# Analysis of high and low physical functioning breast cancer survivors within two years of treatment

by

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## Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

## Abstract

The five year survivorship rate of females diagnosed with breast cancer is 88% across Canada (Canadian Cancer Society, 2015). Often, treatments can cause damage to the tissue which may lead to impairment of upper limb function, specifically range of motion and strength. There have been several attempts to quantify these changes, but to inconclusive extents. This study investigated differences between breast cancer survivors with low and high self-reported physical functioning scores, differences between affected and unaffected limbs, as well as differences after 4 months of usual care. Ten female breast cancer survivors (between 3 months and 2 years post treatment) completed six maximal strength trials (flexion, extension, abduction, adduction, internal and external rotation) per limb and six maximal range of motion trials (flexion, extension, abduction, scapular plane abduction, and internal and external rotation), along with three questionnaires. Groups were split based on scores from the disability of arm, shoulder and hand (DASH) questionnaire. Maximal strength was compared for strength trials, and glenohumeral elevation was compared for range of motion trials. For both sets of trials, peak, median and static muscular activity was compared for high and low physical function scores as well as between affected and unaffected limbs. No differences were found between affected and unaffected limbs for either strength or range of motion. However, flexion, extension, abduction, and adduction strength were 32-52% higher in the group with higher self-reported physical functioning scores compared to the group with lower self-reported physical function scores. Correspondingly, internal rotation range of motion was 1.92 times higher in the group with higher physical function scores (effect size =1.98). The other five range of motion tasks (abduction, flexion, extension, scapular plane abduction and external rotation) were not statistically different between groups of high and low physical function scores but had moderate to large effect sizes (0.42-0.94). Several measures were correlated with DASH scores, indicating

that increased strength and range of motion relate to self-reported physical functioning in breast cancer survivors. Between baseline and follow up, none of the six measured strengths changed, with only one of the six range of motion measures increased over the four month period. Extension range of motion increased by 112% during this period of usual care. Overall, this thesis provides insight into the period of time immediately following treatment. These variables had not been evaluated within the first two years of survivorship. Additionally, this work suggests breast cancer survivors are not a homogenous group, and that function (range of motion and strength) differ. In previous literature, all outcomes are reported from one group and have been inconclusive. However this work shows that there may be a difference in survivors' function. This can help refine future rehabilitation strategies as the deficits for these individuals can be quantified more accurately.

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# Dedication

*To the survivors,*
*Forever warriors who have touched my life and those that follow.*
*You selflessly volunteer for hope that those that come after you will have it better.*
*I thank you endlessly.*

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# 1.0 Introduction

In Canada, 1 in 9 women will be diagnosed with breast cancer in their lifetime, which can have lasting effects beyond the end of treatment into survivorship. With advances in oncological treatment and raised awareness leading to early detection, the 5-year survival rate is currently 88% (Canadian Cancer Society, 2015). Many of these survivors, however, live with residual impairment following primary cancer treatment. Along with physical limitations, approximately 6-70% of breast cancer survivors live with lymphedema (Ahmed et al., 2006; Rietman et al., 2003), 31-61% with pain (Lauridsen et al., 2008), 60-96% with fatigue during treatment, and up to 25% with lasting fatigue (Stasi et al., 2003). These can exist among other co-morbidities that ultimately lead to a decreased quality of life in many survivors. Decreased arm function associates with a decreased quality of life of in breast cancer survivors (Rietman et al., 2003; Yang et al., 2010). Beyond arm functional ability, treatment type, age at diagnosis and body image all affect quality of life scores (Arndt et al., 2008; Howard-Anderson et al., 2012).

Exercise and other therapies are suggested to help mitigate the impairment in the breast cancer survivor population. With many confounding factors across these therapies, it is difficult to determine the effectiveness of each therapy. Exercise is known to increase quality of life (Courneya et al., 2014), and range of motion (McNeely et al., 2010) of breast cancer survivors. However, debate remains around the time to begin exercise, especially as it pertains to secondary symptoms such as lymphedema. Therapies such as acupuncture and massage have further been suggested to help decrease these secondary symptoms (Kang et al., 2014; Yao et al., 2016).

Strength, muscular activation patterns, glenohumeral range of motion and scapular kinematics are influenced by the occurrence of breast cancer. A 10% reduction in grip strength in

the affected limb, compared to the unaffected limb is present in 20-43% of patients (Bendz and Fagevik Olsén, 2002; Kuehn et al., 2000). Additionally, a loss in force production is exhibited in extensors, protractors and retractors of the shoulder on the affected limb (Merchant et al., 2008). The musculature surrounding the glenohumeral joint maintains the stability of the joint, however the strategy to reach this is altered in breast cancer survivors due to specific muscular deficiencies (Brookham and Dickerson, 2015; Chopp-Hurley et al., 2016; Shamley et al., 2007). Range of motion is affected for up to 77% of breast cancer survivors. Decreased range of motion in flexion, abduction and external rotation may be present, particularly in patients who received mastectomies and radiation therapy (Harrington et al., 2013; Lauridsen et al., 2008). Finally, increases in scapular internal rotation and upward rotation have been noted in the affected arm (Borstad and Szucs, 2012; Crosbie et al., 2010), which could increase the likelihood of subacromial impingement syndrome (Ludewig and Reynolds, 2009). Decreased strength and range of motion, and alterations in kinematic strategies and activation patterns affect breast cancer survivor's ability to complete daily activities. However, no existing work has quantified arm and shoulder function over time to account for natural healing processes and establish early recovery characteristics. By quantifying the abilities and function of the affected arm, more targeted exercise programs can be created, and their effectiveness can be evaluated.

### 1.1 Objective

The purpose of this research is to quantify the upper limb function in a group of acute breast cancer survivors (three months to two years post treatment). Specifically, this entails delineating differences in strength and glenohumeral range of motion in high functioning and low functioning breast cancer survivors (as determined by various questionnaires), as well as comparison of these variables in the affected and unaffected limb in a group of survivors.

### 1.2 Research Questions

The primary research questions are:

1. Do breast cancer survivors with lower self-reported function scores have decreased strength and range of motion compared to a group with high self-reported function scores?
2. Does a relationship exist between shoulder strength and/or range of motion and self-reported physical function scores?
3. Does the affected limb of breast cancer survivors have decreased strength and range of motion compared to the unaffected limb?
4. Is traditional care coincident with altered strength and range of motion over a 4 month period?

### 1.3 Hypotheses

It is hypothesized that:

1. Participants with higher physical functioning will have increased strength.
2. Participants with higher physical functioning will have increased range of motion.
3. Participants with higher physical functioning will be more physically active than those with lower physical functioning.
4. There will be no quantifiable differences between baseline and follow up sessions, following four months of usual care.

### 1.4 Significance of Research

This investigation quantified the physical capabilities, such as range of motion and strength, of the shoulder in breast cancer survivors. Additionally, longitudinal changes were

investigated in a subset of participants, providing initial insight into post treatment changes in arm function. With the population of breast cancer survivors increasing consistently, it is imperative to produce full descriptions of the physical capabilities of breast cancer survivors immediately following treatment. Quantification of the consequences of primary breast cancer treatment on the shoulder can lead to more targeted rehabilitation programs, while also providing insight into breast cancer survivors' arm function with respect to early healing. This thesis works to identify differences in survivors with high self-reported physical function with those with low self-reported physical function scores. By identifying the differences in strength, range of motion, and demographics within these two groups, it may provide insight into why there is variability in survivors' function and identify the deficit in the survivors with lower physical function Considering the lack of rigorously collected quantitative data in this population, this thesis work strengthens overall awareness of survivor capabilities and can help to identify return to work strategies.

# 2.0 Literature Review

## 2.1 Breast Cancer Overview

### 2.1.1 Prevalence

Breast cancer is the most common cancer diagnosis in Canadian females. In Canada, 1 in 9 females will be diagnosed with breast cancer in their lifetime and accounts for 25.9% of new cancer cases each year. Of those diagnosed, 52% are between the ages of 50 and 69 years. However, 5-year survivorship has reached 87-90% in women between the ages of 40 and 79 years (Canadian Cancer Society, 2015).

Several factors may increase the likelihood of developing breast cancer. Hormonal factors such as breastfeeding, menopause, older age at pregnancy, and oral contraceptives may increase the risk of diagnosis. A stabilization in new cases occurred (around 2004) when hormone replacement therapy was no longer used among postmenopausal women (Canadian Cancer Society, 2015). Further, a combination of genetic and environmental factors most likely leads to the development of breast cancer. Additionally, a family history of the disease is associated with the likelihood of developing breast cancer, increasing the risk by 2-4 times (Fisher et al., 1986).

### 2.1.2 Stages of Breast Cancer

The stages of breast cancer (Table 1) are defined by four characteristics: size, invasive or non-invasive, whether cancer is in the lymph nodes, and if the cancer has spread beyond the breast tissue (metastasized). The stages increase in severity ranging from stage 1A where there is an invasive tumour up to 2cm in diameter, to Stage IV where cancer has spread beyond the lymph nodes and breast tissue.

Table 1: Stages of breast cancer progression (Edge et al., 2010)

| Stage | Description |
|---|---|
| **Stage IA** | • Non-invasive or Invasive<br>• Tumour is up to 2cm<br>• Contained to breast tissue |
| **Stage IB** | • Invasive<br>• Less than 2mm group of cells in lymph nodes<br>• Less than 2cm tumour in breast tissue |
| **Stage IIA** | • 1 to 3 axillary lymph nodes<br>• Tumour measures 2cm or smaller OR<br>• Tumour between 2-5cm but has not spread to lymph nodes |
| **Stage IIB** | • Tumour is between 2-5cm and spread to 1 to 3 axillary lymph nodes OR<br>• Tumour is larger than 5cm but not spread |
| **Stage IIIA** | • Tumour is in 4 to 9 axillary lymph nodes<br>• Larger than 5cm |
| **Stage IIIB** | • Any size tumour and spread to chest wall causing swelling<br>• Spread to up to 9 axillary lymph nodes |
| **Stage IIIC** | • Tumour of any size<br>• Spread to 10 or more axillary nodes OR<br>• Spread to lymph nodes above or below the clavicle |
| **Stage IV** | • Spread beyond lymph nodes and breast tissue |

### 2.1.3 Surgical Treatments

Surgical treatments are commonly used as an initial intervention for breast cancer, followed by an adjuvant therapy to ensure that the entire tumour has been removed, and no cancerous cells remain. Mastectomy is still the most common surgical treatment (45% of total surgical procedures), followed by breast conserving treatment (5% of the total, only where advanced technology exists) and finally axillary node dissection in more advanced tumours (1.5%) (Courneya et al., 2002; Markes et al., 2006; Nemoto et al., 1980).

