%	1 min				
1	1.5mph	0%	1 min				
2	2.0mph	0%	1 min				
3	2.5mph	0%	1 min				
4	2.5mph	2%	1 min				
5	3.0mph	2%	1 min				
6	3.3mph	3%	1 min				
7	3.4mph	4%	1 min				
8	3.5mph	5%	1 min				
9	3.6mph	6%	1 min				
10	3.7mph	7%	1 min				
11	3.8mph	8%	1 min				
12	3.9mph	9%	1 min				
13	4.0mph	10%	1 min				
14	4.1mph	11%	1 min				
15	4.2mph	12%	1 min				
16	4.3mph	13%	1 min				
17	4.4mph	14%	1 min				
18	4.5mph	15%	1 min				
19	4.6mph	16%	1 min				
20	4.7mph	17%	1 min				
Cool Down	*	0%	**				

*Identify speed for cool-down. **Identify total time of cool-down

Note: If client changes from a walk to a run during this test, identify the time when the gait changed.

UNCCRI GUIDELINES TO STOP TREADMILL TEST

1) Indications to stop the test established by ACSM (pg 119, 8th edition)
2) HR does not increase with increased intensity
3) SBP does not increase with increased intensity
4) DBP fluctuates more than 10 mmHg from baseline
5) Oxygen saturation drops below 80% (pulse ox)
6) HR exceeds calculated maximum HR using the following formula: $HR_{max} = 208 - (0.7 \times age)$

(Based upon ACSM calculation using last completed stage. Use chart in the UNCCRI Assessment and Training Manual)

Time to peak/volitional fatigue: _____ as a decimal: _____

Did patient hold the handrails? ☐ Yes ☐ No

Was the patient running during the last completed stage? ☐ Yes ☐ No

Comments: _____

VO_2peak _____

11) Muscular Strength / Endurance

A) Estimated 1- Repetition Maximum

Reps must be between 1 and 10

EXERCISE	Weight Lifted	Number of Repetitions	Seat Position	Comments	Estimated 1-RM
Lat Pull-Down					
Shoulder/Overhead Press					
Chest Press					
Seated Row					
Leg Curl					
Leg Extension					
Leg Press					

The Brzycki Equation

1-RM = weight lifted (lb) / [1.0278 - (reps to fatigue x 0.0278)]

Example: 45 lbs / [1.0278 - (5 reps x 0.0278)]
Estimated 1-RM = 50.63 lbs

B) Handgrip Dynamometer

Dominant Hand **L R** (circle one) _____ _____ _____

Non-Dominant Hand **L R** (circle one) _____ _____ _____

C) Chair Squat Test Squats until fatigue: _____

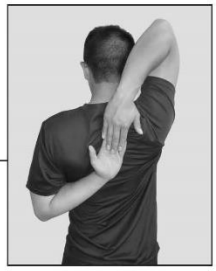
D) Core Stability - Check one

☐ Regular Plank
OR Seconds held: _____
☐ Modified Plank

12) Flexibility

A) Sit-and-Reach: Modified **OR** Chair **(Circle One):**

Use highest value inches: inches: inches:

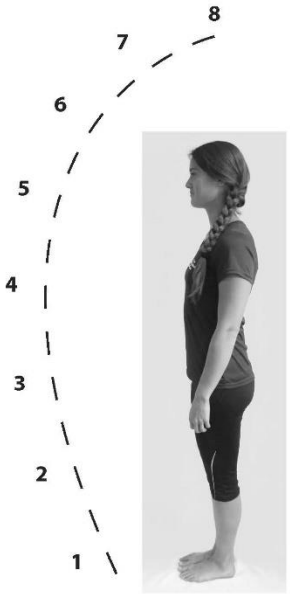


B) Shoulder Back Scratch

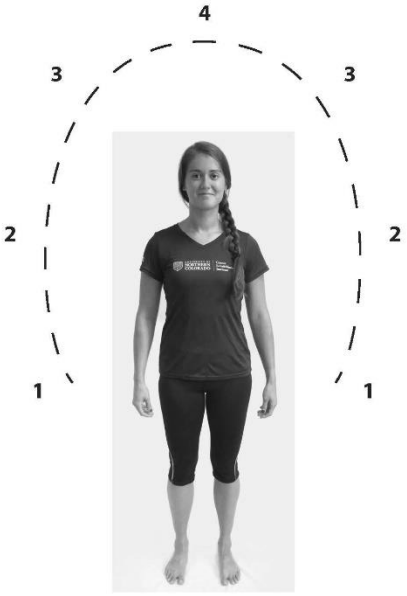
Preferred hand on top **L R** (circle one) inches measured:

C) Reaching Tests

FRONTAL RAISE SCORING



LATERAL RAISE SCORING



Frontal Raise: Left Right Lateral Raise: Left Right

PRINT Assessors' Names:

Would patient be interested in attending cancer rehab? ☐ Yes ☐ No

Best days of the week for exercise? Sun Mon Tues Wed Thurs Fri Sat

Best times of day for exercise?

APPENDIX J

PHASE 2 ASSESSMENT DATA COLLECTION SHEET

PHASE 2
[DATA COLLECTION SHEET]

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

☐ INITIAL ASSESSMENT ☐ REASSESSMENT # _____ ☐ STUDY _____
NAME OF STUDY

Date of Birth _____ Age _____

Subject # _____ ☐ Male ☐ Female

START TIME:		COMPLETION TIME:	
1) Initial BP	mmHg	15) Final BP	mmHg
2) Initial HR (RHR)	bpm	16) Final HR (RHR)	bpm
Method used			
3) Initial SpO_2	%	17) Final SpO_2	%
4) Height	inches (without shoes)	☐ REMOVED Heart Rate Monitor	
5) Weight	pounds (without shoes)		

6) Body Composition

A) Body Fat Percent (Skinfolds)

Jackson and Pollock (1980). *Abdominal fold is vertical*

MALE

	Chest	Abdomen	Thigh
1.			
2.			
3.			
Average			

Sum of skinfolds (SKF) _____

Witness _____

Men % Body Fat

$D_b = 1.109380 - 0.0008267\ (SKF) + 0.0000016\ (SKF)^2 - 0.0002574\ (age)$

Male 18-59: $(4.95 / D_b) - 4.50$

Male 60-90: $(4.97 / D_b) - 4.52$

Body Fat = _____ %

FEMALE

	Triceps	Suprailiac	Thigh
1.			
2.			
3.			
Average			

Sum of skinfolds (SKF) _____

Witness _____

Women % Body Fat

$D_b = 1.0994921 - 0.0009929\ (SKF) + 0.0000023\ (SKF)^2 - 0.0001392\ (age)$

Female 18-59: $(4.96 / D_b) - 4.51$

Female 60-90: $(5.02 / D_b) - 4.57$

Body Fat = _____ %

B) Circumference Measurements (in inches)

Forearm - 3" up from styloid process of ulna (wrist bone)
OR _____" up from styloid process of ulna **L** **R**

Upper Arm - 5" up from olecranon process (point of elbow)
OR _____" up from olecranon process **L** **R**

Lower Leg - 5" up from lateral malleolus (ankle bone)
OR _____" up from lateral malleolus **L** **R**

Thigh - 5" up from superior ridge of patella (knee cap)
OR _____" up from superior ridge of patella **L** **R**