#### *2.1.3.1 Mastectomy*

Both radical and modified radical mastectomies are both commonly used surgical strategies for breast cancer treatment. Mastectomies are the most effective surgical treatment with only 4.4% of patients suffering a relapse (Van Der Sangen et al., 2011). Radical mastectomies involve removing the breast tissue, overlying skin, pectoralis muscle and extensive lymph node dissection (Dalberg et al., 2010). With the complete removal of the muscle and tissue, this surgery (along with any adjuvant treatments) is associated with extensive range of motion and lymphedema iatrogenic complications (up to 79% of patients present with one or both) (Sugden et al., 1998). With increases in imaging accuracy and the effectiveness of adjuvant therapies, modified radical mastectomy procedures have increased in popularity. In this treatment, the pectoral fascia is removed, but the muscle itself remains intact. Removing the fascia increases difficulty in reconstruction following treatment (compared to sparing the pectoral fascia), but decreases cancer reoccurrence at the chest-wall (Dalberg et al., 2010). The modified radical mastectomy significantly reduces the incidence of lymphedema, and improves the range of motion restrictions apparent in this population (Dalberg et al., 2010; Sugden et al., 1998). Even when radiation therapy is added following surgery, range of motion remains compromised as scar tissue forms between layers of muscle, causing adhesions. Of patients that received modified radical mastectomy and radiation therapy, 35% had range of motion restrictions in one or more directions (Lauridsen et al., 2008).

#### *2.1.3.2 Breast Conserving Therapy (Wide Local Excision/Lumpectomy)*

Breast conserving therapy is a less severe surgical treatment used in breast cancer diagnoses. In western countries, breast conserving treatment is the currently preferred method of treatment. Although used 4% world-wide, breast conserving treatment is used ~30% in

developed countries (Nemoto et al., 1980; Van Der Sangen et al., 2011). However, large tumours, and tumours that have spread, require mastectomies. Additionally, mastectomies remain dominant due to their preference in less developed countries, (Dalberg et al., 2010). Breast conserving treatments are more readily available in western countries, as they are dependent on early diagnosis (Markes et al., 2006) and are highly effective with a 6% relapse rate (Van Der Sangen et al., 2011). This treatment involves removing only the cancerous tissues, with a margin of 3mm (Rietman et al., 2003) without removal of lymph nodes, reducing occurrences of lymphedema (Nesvold et al., 2008). However, differences in limb function between breast conserving therapy and modified radial mastectomies are unclear. Several studies detected no differences between upper limb function after each surgery (without radiation therapy following) (Kuehn et al., 2000; Lauridsen et al., 2008), while others reported that patients receiving breast conserving therapy had less impairment than those receiving modified radical mastectomies (Nesvold et al., 2008; Sugden et al., 1998). The decrease in impairment is likely impacted by differences in follow up time and quantification of impairment. Impairment was defined as a reduction in range of motion greater than $25^{\circ}$ (Nesvold et al., 2008), or greater than $10^{\circ}$ (Kuehn et al., 2000). The differences in classifications of impairments may lead to the inconclusive findings.

#### *2.1.3.3 Axillary Lymph Node Dissection*

Axillary lymph node dissection is used when the cancer has spread beyond the breast tissue into the lymphatic system. It is suggested that if the tumour is larger than 5mm, the lymphatic nodes in the axilla will test positive for cancerous tissue and therefore it is beneficial to have this surgery (Hack et al., 1999). This surgery is more invasive than the aforementioned techniques, and therefore pain, numbness, lymphedema and dysfunction are all more likely to

occur with this approach. Although these symptoms decrease in severity, for many women they persist. Six months post surgery, 61% of survivors reported numbness, but only 17% reported pain, while functional deficits (range of motion and strength decreases) existed in 31% of patients (Hack et al., 1999).

Many complications may arise from axillary lymph node dissection. Compared to other less invasive surgical treatments, breast cancer survivors who had axillary lymph node dissection experienced more pain and greater restrictions in range of motion. As well, occurrence of lymphedema increased when this surgery was performed in combination with radiation. Range of motion was also compromised, and related to the number of lymph nodes that were dissected (Hack et al., 2010). Specifically, at 2 years post surgery, there was a statistically significant decrease in abduction and flexion range of motion in patients who received axillary lymph node dissection. This decrease was more prominent in patients who immobilized the arm for 2 weeks following surgery prior to commencing exercise (Bendz and Fagevik Olsén, 2002).

### 2.1.4 Radiation Therapy

Radiation therapy is a localized adjuvant therapy used after surgical intervention with several known side effects. The localization of radiation therapy can help control cancer within a region. Radiation damages the DNA of cells directly (or through the release of free radicals). However, radiation frequently damages other local cells (Courneya et al., 2002), causing fatigue and skin erythema, lymphedema, cardiac and pulmonary toxicities and brachial plexopathy (Truong et al., 2004). When combining surgical interventions with radiation in breast cancer treatment, scar tissue often forms between the musculature at the glenohumeral joint, limiting the range of motion due to adhesions (Lauridsen et al., 2008; Markes et al., 2006). Although it is the most common adjuvant therapy due to its ability to localize treatment, radiation increases range

of motion deficits, while also increasing the likelihood of developing lymphedema (Hack et al., 1999). As the lymphatic system is present in the axilla, radiation damages the nodes, and affects the drainage of the limb. When the damage is too intense, lymphedema occurs (Truong et al., 2004).

### 2.1.5 Chemotherapy Treatment

Chemotherapy is a common cancer treatment chosen to manage suspected rnicrometastases (cancerous cells that have spread, but are too small to detect). Generally, 9-21 weeks of this treatment are completed in 4-8 cycles, most often intravenously but can also be taken orally (Courneya et al., 2002). Unlike radiation and surgical procedures, chemotherapy is not localized. The drugs utilized in chemotherapy affect many tissues in the body, as it can be difficult to only attack cancerous cells, causing many additional side-effects.

Chemotherapy is implicated as a cause for fatigue, nausea, weight gain and an overall decrease in patient quality of life (Markes et al., 2006). Chemotherapy recipients reported generally decreased arm function, and were less likely to participate in exercise compared to those who did not receive chemotherapy (Markes et al., 2006; Tiezzi et al., 2016). Combined with fatigue and weight gain, the lack of exercise perpetuates physical dysfunction, and quality of life remains poor. Additionally, patients demonstrate lack of motivation to exercise during or after chemotherapy treatments, unless the apparent benefits are clear or the program is perceived as enjoyable (Courneya et al., 2016).

### 2.1.6 Hormonal Treatment

Hormonal therapy is a treatment prescribed if the tumour is considered estrogen receptor positive. This indicates that estrogen promotes tumor growth. The hormone therapy stops or slows down the production of estrogen production and is often taken orally, everyday and can be

continued for many years. The therapy may cause fatigue and weight gain (Courneya et al., 2002). In some scenarios, the ovaries are removed to halt estrogen production. For both surgical hormonal treatment and oral medication, the production of estrogen is slowed or ceased to prevent the continuous growth of the tumour (Canadian Cancer Society, 2015). This treatment promotes early menopause, and affects bone resorption, leading to increased bone loss and ultimately an increased likelihood of fractures (Courneya et al., 2002; Poznak, 2015). This treatment does not appear to explicitly affect shoulder musculature or function.

## 2.2 Survivorship

### 2.2.1 Quality of Life following Breast Cancer Diagnosis and Treatment

Quality of life provides insight into perceived abilities of survivors, and how these differ with various treatments. With a large breast cancer survivor population, it is increasingly important to identify address issues associated with quality of life. Women undergoing breast conserving therapy tend to have higher quality of life ratings than those who have a mastectomy. They report better physical function, social function, and continue to pursue work and leisure activities. Comparatively, women who have a mastectomy report poor scores for almost all physical function scales (Arndt et al., 2008). The differences in these two surgical methods are likely determinants of the divergent post-operative quality of life measures. The less invasive breast conserving therapy, complemented by breast reconstruction enhances quality of life by increasing body image and self-confidence in breast cancer survivors (Arndt et al., 2008). Further, decreases in quality of life are correlated with decreased function of the upper extremity more than body image (Kuehn et al., 2000; Rietman et al., 2003; Yang et al., 2010).

Beyond physical function, quality of life can be influenced by changes in psychological health. Depression, anxiety and increased stress are prevalent in breast cancer survivors.

Particularly, younger women diagnosed have concerns with fertility, weight gain and premature menopause, which all lead to psychological distress (Howard-Anderson et al., 2012). However, the decreases in quality of life associated with this distress is generally greatest during treatment, but 10 years post-diagnosis, life satisfaction and quality of life return to near-normal levels (Kessler, 2002). Additionally, greater social and emotional support increases quality of life, as well as missing fewer days of work and remaining employed after diagnosis (Howard-Anderson et al., 2012). All of these factors contribute to the interaction of social and psychological health with physical function. By identifying the dysfunctions common in a breast cancer survivor population, it may be possible to help mitigate this initial drop in quality of life and shorten the time period to reach 'normal' levels of life satisfaction.

### 2.2.2 Exercise as Rehabilitation for Breast Cancer Survivors

Exercise can enhance function across body systems. Resistance training is generally used to increase or maintain strength and muscle tone, and aerobic training increases endurance and aerobic capacity (Herrero et al., 2006). Although beneficial for breast cancer survivors, decreases in physical activity levels are prominent relative to pre surgery levels (Devoogdt et al., 2010).

Exercise has additional effects such as increased quality of life, range of motion and grip strength. Exercise does not appear to decrease lymphedema, but has positive effects on quality of life in moderate doses (Courneya et al., 2014; Hayes et al., 2009; McKenzie and Kalda, 2003). However, by starting exercises immediately after surgery, breast cancer survivors recover more range of motion. Although significant, the differences were modest: 3° in flexion (164° for delayed start compared with 167° for immediate start) and 11° in abduction (145° and 154° respectively). No differences in the two groups existed in development of secondary symptoms, or recovery of grip strength (Bendz and Fagevik Olsén, 2002).

### 2.2.3 Additional therapies following Breast Cancer Diagnosis and Treatment

Beyond exercise, other modalities have been explored for the rehabilitation of breast cancer survivors. Ultrasound, acupuncture and complimentary and alternative medicine (CAM), among others, have all been suggested to improve function in this population. Both ultrasound and acupuncture have been utilized to decrease the effects of lymphedema. Ultrasound is used to determine the severity of the issue and identify problematic regions. With this, corsets can be fitted to help decrease tissue swelling (Hansdorfer-Korzon et al., 2016), or accurately place nerve blocks to decrease pain (Wijayasinghe et al., 2016). Further, following acupuncture survivors had a decrease in lymphedema of up to 50% (compared to 25% with those taking medication), and an overall increase in quality of life (Yao et al., 2016), although no change in function was observed. Complimentary and alternative medicine combines spiritual, medical and physical (chiropractic, massage) aspects to improve the quality of life of survivors. The theory behind this strategy is to holistically help both the mind and body heal from the disease. However, an increase of arm function has yet to be observed (Kang et al., 2014). Any effects from complimentary and alternative medicine, cannot be targeted to one therapy as a combination of therapies typifies this strategy. Well-rounded recovery of the breast cancer survivor population is likely dependent on a combination of additional modalities (ultrasound, acupuncture, chiropractic, massage) and exercise.

## 2.3 Additional Symptoms Associated with Breast Cancer Survivorship

### 2.3.1 Lymphedema

Lymphedema is a common complication following axillary node dissection in breast cancer treatments. It is defined as a retention of fluid in the arm which ultimately causes swelling of the ipsilateral arm. This hinders many activities of daily living, and ultimately reduces quality

of life among breast cancer survivors. Additionally, survivor age (>60 years), number of nodes dissected, radiation therapy, and higher BMI may predispose breast cancer survivors to developing lymphedema (Hack et al., 2010; Sakorafas et al., 2006).

The presence of lymphedema is generally measured one of two ways. The first is a measurement of the arm circumference, which is compared to the non-affected limb. A difference greater than 2cm is considered indicative of lymphedema (Ahmed et al., 2006). The second technique is to measure the volume of the arm. Volume increases greater than 20% indicates lymphedema (Sakorafas et al., 2006; Swedborg and Wallgren, 1981). Reported prevalence varies from 6% to 70%, developing from a few months to 20 years post-surgery (Ahmed et al., 2006; Petrek et al., 2000; Rietman et al., 2003; Sakorafas et al., 2006; Schmitz et al., 2010; Sugden et al., 1998; Swedborg and Wallgren, 1981). For many, arm functional deficits are not a lifestyle priority, therefore lymphedema may go unreported (Sakorafas et al., 2006).

The swelling in the arm can cause severe disability for breast cancer survivors. Survivors with clinically diagnosed lymphedema scored lower on several quality of life measures, such as body pain and mental health (Velanovich and Szymanski, 1999). Due to the swelling and pain that characterizes lymphedema, daily tasks can be difficult. Recently, focus has shifted to exercise programs to mitigate the effects of lymphedema. Many programs were able to increase range of motion of the arm, but there were not any significant changes in reducing lymphedema, or decreasing onset (Chan et al., 2010). Although the true prevalence is not known, it is clear that lymphedema has an impact on function and quality of life.

### 2.3.2 Pain

Pain is a common post treatment symptom for many breast cancer survivors and it is present in 31-61% of breast cancer survivors, with a positive occurrence being pain in the neck,

arm and/or shoulder at least twice a week (Lauridsen et al., 2008; Tasmuth et al., 1995). In a survey of 316 breast cancer survivors, the mean pain score was 21.6 out of 78, indicating that pain is present but generally not debilitating. Further, it is prevalent in 55-61% of breast cancer survivors who receive mastectomies and radiation, and 24-28% of those who receive breast conserving therapy (Lauridsen et al., 2008; Shamley et al., 2012; Tasmuth et al., 1995). In particular, pain is often greater in younger breast cancer survivors, and persons who had recurrences of the disease (Tasmuth et al., 1995). It has been suggested that the younger patients have greater neural disruption which increases pain (Downing and Windsor, 1984). It is most often identified via self-reporting through a visual analog scale or questionnaire, reporting discomfort in ipsilateral shoulder, arm axilla, breast, neck and/or chest wall. While the whole body is negatively affected following surgery, chemotherapy and/or radiation, damage occurs to muscles and other soft tissues most often in the upper extremities and anterior chest. However, pain does not predict arm morbidity well, including outcomes such as loss of range of motion or lymphedema (Hack et al., 2010). Variable pain affects a large portion of breast cancer survivors and must be considered when addressing the potential physical limitations of this population.

### 2.3.3 Fatigue

Fatigue is common during cancer treatment. It is generally recognized as the state of weariness after a period of mental or physical exertion and is characterized by a decreased capacity for work and reduced efficiency to respond to stimuli. Fatigue is common among many cancer patients, and affects everyday tasks. Stasi et al., (2003) found a strong link between fatigue and treatments for cancer, occurring in 80-96% of patients receiving chemotherapy, and 60-93% of patients receiving radiation therapy. Fatigue was indicated as a preventative agent for completing daily tasks by 91% of cancer survivors. Although more prominent during treatment,

25% of survivors stated fatigue as an ongoing symptom (Stasi et al., 2003). These levels of fatigue are consistent in the breast cancer population (Hsieh et al., 2008; Mock et al., 2005).

To mitigate levels of muscular fatigue, exercise interventions have been implemented. Breast cancer survivors who had received surgery and radiation or chemotherapy had the greatest reduction in fatigue when participating in an individualized exercise program (Hsieh et al., 2008). Breast cancer survivors were instructed to focus more on aerobic exercises to combat fatigue, with the addition of resistance training and flexibility to include a well-rounded exercise program. This whole body approach leads to improvements in both cognitive and muscular fatigue symptoms (Hsieh et al., 2008). Similarly, Mock et al., (2005) implemented a general home-based walking exercise protocol. Participants who exercised more than 60 minutes a week (in 3 sessions or more), had significantly less fatigue symptoms following the exercise program. Fatigue was not completely diminished, but participants who adhered to the protocol reported approximately 40% less fatigue, as determined by the Piper Fatigue Scale (Mock et al., 2005). Although both cognitive and muscular fatigue continues after treatment, they may be partially mitigated with proper attention.

## 2.4 Primary Functional Deficits in the Breast Cancer Survivor Population

### 2.4.1 Strength

Strength in the breast cancer survivor population is often quantified by grip strength as a surrogate for upper arm strength. Differences greater than 10% between affected and unaffected arm existed in 20-43% of survivors (Kuehn et al., 2000; Rietman et al., 2004; Swedborg and Wallgren, 1981). Grip strength has also been used to compare pre and post-surgical treatment. Combined grip strength decreased 2 weeks postoperatively (74kg from 78kg ($p<0.05$), but returned to preoperative levels within the first month. However, at a 2-year follow up grip

strength was 73kg, lower than preoperative measures of 78kg (Bendz and Fagevik Olsén, 2002). It is important to know deficits in strength to better determine which tasks may be difficult.

Certain muscle groups are affected more in the breast cancer survivor group due to the localization of the cancer. Merchant et al., (2008), investigated the strength, power and endurance of muscles of the affected limb and compared that to the unaffected limb. Flexors were not significantly different, likely due to the high variability in strength measurement. A 7% decrease in extensor strength was measured on the affected side compared to the unaffected side, with a 6% decrease in protractor and 4% decrease in retractor strengths on the affected side and unaffected sides, respectfully (Merchant et al., 2008).. Harrington et al (2013) measured strength isometrically in all fundamental shoulder exertions, and overall strength decreased compared to the control group. The breast cancer survivor group had on average, 20- 31.2% less strength compared to healthy controls in each fundamental shoulder exertion (Harrington et al., 2011). A negative relationship (r=-0.58) existed with decreased strength in the affected limb, and self-reported disability which was determined based on DASH questionnaire (Harrington et al., 2013). Survivors reported more disability when a decrease of strength was present. Current literature utilizes multiple methods to measure strength and is focused more heavily on strength measures such as grip strength, as they are easily attainable and performed more often in a clinical setting. A focus on shoulder exertions will provide a picture of the deficits at the affected shoulder and provide guidance to limit any compensations that may be occurring.

### 2.4.2 Range of Motion

Range of motion is reduced in breast cancer survivors, and varies depending on the treatment used. Reduced arm function was reported in 51% of breast cancer survivors in a recent self-reported survey (Sugden et al., 1998). Mastectomy patients reported reduction more often

(77%) than those with breast conserving therapy (33-39%), and reduction in flexion, abduction and external rotation was more prominent in patients treated with mastectomies (Ebaugh et al., 2011; Harrington et al., 2013; Lauridsen et al., 2008; Nesvold et al., 2008; Sugden et al., 1998). Adding radiotherapy to a more invasive surgery technique resulted in increased reduction in abduction with external rotation and adduction with internal rotation, compared to radiation therapy and breast conserving therapy (Lauridsen et al., 2008; Sugden et al., 1998; Thompson et al., 1995).

There have been many different attempts to quantify reduction in range of motion but they have yielded inconsistent findings. A minimum of 120° in abduction is necessary to complete daily tasks (Badley et al., 1984). However, in current literature impairment is sometimes determined by a 10° loss in range of motion compared to the unaffected limb (Kuehn et al., 2000). Reduction in range of motion has been reported in 1-67% of survivors (Ernst et al., 2002; Lee et al., 2008; Tengrup et al., 2000; Voogd et al., 2003). Various fundamental shoulder movements appear to be affected differently. A study involving 396 breast cancer survivors reported mean restrictions of 21° in abduction, and 12° in forward flexion compared to the unaffected arm (Kuehn et al., 2000). Similar results emerged from smaller studies focused on surgical patients receiving an adjuvant therapy. Rietman et al. (2004) reported forward flexion of 158.9° in the non-affected side, and 153.2° on the affected side ($p=0.004$), abduction of 164.1° and 156.6° respectively, and external rotation of 63.5° and 57.3° (Rietman et al., 2004). However, only 6-16% of persons with lower ranges of motion were considered impaired (greater than 20° reduction in range of motion) 2.7 years after surgery (Rietman et al., 2004). A second study by Reitman et al. (2006) involving 181 participants tested pre-surgery and 2 years post-surgery to determine residual deficits revealed forward flexion was 172.4° pre surgery and was

reduced by 4.4° two years after the surgery, while abduction was 168.0° and decreased by 16.2°, and external rotation was 67.7° - 5.9° less post-surgery (Rietman et al., 2006).