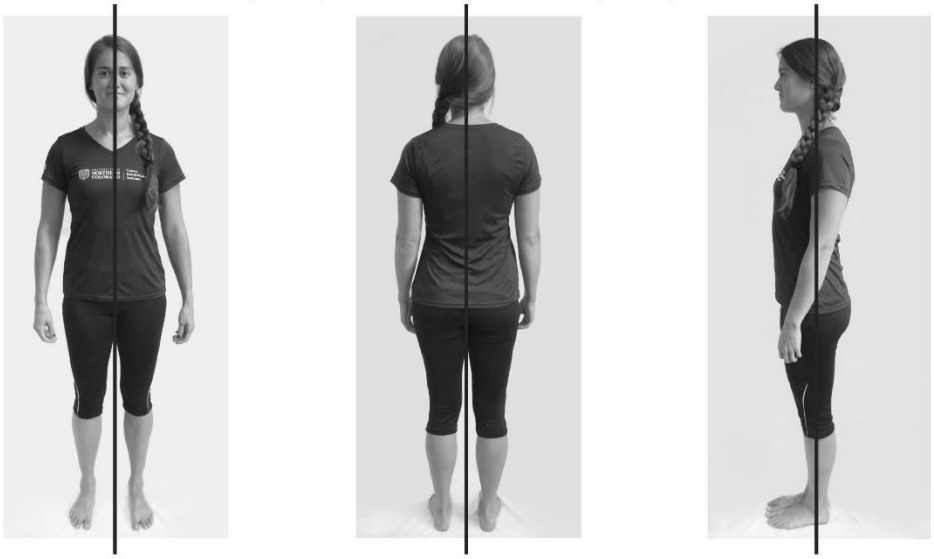
Waist - narrowest part of torso

Hip - widest part of torso

Waist-to-Hip Ratio

7) Anatomical Plumb Line

ANTERIOR VIEW **POSTERIOR VIEW** **SAGITTAL/ TRANSVERSE VIEW**



Note any irregularities in posture or stance and/or corrections that need to be made.