This reduction in range of motion is thought to be potentially mitigated through breast reconstruction techniques, including the latissimus dorsi flap reconstruction technique. Garusi et al., (2016) reported more than 90% of patients recovered over 80% of normal range of motion in extension, flexion and internal/external rotation. However, 75% of patients only recovered 60-80% of normal range of motion in abduction (Garusi et al., 2016). Residual loss in range of motion has implications on productivity. Combined with presence of pain or lymphedema, 75% of women presented with one or more of those symptoms and had an associated reduced capacity to continue working in their previous roles (Quinlan et al., 2009). Overall, range of motion is affected differently in all breast cancer survivors, but it is important to quantify the range of motion loss to determine rehabilitation strategies, and work capacity.

**2.5 Relevance to Current Research**

It has been established that changes to upper limb function occur after breast cancer treatment. Strength and range of motion may be decreased in the affected arm, but the magnitude of this decrease is inconclusive. Varied populations and measurement techniques likely attribute to this uncertainty. Further, the muscle activation patterns of this population are variable, with increased muscular activity necessary to complete the same tasks as a healthy population. There has been no research, to date, on the differences between those with high and low self-reported physical function scores. By exploring the differences in these two groups more insight can be provided into the variability in this population, and why these differences in function exists.

# 3.0 Methodology

## 3.1 Participants

Ten adult female breast cancer survivors participated [age; 58.1 ± 10 years, height; 163.6cm ± 6.8cm, weight; 83.2 ± 29.0kg]. Survivors were 3 months post-treatment, but no more than 2 years. This ensured the survivors had time to heal from adjuvant therapy, but did not seek additional therapy that may have contributed to increases in function. Additionally, radiation therapy has shown to continue to affect tissue for up to two years following last treatment (American Cancer Society, 2016). Breast cancer survivors must have: a) undergone any form of surgical procedure for breast tumour removal; b) received any form of radiation or chemotherapy; and c) had any form of breast cancer pathology (i.e. from Stage I – IIIa). Breast cancer survivors were excluded from participation if they had bilateral cancer, metastases, upper arm dysfunction that preceded cancer treatments, barium swallow within 3 weeks of participation, and women who were or suspected they were pregnant. Survivors screened for participation are detailed in Figure 1. Informed consent was obtained prior to experimental data collection and the study was reviewed by and received ethics clearance through a University of Waterloo Office of Research Ethics Committee.

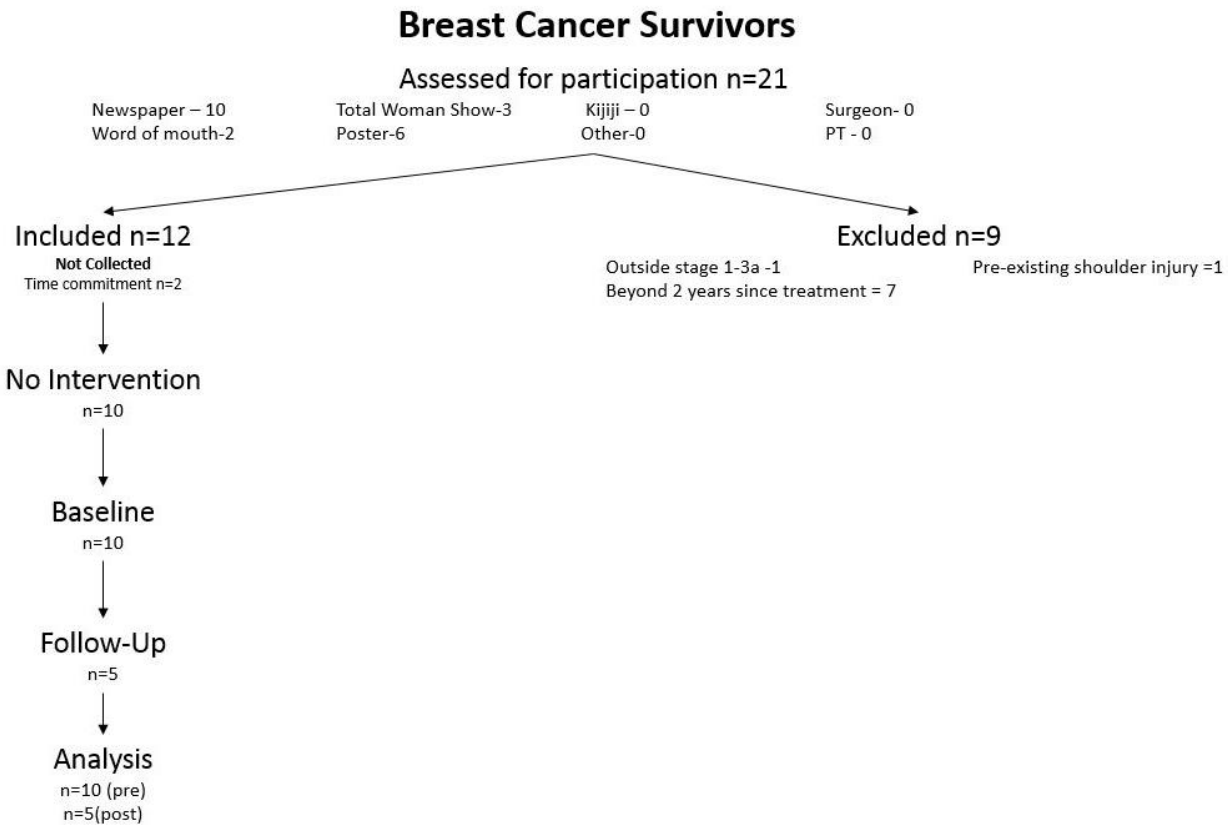


Figure 1: Consort diagram detailing breast cancer survivors who were screened for participation and reasons for exclusion

### 3.2 Instrumentation

#### 3.2.1 Motion Capture

Three-dimensional kinematic data were collected using an 8-camera optoelectronic VICON MX20 Motion capture system (VICON, Oxford, UK) at 50Hz. Prior to participant arrival, the collection space was calibrated using Vicon Nexus 1.8.5 software. The global origin was set with the positive global Z-axis being upwards, the positive X-axis being to the right and the positive global Y-axis in the anterior direction. This was rotated into ISB standards following collections (Wu et al., 2005). Twenty-one reflective markers were placed on the torso and both upper extremities over anatomical landmarks (Figure 2). Additionally, two cluster sets (upper

arm and forearm) were attached on each arm. The upper arm and forearm clusters were used to mathematically reconstruct trials where original bony landmark data were missing (Howarth and Callaghan, 2010). A static calibration frame was taken with the participant in anatomical position to establish a relationship between anatomical landmarks and the marker clusters.

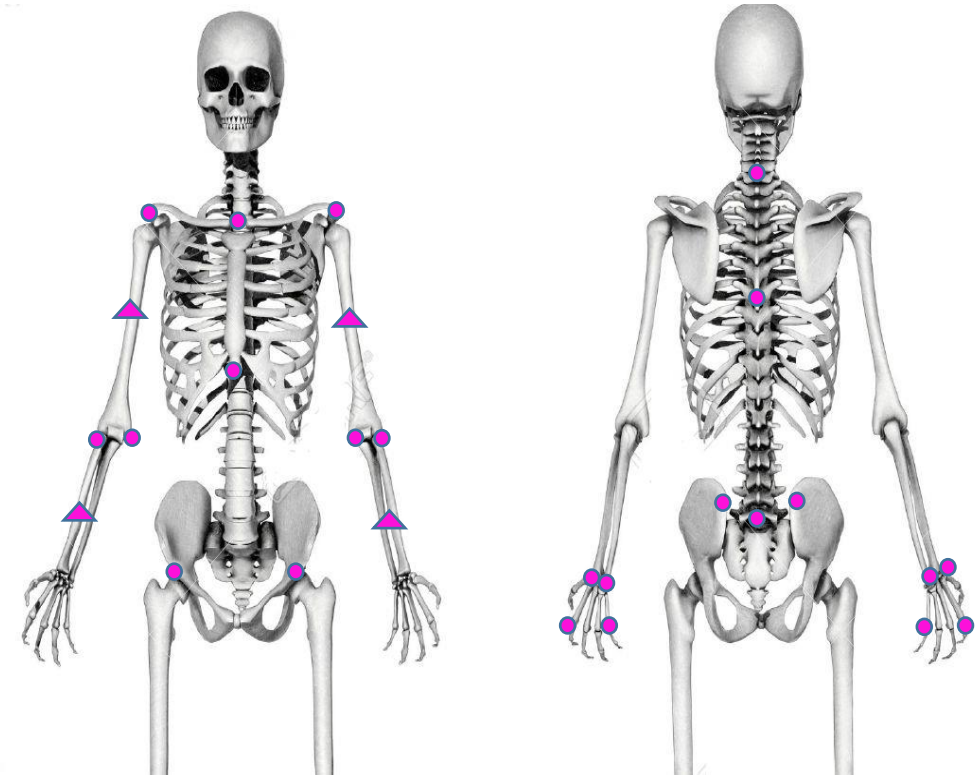

Figure 2: VICON marker placement - circles indicate individual bony landmarks and triangles indicate clusters

### 3.3 Experimental Protocol

Five participants visited the lab on two separate occasions, with a minimum of 16 weeks between visits. The other five participants were assessed on a single occasion. Monthly questionnaires were administered to identify any rehabilitation and physical activity completed between visits (Godin and Shephard, 1997). The time between collections represented a period of normal activity to capture the change in functionality over time without specific intervention. The collection protocol (Figure 3) during each visit was identical.

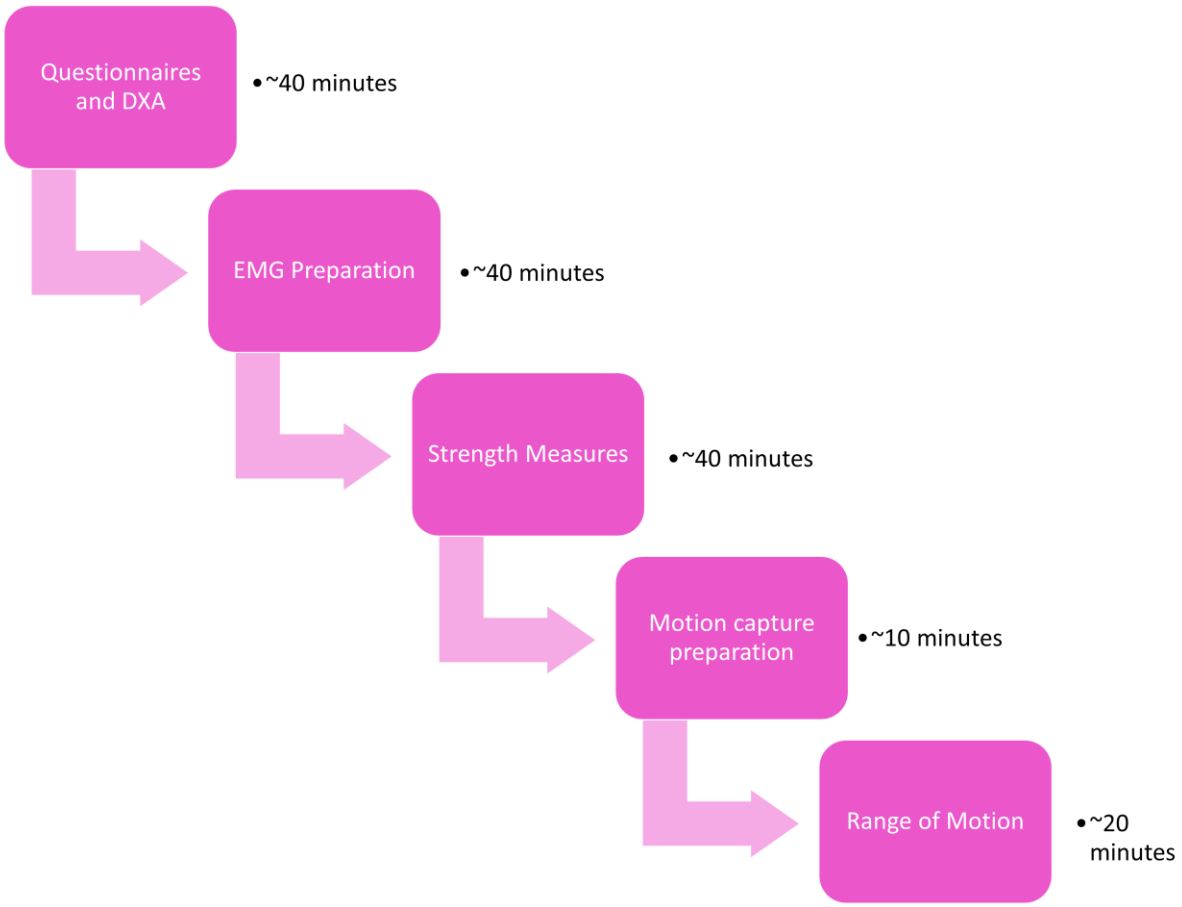


Figure 3: Overview of Laboratory Collection Protocol

#### 3.3.1 General Laboratory Collection Protocol Overview .

Prior to experimental data collection, the participants reviewed the information consent form and provided informed consent. Participants completed a general information form

(Appendix A). Within this form, participants were asked to detail diagnosis, treatment types and length, current physical activity levels, co-morbidities, present medications, and history of upper extremity discomfort prior to diagnosis. Following this, basic anthropometric data were collected by the researcher, including height, weight, and age.

Each visit to the lab began with participants completing the three standardized questionnaires followed by a dual-energy x-ray absorptiometry (DXA) scan. Following this, electrode placement took place for both the affected and unaffected limbs. Participants then performed one round of MVCs for each muscle, for a total of 14 exertions. Voltage output was monitored and in trials which participants did not reach a plateau, a second MVC was taken. This approach was used to avoid pain and fatigue in this clinical population due to multiple trials. There was a minimum of two minutes of rest between each exertion to avoid fatigue (Chaffin, 1975). Extra time was given between trials at the participant's request, and for one participant positions were altered by decreasing the elevation of the arm when pain was present. This allowed the participant to perform maximally, as pain was no longer a hindrance to performance.

Next, strength measures were collected. After each strength measure (and all trials to follow) a rating of perceived discomfort (RPD) and rating of perceived exertion (RPE) value was taken and two minutes of rest was given, with extra time at the participant's request. To avoid fatigue, only one strength trial was collected for each posture for both the affected and unaffected limbs (described in Table 3 below). Position and force were monitored. Any variation in position indicated a second trial needed to be collected. The force was also observed for a distinct plateau; when this was not reached a second trial was also collected. Reflective markers were placed on the participant following these trials.

Next, the participant performed maximal range of motion trials. One trial of each active range of motion (described in section 3.4.4) was taken for both the affected and unaffected limb, for a total of 12 trials per participant. If participants were unable to reach their maximum in five seconds, a second trial was performed to ensure the entire range was collected.

### 3.3.2 Non-Intervention Period

During the 16 weeks between laboratory visits, usual care took place. However, activity of participants was monitored by asking participants to fill out the modified Godin questionnaire at the end of every month via email or phone call (Godin and Shephard, 1997).

## 3.4 Experimental Measures

### 3.4.1 Questionnaires

Questionnaires were used to provide insight into quality of life. These questionnaires were given to the participants both at the baseline collection and the follow up visit (when applicable). The three questionnaires that were administered (Appendix F) are the Functional Assessment of Cancer Therapy – Breast Cancer (FACT-B) (Cella, 2007), Rand-36 Health Survey short form (RAND 36/SF 36) (Hays et al., 1993) and the Disabilities of the Arm, Shoulder and Hand (DASH) (Hudak et al., 1996). FACT-B is a standardized quality of life survey wherein participants were asked to use a rating scale to quantify their physical well-being. SF 36 is also a quality of life survey, but includes additional questions on physical functioning. Finally, the DASH questionnaire is related specifically to the upper extremity and asks participants to respond to questions regarding symptoms relating to their physical capabilities. Each questionnaire was scored as outlined and validated by the creators. For FACT-B and SF-36 higher scores indicated belter quality of life/physical functioning. For the DASH questionnaire a lower score indicated higher quality of life/physical functioning.

In order to account for physical activity that may induce changes in upper extremity function between visits, a modified version of the Godin Leisure Time Activity questionnaire (Appendix A) was given to participants at baseline and follow up, as well as monthly via email or phone call. Additional questions were added to incorporate possible physical therapy the participant may be receiving. This data may allow future grouping of participants based on their activity levels. As physical therapy may have implications on function in this population, characterizing the differences in participants' activity level between visits may help clarify the potential origins of observed changes.

### 3.4.2 Rating of Perceived Exertion/Discomfort

Rating of Perceived Exertion (RPE) is a qualitative measure that was implemented to both monitor participants as they complete tasks, and track fatigue. Participants verbally provided a rating between 0 and 10 (Borg, 1998) (Figure 4 Below). Participants were instructed to choose any value, and were not restricted to whole numbers. They were reminded that this pertains solely to the shoulder and not to the whole body. RPE was recorded at the end of every trial to ensure participants are receiving adequate rest and are not performing tasks in a fatigued state. Rating of Perceived Discomfort (RPD) can provide insight into movements which cause discomfort. RPD was taken at the same time as RPE. Similar to RPE, RPD can help ensure adequate rest was given between trials. Additionally, RPD provides insight into which tasks prove to be the most challenging for participants. For both scales, a baseline score was taken prior to EMG placements, and all subsequent rating were calculated as an increase from baseline.

| | | |
|---|---|---|
| 0 | Nothing at all | |
| 0.5 | Extremely Weak | (just noticeable) |
| 1 | Very Weak | |
| 2 | Weak | (light) |
| 3 | Moderate | |
| 4 | | |
| 5 | Strong | (heavy) |
| 6 | | |
| 7 | Very Strong | |
| 8 | | |
| 9 | | |
| 10 | Extremely Strong | (almost max) |
| • | Maximal | |

Figure 4: Modified Borg Scale – Rating of Perceived Exertion (Borg, 1998)

### 3.4.3 Strength Measures

Maximum voluntary strength was measured for several fundamental shoulder exertions (flexion/extension, abduction/adduction, and internal/external rotation). Arm positions were chosen to replicate maximal strength outputs as described in previous literature (Hughes et al., 1999; Stobbe, 1982) (Table 2). A cuff was placed on the upper arm and attached to a 6 degree of freedom force transducer (MC3A, AMTI, Watertown, MA, USA) with a chain (Figure 5). The participants were strapped to a chair to decrease potential compensations, and increase replicability. The force cube was positioned to ensure that the chain was pulled tight and force exerted is in the z axis, while the x and y axis forces were minimized. Strength measures were taken on both affected and unaffected side and were sampled for 5 seconds at 1500Hz.

Table 2: Arm positions for strength trials (Hughes et al., 1999; Stobbe, 1982)

| Motion | Position |
|---|---|
| **Adduction** | Abducted 60° in the coronal plane |
| **Abduction** | Abducted 30° in the coronal plane |
| **Flexion** | Abducted 30° in the sagittal plane |
| **Extension** | Abducted 60° in the sagittal plane |
| **Internal Rotation** | Abducted 90° in the coronal plane, elbow flexed 90°, forearm neutral |
| **External Rotation** | Abducted 0° in the coronal plane, elbow flexed 90°, forearm neutral |


Figure 5: Example of a flexion strength trial with cuff above the elbow to ensure force was generated at the shoulder

### 3.4.4 Range of Motion

Maximal range of motion trials for each plane of motion, for the affected and unaffected shoulders, were completed. Participants moved from a neutral position to their maximum in each fundamental shoulder movement (flexion/extension, abduction, internal/external rotation and scapular plane elevation). For all motions, a pole was placed in a location that ensured the motion remained in the desired plane (Figure 6).