8) NASM Overhead Squat Solutions Table

Adapted from the National Academy of Sports Medicine

View	Checkpoint	Compensation	Probable Overactive Muscles	Probable Overactive Muscles	Example Flexibility Exercise (SMR and Static)	Example Strengthening Exercise
ANTERIOR	Foot	Foot Turns Out	Soleus Lateral Gastrocnemius Biceps Femoris (Short Head) Tensor Fasciae Latae	Medial Gastrocnemius Medial Hamstring Gluteus Medius/Maximus Gracilis Popliteus	Calf Stretch Hamstring Stretch Standing Tensor Fasciae Latae Stretch	Single-Leg Balance Reach
	Knee	Moves Inward	Adductor Complex Biceps Femoris (Short Head) Tensor Fasciae Latae Vastus Lateralis Lateral Gastrocnemius	Gluteus Medius/Maximus Vastus Medialis Oblique Medial Hamstring Medial Gastrocnemius	Adductor Stretch Hamstring Stretch Tensor Fasciae Latae Stretch Calf Stretch	Lateral Tube Walking Ball Squat with Abduction Ball Bridge with Abduction
		Moves Outward	Piriformis Biceps Femoris Tensor Fasciae Latae Gluteus Minimus/Medius	Adductor Complex Medial Hamstring Gluteus Maximus	Piriformis Stretch Hamstring Stretch Tensor Fasciae Latae Stretch	Ball Squat with Adduction Ball Bridge with Adduction
LATERAL	L-P-H-C	Excessive Forward Lean	Soleus Gastrocnemius Hip Flexor Complex Abdominal Complex (Rectus Abdominis, External Oblique)	Anterior Tibialis Gluteus Maximus Erector Spinae	Calf Stretch Hip Flexor Stretch Ball Abdominal Stretch	Ball Squat
		Low Back Arches	Hip Flexor Complex Erector Spinae Latissimus Dorsi	Gluteus Maximus Hamstrings Intrinsic Core Stabilizers (Transverse Abdominis, Multifidus, Internal Oblique, Transversospinalis, Pelvic Floor Muscles)	Hip Flexor Stretch Latissimus Dorsi Stretch Erector Spinae Stretch	Ball Squat Floor Bridge Ball Bridge
		Low Back Rounds	Hamstrings Adductor Magnus Rectus Abdominis External Obliques	Gluteus Maximus Erector Spinae Intrinsic Core Stabilizers (Transverse Abdominis, Multifidus, Internal Oblique, Transversospinalis, Pelvic Floor Muscles)	Hamstring Stretch Adductor Magnus Stretch Ball Abdominal Stretch	Floor Cobra Ball Cobra Ball Back Extension
	Upper Body	Arms Fall Forward	Latissimus Dorsi Pectoralis Major/Minor Teres Major Coracobrachialis	Mid/Lower Trapezius Rhomboids Rotator Cuff Posterior Deltoid	Latissimus Dorsi Stretch Pectoralis Stretch Self-Myofascial Release Thoracic Spine	Floor Cobra Ball Cobra Squat to Row
		Forward Head (Pushing-Pulling Assessment)	Levator Scapulae Sternocleidomastoid Scalenes	Deep Cervical Flexors	Levator Scapulae Stretch Sternocleidomastoid Stretch Scalene Stretch	Tuck Chin, Keeping Head In Neutral Position During All Exercises
		Shoulder Elevation (Pushing-Pulling Assessment)	Upper Trapezius Sternocleidomastoid Levator Scapulae	Mid/Lower Trapezius Rhomboids Rotator Cuff	Upper Trapezius Stretch Sternocleidomastoid Stretch Levator Scapulae Stretch	Floor Cobra Ball Cobra
POSTERIOR	Foot	Foot Flattens	Peroneals Lateral Gastrocnemius Biceps Femoris (Short Head) Tensor Fasciae Latae	Anterior Tibialis Posterior Tibialis Medial Gastrocnemius Gluteus Medius	Peroneal Stretch Calf Stretch Hamstring Stretch Standing Tensor Fasciae Latae Stretch	Single-Leg Balance Reach Single-Leg Medial Calf Raise
		Heel Rises	Soleus	Anterior Tibialis	Soleus Stretch	Single-Leg Balance Reach Single-Leg Squat
	L-P-H-C	Asymmetrical Weight Shift	Adductor Complex Tensor Fasciae Latae (Same Side) Piriformis Biceps Femoris Gluteus Medius (Opp. Side)	Gluteus Medius (Same Side) Adductor Complex (Opposite Side)	Adductor Stretch (Same Side) Tensor Fasciae Latae Stretch Piriformis Stretch Hamstring Stretch (Opposite Side)	Gluteus Medius (Same Side) Adductor Complex (Opposite Side)

9) InBody Percent Body Fat

10) Balance (Bertec Balance Screener) **OR** (Unipedal Stance Test):
Client stands with malleolus on the medial-lateral line, at a comfortable width apart, symmetric around the center line.

BERTEC BALANCE SCREENER

	CLINICAL SCORES		LOS (%)
Hard Surface	Eyes Open	%	Front
	Eyes Closed	%	Back
			Left
Foam Pad Surface	Eyes Open	%	Right
	Eyes Closed	%	

LOS %

UNIPEDAL STANCE TEST

Circle best time in each category.
Dominant Leg (circle one): **L R**

	TRIAL 1 (SECONDS)	TRIAL 2 (SECONDS)	TRIAL 3 (SECONDS)
Eyes Open			
Eyes Closed			

11) Pulmonary Function: Record measured liters, not predicted liters.

Attempt 1: FVC liters % predicted FEV1 liters % predicted

Attempt 2: FVC liters % predicted FEV1 liters % predicted

% var between FVC trials (If greater than 5%, repeat the test)

Attempt 3: FVC liters % predicted FEV1 liters % predicted

12) Cardiovascular Endurance: Perform a VO_{2peak} test using the UNCCRI protocol. Estimated HR MAX

UNCCRI CANCER TREADMILL PROTOCOL WORKSHEET

Stage	Speed	Grade	Time	BP	HR	RPE	SpO_2
0	1.0mph	0%	1 min				
1	1.5mph	0%	1 min				
2	2.0mph	0%	1 min				
3	2.5mph	0%	1 min				
4	2.5mph	2%	1 min				
5	3.0mph	2%	1 min				
6	3.3mph	3%	1 min				
7	3.4mph	4%	1 min				
8	3.5mph	5%	1 min				
9	3.6mph	6%	1 min				
10	3.7mph	7%	1 min				
11	3.8mph	8%	1 min				
12	3.9mph	9%	1 min				
13	4.0mph	10%	1 min				
14	4.1mph	11%	1 min				
15	4.2mph	12%	1 min				
16	4.3mph	13%	1 min				
17	4.4mph	14%	1 min				
18	4.5mph	15%	1 min				
19	4.6mph	16%	1 min				
20	4.7mph	17%	1 min				
Cool Down	*	0%	**				

*Identify speed for cool-down. **Identify total time of cool-down

Note: If client changes from a walk to a run during this test, identify the time when the gait changed.

UNCCRI GUIDELINES TO STOP TREADMILL TEST

1) Indications to stop the test established by ACSM (pg 119, 8th edition)
2) HR does not increase with increased intensity
3) SBP does not increase with increased intensity
4) DBP fluctuates more than 10 mmHg from baseline
5) Oxygen saturation drops below 80% (pulse ox)
6) HR exceeds calculated maximum HR using the following formula: $HR_{max} = 208 - (0.7 \times age)$

(Based upon ACSM calculation using last completed stage. Use chart in the UNCCRI Assessment and Training Manual)

Time to peak/volitional fatigue: _____ as a decimal: _____

Did patient hold the handrails? ☐ Yes ☐ No

Was the patient running during the last completed stage? ☐ Yes ☐ No

Comments: _____

VO_2peak _____

13) Muscular Strength / Endurance

A) Estimated 1- Repetition Maximum

Reps must be between 1 and 10

EXERCISE	Weight Lifted	Number of Repetitions	Seat Position	Comments	Estimated 1-RM
Lat Pull-Down					
Shoulder/Overhead Press					
Chest Press					
Seated Row					
Leg Curl					
Leg Extension					
Leg Press					

The Brzycki Equation

1-RM = weight lifted (lb) / [1.0278 - (reps to fatigue x 0.0278)]

Example: 45 lbs / [1.0278 - (5 reps x 0.0278)]
Estimated 1-RM = 50.63 lbs

B) Handgrip Dynamometer

Dominant Hand **L R** (circle one) _____ _____ _____

Non-Dominant Hand **L R** (circle one) _____ _____ _____

C) Chair Squat Test Squats until fatigue: _____

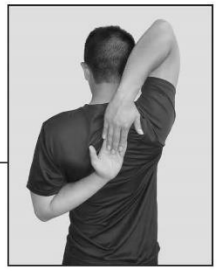
D) Core Stability - Check one

☐ Regular Plank
OR Seconds held: _____
☐ Modified Plank

14) Flexibility

A) Sit-and-Reach: Modified **OR** Chair **(Circle One):**

Use highest value inches: inches: inches:

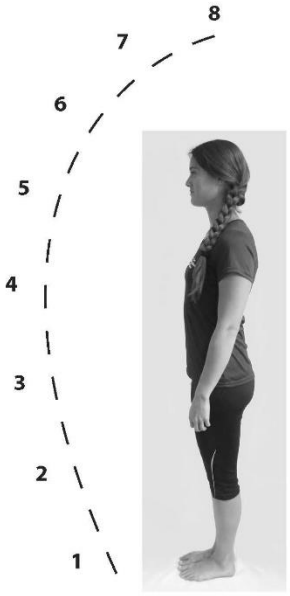


B) Shoulder Back Scratch

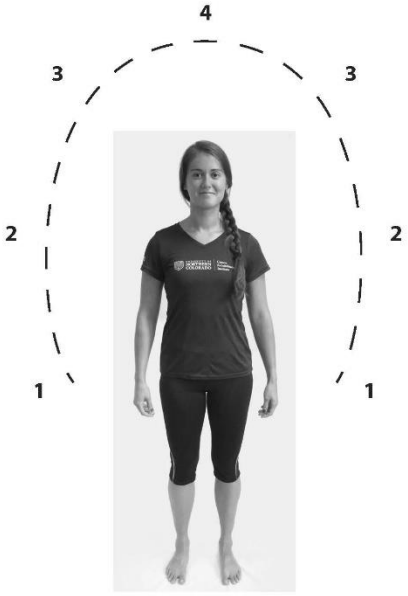
Preferred hand on top **L R** (circle one) inches measured:

C) Reaching Tests

FRONTAL RAISE SCORING



LATERAL RAISE SCORING



Frontal Raise: Left Right Lateral Raise: Left Right

PRINT Assessors' Names:

Would patient be interested in attending cancer rehab? ☐ Yes ☐ No

Best days of the week for exercise? Sun Mon Tues Wed Thurs Fri Sat

Best times of day for exercise?

APPENDIX K

PHASES 3 AND 4 ASSESSMENT DATA COLLECTION SHEET

PHASE 3&4
[DATA COLLECTION SHEET]

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ **DATE** _____

PHASE 3 4 (CIRCLE ONE)

☐ **INITIAL ASSESSMENT** ☐ **REASSESSMENT #** _____ ☐ **STUDY** _____ NAME OF STUDY

Date of Birth _____ Age _____

Subject # _____ ☐ Male ☐ Female

START TIME:

1) Initial BP	mmHg
2) Initial HR (RHR)	bpm
Method used	
3) Initial SpO_2	%
4) Height	inches (without shoes)
5) Weight	pounds (without shoes)

COMPLETION TIME:

13) Final BP	mmHg
14) Final HR (RHR)	bpm
15) Final SpO_2	%

☐ REMOVED Heart Rate Monitor

6) Body Composition

A) Body Fat Percent (Skinfolds)

Jackson and Pollock (1980). *Abdominal fold is vertical*

MALE

	Chest	Abdomen	Thigh
1.			
2.			
3.			
Average			

Sum of skinfolds (SKF) _____

Witness _____

Men % Body Fat

$D_b = 1.109380 - 0.0008267\ (SKF) + 0.0000016\ (SKF)^2 - 0.0002574\ (age)$

Male 18-59: $(4.95 / D_b) - 4.50$

Male 60-90: $(4.97 / D_b) - 4.52$

Body Fat = _____ %

FEMALE

	Triceps	Suprailiac	Thigh
1.			
2.			
3.			
Average			

Sum of skinfolds (SKF) _____

Witness _____

Women % Body Fat

$D_b = 1.0994921 - 0.0009929\ (SKF) + 0.0000023\ (SKF)^2 - 0.0001392\ (age)$

Female 18-59: $(4.96 / D_b) - 4.51$

Female 60-90: $(5.02 / D_b) - 4.57$

Body Fat = _____ %

B) Circumference Measurements (in inches)

Forearm - 3" up from styloid process of ulna (wrist bone)
OR _____" up from styloid process of ulna **L** **R**

Upper Arm - 5" up from olecranon process (point of elbow)
OR _____" up from olecranon process **L** **R**

Lower Leg - 5" up from lateral malleolus (ankle bone)
OR _____" up from lateral malleolus **L** **R**

Thigh - 5" up from superior ridge of patella (knee cap)
OR _____" up from superior ridge of patella **L** **R**

Waist - narrowest part of torso

Hip - widest part of torso

Waist-to-Hip Ratio

7) InBody Percent Body Fat

8) Balance (Bertec Balance Screener) **OR** (Unipedal Stance Test):
Client stands with malleolus on the medial-lateral line, at a comfortable width apart, symmetric around the center line.