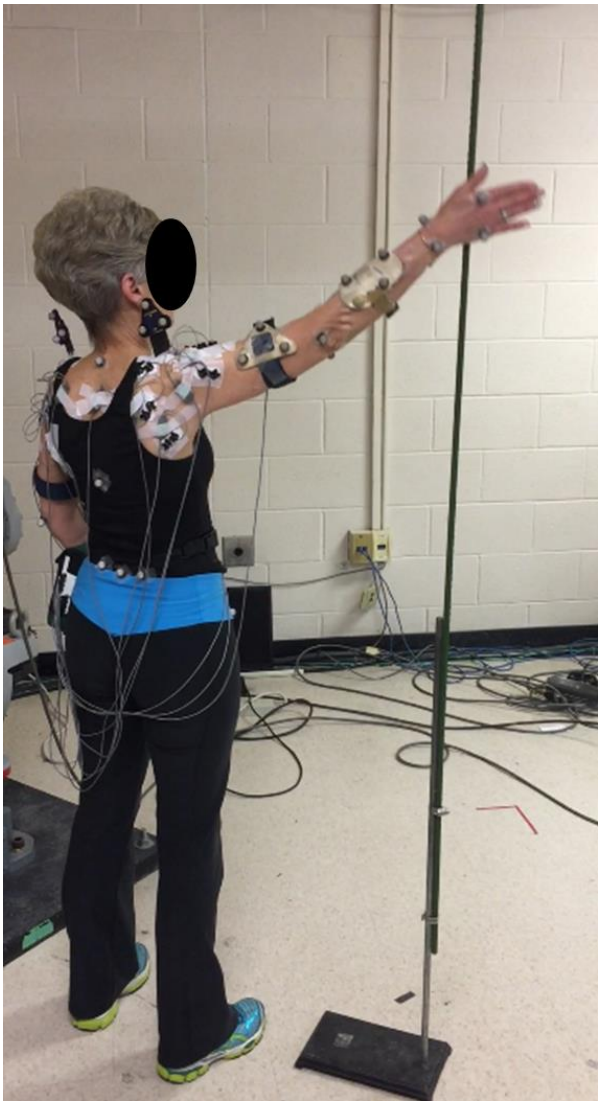

Figure 6: Example of abduction range of motion trial with a pole to guide movement

### 3.5 Data Analysis

#### 3.5.1 Kinematic Data Processing

Raw 3D kinematic marker position data were labelled, and missing markers were pattern-filled by reconstructing the marker trajectory using markers present in the trial using Vicon Nexus 1.8.5 (Vicon, Oxford, UK). Kinematic data were dual pass filtered with a second order, low pass Butterworth filter with a cut-off frequency of 4Hz.

Joint centres and segments were calculated in accordance with previous literature. The humeral head was located by adding 60mm in the negative direction of the y-axis of the torso (which connects the centre of SS and C7 and the centre of XP and T8, pointing upwards) from the acromion marker (Nussbaum and Zhang, 2000). The joint centres, upper arm segment and torso segments and local coordinate system for each segment were defined according to ISB recommendations, described in Table 3 (Wu et al., 2005).

Table 3: Description of segments and local coordinate systems (Wu et al., 2005)

| | **Upper arm** | **Torso** |
|---|---|---|
| **Positive y axis** | The line created between the humeral head and the joint centre of the elbow (1/2 way between lateral and medial epicondyles), pointing upwards | The line created by the centre of C7 and SS and the centre of T8 and XP, pointing upwards |
| **Positive x axis** | Cross multiplication of the y axis and temporary Z axis (line formed between the lateral and medial epicondyles), pointing forwards | ** X is created last for this axis system<br>A true X axis is then formed by crossing the Y and Z axes, pointing forwards |
| **Positive z axis** | A true Z axis is then formed by crossing the Y and X axes, pointing to the right | Cross multiplication of the y axis and temporary X axis (line formed between SS and C7), pointing to the right |

The relative rotation matrices were found by multiplying the distal segment (humerus) by the transpose of the proximal segment (thorax). Humerothoracic joint descriptions were based on the Euler YXY' rotation sequences (Wu et al., 2005). The clinically relevant rotations are described below in Table 4. For each range of motion trial maximum and minimum angles for rotations about each axis were extracted using a custom Matlab $^{TM}$ R2016b program (Mathworks Inc., USA). Finally, the range of motion was determined by subtracting the minimum from the maximum for each rotation (Hall et al., 2011).

Table 4: Humerothoracic rotation descriptions (Wu et al., 2005)

| **Segment** | **Rotation** |
|---|---|
| **Humerothoracic Rotations (Y-X-Y')** | el: Glenohumeral plane of elevation (0 is pure abduction, 90 is forward flexion)<br>e3: internal rotation (positive); external rotation (negative)<br>e2:elevation (negative) |

### 3.5.2 Strength Data

Force data were smoothed using a low pass, second order, dual pass Butterworth filter, with a cut-off frequency of 6 Hz. A particular joint strength was assumed to be the maximum force output, from each respective strength trial, and was extracted to use for analysis using a custom Matlab$^{TM}$ R2016b program (Mathworks Inc., USA).

### 3.5.3 Statistical Analysis

Prior to any statistical analyses, data were screened for outliers using Grubb's tests (Grubbs, 1950). The confidence interval was set to 95%, and with only ten observations per variable, any experimental data point with an absolute z-score above 2.176 was removed and considered an outlier.

For all strength and range of motion trials, Pearson correlation coefficients (r) were computed for all dependent variables. DASH scores were viewed as the independent variable, with strength (n=6) and range of motion (n=6) as the dependent variables. A correlation coefficient of less than 0.3 was considered weak, 0.3 -0.7 was considered moderate, and anything above 0.7 was considered strong (Vincent and Weir, 2012).

Two comparisons were made using t-tests. Firstly, the data were split between high and low DASH scores, for each variable. Group A refers to the groups with higher QOL as defined by DASH scores (score of 10 or lower), and group B as those with a higher DASH score (greater than 10). Five participants were allocated into each group. Additionally, affected and unaffected limbs were compared for each variable. Independent sample, one-tailed, t-tests were completed for each variable. The p-value was originally set for 0.05. A Shapiro-Wilk Test was used to assess normality of all variables. Any variables that did not fit within a normal distribution were discarded from t-tests to ensure no false positives were considered (Shapiro and Wilk, 1965). Normality tests were completed using JMP 13 (SAS Institute Inc., Cary, NC). A Bonferroni correction was completed, altering the p-value to 0.03 for strength, range of motion and EMG data. All t-tests were completed using a custom Matlab ™ R2016b program (Mathworks Inc., USA). Finally, effect sizes were calculated for strength and range of motion data, using the following equation, where M represents mean, and SD represents standard deviation of each of the groups. Effect sizes of 0.2-0.5 were considered small, 0.5-0.8 were moderate and above 0.8 were considered large effect sizes (Cohen, 1988).

$$\text{Cohen's d} = (M_1 - M_2)/\sqrt{((SD_1^2 + SD_2^2/2}$$

# 4.0 Results

## 4.1 Questionnaires

Out of the ten participants, five were classified as high physical functioning and five as low physical functioning. These two groups were equally split on the basis of DASH scores. Using the SF-36 questionnaire, the physical functioning section of the questionnaire is reported in the table below and showed a significant difference between the two groups (Table 5), such that participants with higher physical functioning scored 49% higher than that of the group with lower physical functioning. The FACT-B questionnaire showed no differences between low and high physically functioning participants (p=0.11).

Table 5: Questionnaire results (A higher score indicates higher QOL for FACT-B and SF-36, whereas a lower score for DASH indicates a higher physical functioning)

| | High Physical Function (n=5) | Low Physical Function (n=5) | p-value |
|---|---|---|---|
| **DASH** | 5 (± 3.9) | 30.67 (± 15.6) | 0.003 |
| **FACT-B** | 122.4 (± 13.8) | 105.2 (± 16.3) | 0.110 |
| **SF-36** | 94 (± 10.8) | 63 (± 12.5) | 0.007 |

## 4.2 Demographics

The two groups were compared based on demographics. No significant differences existed for stage, side affected, whether dominant limb was affected, and surgical treatment. Notably, significant differences between groups existed in the adjuvant therapy received. The group with higher physical function scores received a combination of both chemotherapy and radiation (n=4) and just chemotherapy (n=1) for adjuvant therapy, and those with lower physical function scores received only radiation therapy (n=4) and both radiation and chemotherapy (n=1) (Table 6).

Table 6: Qualitative demographics of each breast cancer survivor group. Participants were tallied based on the information given characterizing diagnosis and treatment

| | | High Physical Function | Low Physical Function |
|---|---|---|---|
| **Stage** | **1** | 2 | 3 |
| | **2** | 1 | 2 |
| | **3** | 2 | 0 |
| **Side** | **Right** | 3 | 3 |
| | **Left** | 2 | 2 |
| **Dominant Affected?** | **Yes** | 3 | 3 |
| | **No** | 2 | 2 |
| **Surgery** | **Mastectomy** | 2 | 2 |
| | **Lumpectomy** | 3 | 3 |
| **Adjuvant Therapy** | **Radiation** | 0 | 4 |
| | **Chemotherapy** | 1 | 0 |
| | **Both** | 4 | 1 |

Comparison quantitative anthropometric and medical history data were also collected (Table 7). There were no statistical differences between the two groups for all variables examined. Although not statistically significant, there was a trend in both % body fat and affected limb % fat with the 10 participants collected (p=0.07-0.08), warranting further investigation, specifically that those with lower body fat percentage had higher self-reported physical function. There was 8% difference in total % body fat, and 13% difference in affected limb % fat. For both variables, the group with higher physical function scores had lower body fat % and lower affected limb % fat than that of the group with lower physical function scores. Additionally, there was a moderate negative correlation between DASH scores (where a lower score represents higher physical function) and mild physical activity/week ($r = -0.54$), where 1.2 day of mild physical activity results in approximately 10 point decrease in physical function.

Table 7: Quantitative demographics of each breast cancer survivor group

| | High Physical Function | Low Physical Function | p-value | Cohen's d |
|---|---|---|---|---|
| **Physical Activity** | 4 (± 2.8) times a week | 2 (± 1.2) times a week | 0.18 | 0.92 |
| **Time since Treatment** | 9.8 (± 6.2) months | 8.6 (± 3.8) months | 0.72 | 0.23 |
| **Age** | 57 (± 4.8) years old | 59.2 (± 14.2) years old | 0.75 | 0.21 |
| **Height** | 161.6 (± 2.0) cm | 165.5 (± 9.5) cm | 0.39 | 0.57 |
| **Weight** | 69.0 (± 16.2) kg | 97.5 (± 33.5) kg | 0.12 | 1.08 |
| **% Body Fat** | 40.3 (± 7.7) % | 48.5 (± 5.0) % | 0.08 | 1.26 |
| **Affected Limb Fat Mass** | 1644.78 (± 836.8) g | 2431.3 (± 577.3) g | 0.12 | 1.09 |
| **Affected Limb Lean Mass** | 1850.3 (± 145.0) g | 1741.1 (± 344.5) g | 0.53 | 0.41 |
| **Affected Limb % Fat** | 43.2 (± 11.1) % | 56.3 (± 8.7) % | 0.07 | 1.31 |

### 4.3 Strength

Strength was analyzed in two ways. For each strength measure the correlation with DASH scores as well as a comparison between the two groups was performed (Tables 8 and 9). Each strength measure was below that of a 50$^{th}$ percentile adult female, indicated by the green line on Figures 7-12.

#### 4.3.1 Group Comparisons for Strength Measures

The affected limb of the two groups (low and high physical function scores), as described above were compared (Table 8). Abduction (Figure 7), adduction (Figure 8), extension (Figure 9) and flexion (Figure 10) exhibited significantly different strengths between the two groups. The largest strength difference was in flexion, with the group with high physical function scores having 51.7% higher strength than the group with lower physical function scores. Extension strength was 38.9% higher in the group with higher physical function scores compared to the group with lower physical function scores. Abduction and adduction strengths were 32.3 and 33.5% higher in those with higher physical function scores than those with lower physical

function scores. Of the measures collected, external rotation (Figure 11) and internal rotation (Figure 12) were not decreased in the group with lower physical functioning despite having differences of 26.8 and 16.3%, respectively ($p > 0.03$). However, external rotation strength had a moderate effect size of 0.63, where internal rotation strength had a small effect size of 0.32.

Table 8: Mean (SD) strength measures for each group (Nm). Percent change represents the increase from low physical function to high physical function.

| | High Physical Function | Low Physical Function | Percent Change | p-value | Cohen's d |
|---|---|---|---|---|---|
| **Abduction** | 16.47 (± 4.71) | 12.45 (± 4.77) | 32.3% | **0.03** | 0.85 |
| **Adduction** | 17.60 (± 7.43) | 13.18 (± 4.50) | 33.5% | **0.003** | 0.72 |
| **Extension** | 21.16 (± 5.80) | 15.24 (± 7.11) | 38.9% | **0.03** | 0.92 |
| **External Rotation** | 24.44 (± 10.45) | 19.28 (± 5.03) | 26.8% | 0.17 | 0.63 |
| **Flexion** | 19.25 (± 5.27) | 12.69 (± 6.91) | 51.7% | **0.004** | 1.07 |
| **Internal Rotation** | 18.85 (± 2.51) | 16.20 (±11.45) | 16.3% | 0.31 | 0.32 |

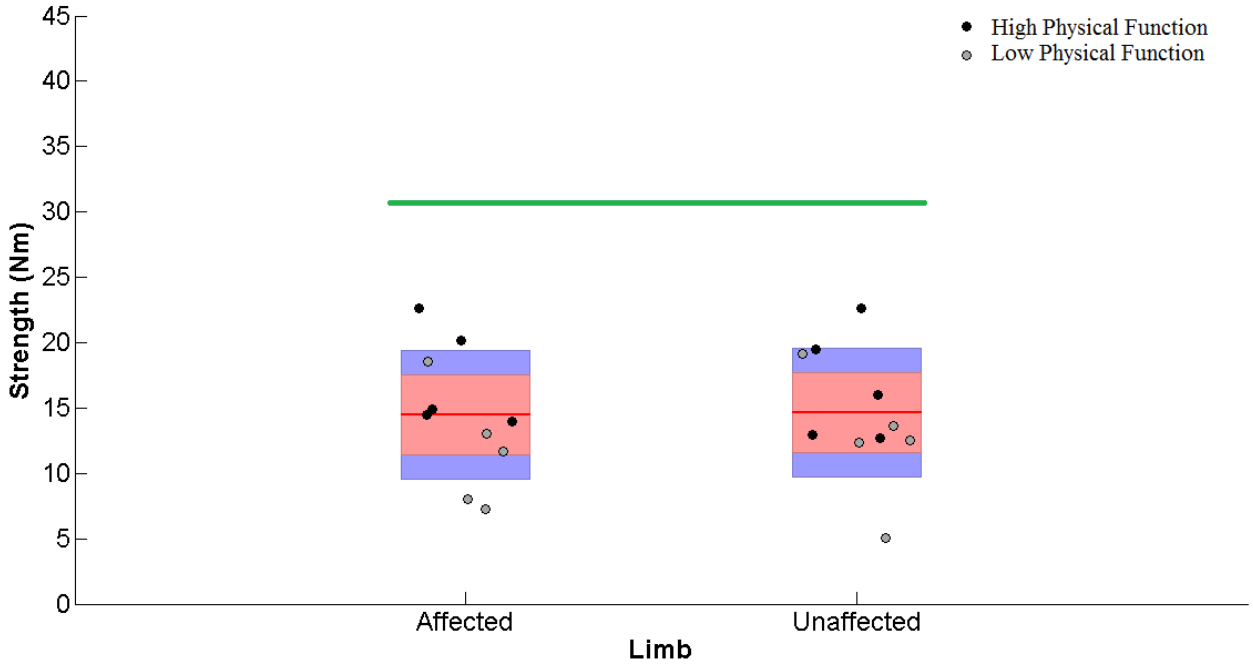


Figure 7: Abduction strength for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line, and 50th percentile strength of an adult female is indicated with the thick green line.

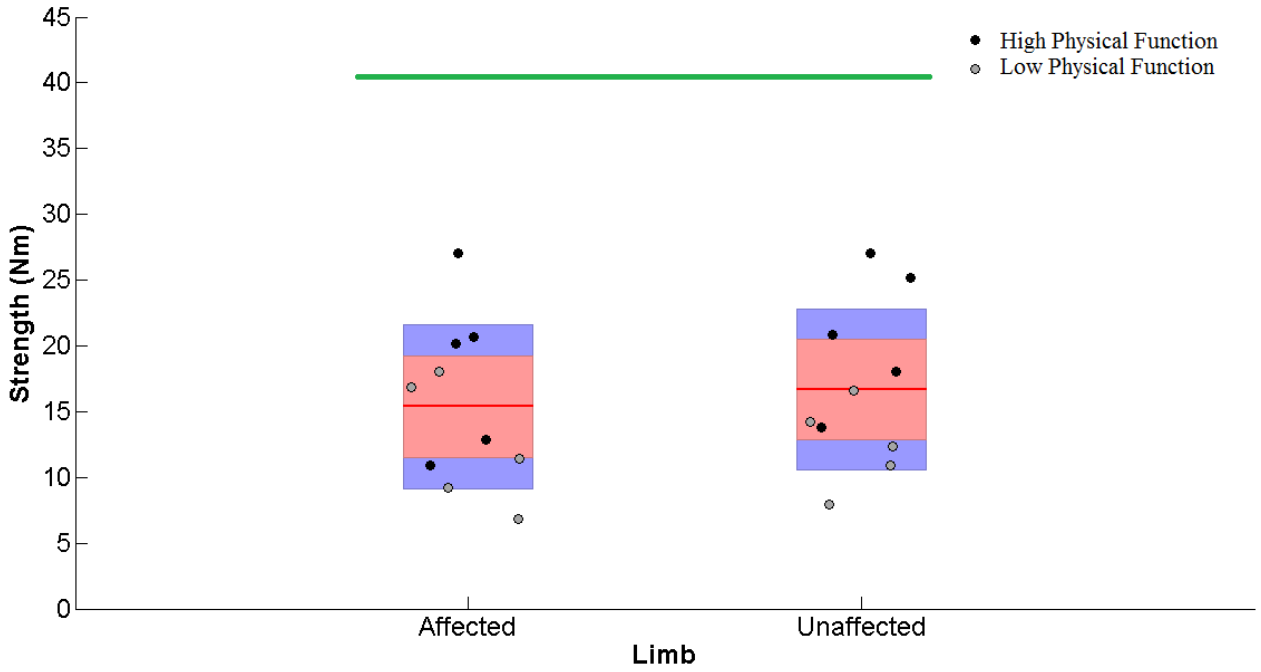


Figure 8: Adduction strength for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line, and 50th percentile strength of an adult female is indicated with the thick green line.

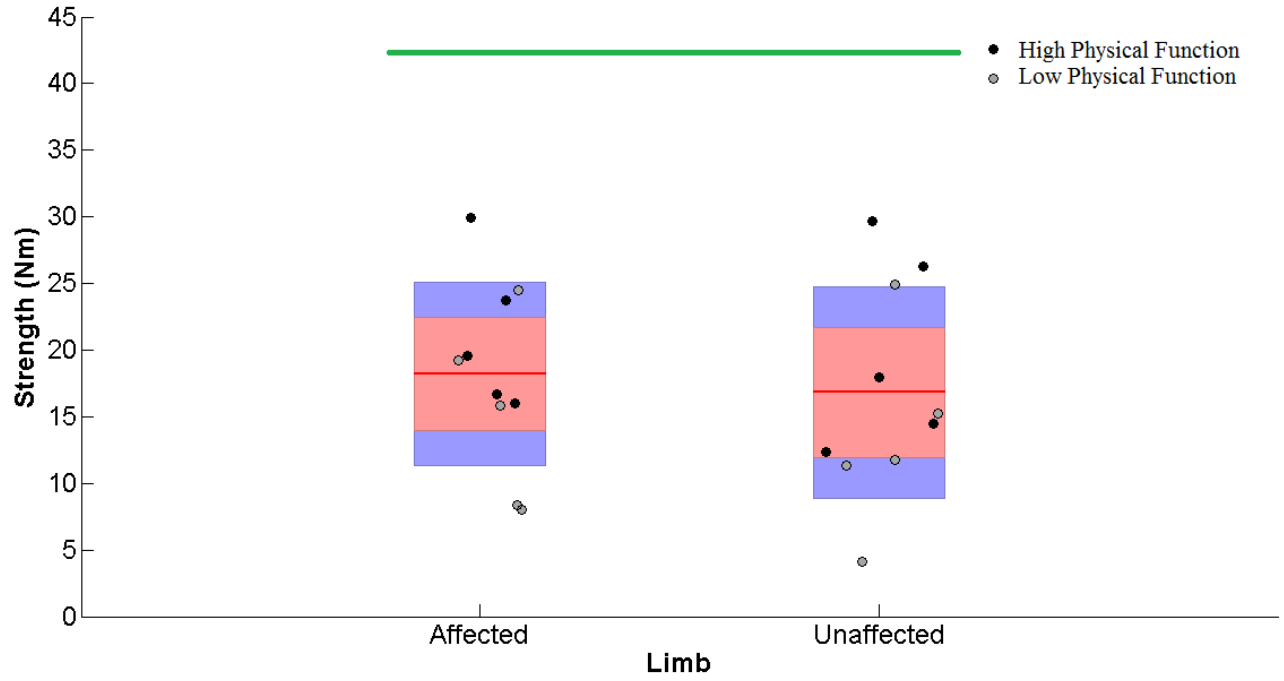


Figure 9: Extension strength for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line, and 50th percentile strength of an adult female is indicated with the thick green line.