BERTEC BALANCE SCREENER

CLINICAL SCORES			LOS (%)
Hard Surface	Eyes Open	%	Front
	Eyes Closed	%	Back
			Left
Foam Pad Surface	Eyes Open	%	Right
	Eyes Closed	%	

LOS %

UNIPEDAL STANCE TEST

Circle best time in each category. Dominant Leg (circle one): **L** **R**

	TRIAL 1 (SECONDS)	TRIAL 2 (SECONDS)	TRIAL 3 (SECONDS)
Eyes Open			
Eyes Closed			

9) Pulmonary Function: Record measured liters, not predicted liters.

Attempt 1: FVC liters % predicted FEV1 liters % predicted

Attempt 2: FVC liters % predicted FEV1 liters % predicted

% var between FVC trials (If greater than 5%, repeat the test)

Attempt 3: FVC liters % predicted FEV1 liters % predicted

10) Cardiovascular Endurance: Perform a VO_{2peak} test using the UNCCRI protocol. Estimated HR MAX

UNCCRI CANCER TREADMILL PROTOCOL WORKSHEET

Stage	Speed	Grade	Time	BP	HR	RPE	SpO_2
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6	3.3mph	3%	1 min				
7	3.4mph	4%	1 min				
8	3.5mph	5%	1 min				
9	3.6mph	6%	1 min				
10	3.7mph	7%	1 min				
11	3.8mph	8%	1 min				
12	3.9mph	9%	1 min				
13	4.0mph	10%	1 min				
14	4.1mph	11%	1 min				
15	4.2mph	12%	1 min				
16	4.3mph	13%	1 min				
17	4.4mph	14%	1 min				
18	4.5mph	15%	1 min				
19	4.6mph	16%	1 min				
20	4.7mph	17%	1 min				
Cool Down	*	0%	**				

*Identify speed for cool-down. **Identify total time of cool-down

Note: If client changes from a walk to a run during this test, identify the time when the gait changed.

UNCCRI GUIDELINES TO STOP TREADMILL TEST

1) Indications to stop the test established by ACSM (pg 119, 8th edition)
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4) DBP fluctuates more than 10 mmHg from baseline
5) Oxygen saturation drops below 80% (pulse ox)
6) HR exceeds calculated maximum HR using the following formula: $HR_{max} = 208 - (0.7 \times age)$

(Based upon ACSM calculation using last completed stage. Use chart in the UNCCRI Assessment and Training Manual)

Time to peak/volitional fatigue: _____ as a decimal: _____

Did patient hold the handrails? ☐ Yes ☐ No

Was the patient running during the last completed stage? ☐ Yes ☐ No

Comments: _____

VO_2peak _____

11) Muscular Strength / Endurance

A) Estimated 1- Repetition Maximum

Reps must be between 1 and 10

EXERCISE	Weight Lifted	Number of Repetitions	Seat Position	Comments	Estimated 1-RM
Lat Pull-Down					
Shoulder/Overhead Press					
Chest Press					
Seated Row					
Leg Curl					
Leg Extension					
Leg Press					

The Brzycki Equation

1-RM = weight lifted (lb) / [1.0278 - (reps to fatigue x 0.0278)]

Example: 45 lbs / [1.0278 - (5 reps x 0.0278)]
Estimated 1-RM = 50.63 lbs

B) Handgrip Dynamometer

Dominant Hand **L R** (circle one) _____ _____ _____

Non-Dominant Hand **L R** (circle one) _____ _____ _____

C) Chair Squat Test Squats until fatigue: _____

D) Core Stability - Check one

☐ Regular Plank
OR Seconds held: _____
☐ Modified Plank

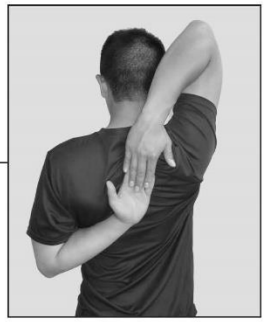
12) Flexibility

A) Sit-and-Reach: Modified **OR** Chair **(Circle One):**

Use highest value inches: inches: inches:

B) Shoulder Back Scratch

Preferred hand on top **L R** (circle one) inches measured:



PRINT Assessors' Names:

Would patient be interested in attending cancer rehab? ☐ Yes ☐ No

Best days of the week for exercise? Sun Mon Tues Wed Thurs Fri Sat

Best times of day for exercise?

APPENDIX L

CLIENT OVERVIEW

CLIENT OVERVIEW
[EXERCISE PRESCRIPTION]

UNIVERSITY OF NORTHERN COLORADO | Cancer Rehabilitation Institute

NAME _____ DATE _____

PHASE 1 2 3 4 (CIRCLE ONE)

SECTION I : GENERAL INFORMATION

Age _____ Gender _____ Resting Heart Rate _____

Height _____ Weight _____ Blood Pressure _____

SECTION II : CANCER HISTORY

Cancer Type 1 _____ Cancer Stage _____

Cancer Treatment(s) and Date(s) _____

SECTION III : PROBLEM LIST & CONSIDERATIONS

Problem List _____

Exercise Considerations _____

SECTION IV : CARDIOVASCULAR FITNESS RESULTS

Estimated VO_2peak _____ Classification Cancer/General _____

Estimated HR max _____ Estimated Resting HR _____

SECTION V : MUSCULAR STRENGTH AND ENDURANCE RESULTS

MUSCULAR STRENGTH TEST	PREDICTED 1-RM (lbs)	SEAT POSITION
Lat Pull-Down		
Shoulder Press		
Chest Press		
Seated Row		
Leg Curl		
Leg Extension		
Leg Press		

Chair Test (Reps) _____

SWR Chest _____

Classification _____

SWR Leg Press _____

Classification _____

SECTION VI : FUNCTIONAL ASSESSMENT RESULTS AND PROBLEM LIST

NASM Squat Test Results

1. _____

2. _____

3. _____

SECTION VII : FLEXIBILITY AND RANGE OF MOTION RESULTS

Frontal Raise: **R** _____ **L** _____

Lateral Raise: **R** _____ **L** _____

Modified Sit and Reach _____

SECTION VIII : CLIENT GOALS

Short-Term Goal

Long-Term Goal

SECTION IX : PRESCRIBED CARDIOVASCULAR AND MUSCULAR INTENSITIES

PHASE	%HRR Estimated 1-RM	RPE	CARDIOVASCULAR IMPROVEMENT	MUSCULAR STRENGTH IMPROVEMENT
One	30%-45%	1-3 (Light to moderate)	Maintain – 5%	10% - 15%
Two	40%-60%	3-6 (Light to moderate)	10% - 20%	30% - 50%
Three	60%-85%	4-8 (Moderate to hard)	5% - 15%	30% - 50%
Four	65%-95%	6-10 (Moderate to hard)	>5% increments / Maintain	>5% increments / Maintain

Starting HR _____ %

Ending HR _____ %

PRESCRIBED HR _____

_____ _____ bpm

Starting _____ % 1-RM (lbs)

Ending _____ % 1-RM (lbs)

PRESCRIBED LBS _____

Lat Pull-Down		
Shoulder Press		
Chest Press		
Seated Row		
Leg Curl		
Leg Extension		
Leg Press		

In 12 weeks, my client should improve in cardiovascular endurance by _____ % and in muscular strength by _____ %.

SECTION X : WEEKLY RESULTS

		ESTIMATED WEIGHT LIFTED						
	PRESCRIBED HR/RPE	LPD	SP	CP	SR	LC	LE	LP
WEEK 1								
NOTES								
WEEK 2								
NOTES								
WEEK 3								
NOTES								
WEEK 4								
NOTES								
WEEK 5								
NOTES								
WEEK 6								
NOTES								
WEEK 7								
NOTES								
WEEK 8								
NOTES								
WEEK 9								
NOTES								
WEEK 10								
NOTES								
WEEK 11								
NOTES								
WEEK 12								
NOTES								

Cancer Exercise Specialist Signature _____ Client Signature _____