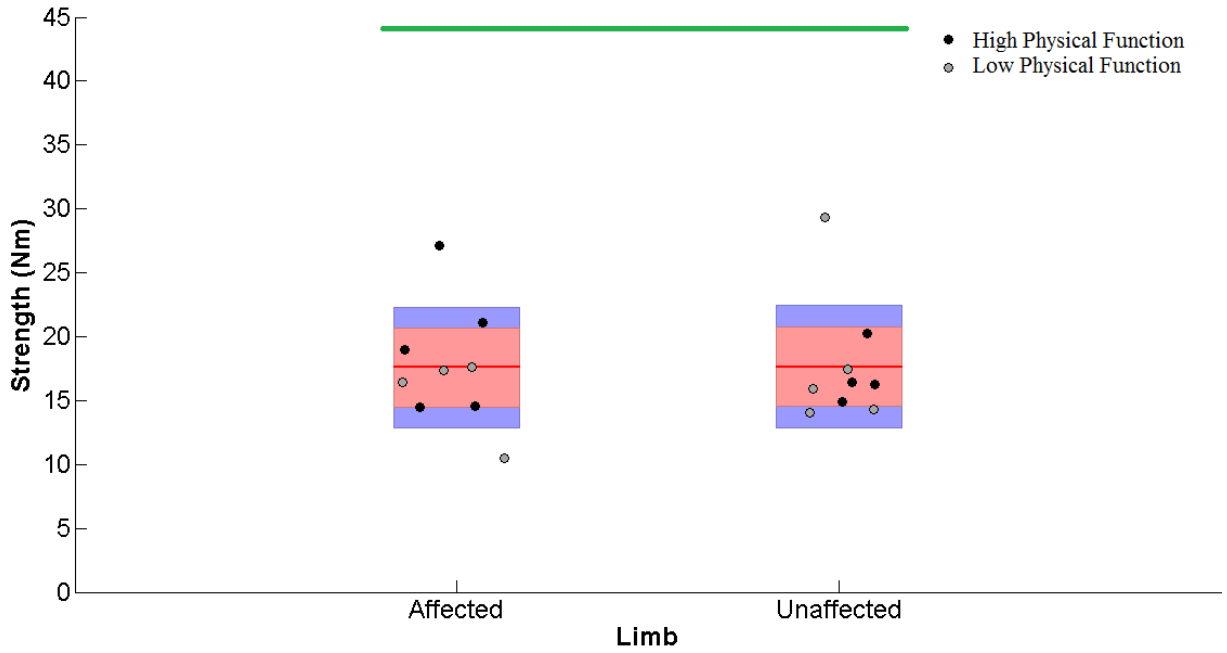


Figure 10: Flexion strength for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line, and 50th percentile strength of an adult female is indicated with the thick green line.

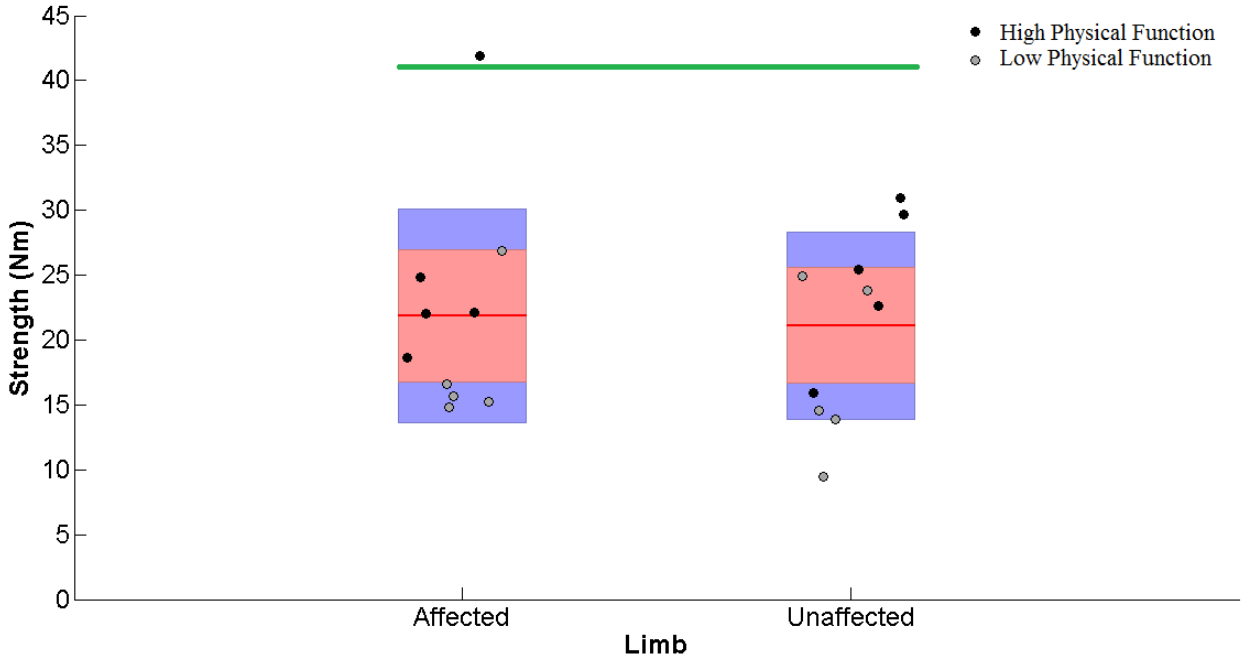


Figure 11: External rotation strength for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line, and 50th percentile strength of an adult female is indicated with the thick green line.

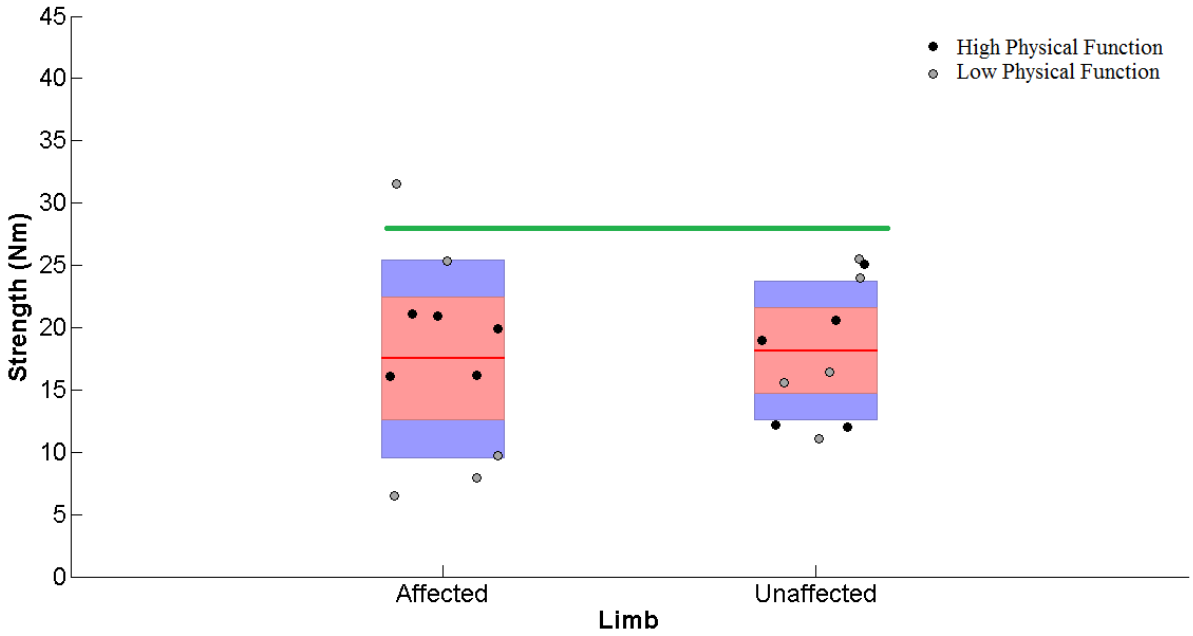


Figure 12: Internal rotation strength for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line, and 50th percentile strength of an adult female is indicated with the thick green line.

### 4.3.2 Limb Comparisons for Strength Measures

For all six strength measures there were no bilateral limb differences ($p > 0.03$; Table 9; Figures 7-12). On average, strength differed by approximately 2 Nm. However, individual participants' unaffected limb was between 0 and 15 Nm higher than that of the affected limb across the strength measurements collected. All effect sizes were small, ranging from 0.002-0.08.

Table 9: Mean (SD) strength measures for each limb (Nm). Percent change represents the increase from affected limb to unaffected limb.

| | Affected | Unaffected | Percent Change | p-value | Cohen's d |
|---|---|---|---|---|---|
| **Abduction** | 14.46 (± 4.95) | 14.65 (± 4.94) | 1.3% | 0.98 | 0.01 |
| **Adduction** | 15.39 (± 6.25) | 16.67 (± 6.15) | 8.4% | 0.71 | 0.08 |
| **Extension** | 18.20 (± 6.87) | 18.23 (± 6.95) | -0.2% | 0.76 | 0.002 |
| **External Rotation** | 21.86 (± 8.19) | 21.13 (± 7.23) | -3.5% | 0.99 | 0.03 |
| **Flexion** | 15.97 (± 6.75) | 16.15 (± 6.53) | 1.1% | 0.71 | 0.01 |
| **Internal Rotation** | 17.53 (± 7.93) | 18.15 (± 5.55) | 3.5% | 0.87 | 0.03 |

### 4.3.3 Correlation of DASH Scores and Strength

Correlation of DASH scores and strength of the affected limb was computed for all strength measures collected. One participant's DASH score was identified as an outlier, and was thus was removed from all correlations. A moderate negative relationship existed between flexion and DASH score (r = -0.50, Table 10) and extension and DASH score (r = -0.41). Further, moderate negative correlations were quantified for abduction and DASH score (r = -0.45) and adduction and DASH score (-0.48). A 1Nm decrease in flexion strength, and a 1.2Nm decrease in extension strength represented approximately a 5 point increase in DASH scores (Figures 8, 9). Similarly, a 1.8Nm decrease in adduction strength, and a 1.3Nm decrease in abduction strength represented a 5 point increase in DASH scores. External and internal rotation showed a weak negative correlation with DASH scores (r=-0.24 and -0.25, respectively). It should be noted, however, that internal and external rotation included forces that may have been generated at the elbow, whereas the others were isolated to just shoulder strength.

Table 10: Correlation of strength and DASH scores

| | Coefficient of Determination | Correlation Coefficient | p-value |
|---|---|---|---|
| **Abduction** | $r^2$=- 0.2037 | r=-0.45 | 0.19 |
| **Adduction** | $r^2$=- 0.2318 | r=-0.48 | 0.27 |
| **Extension** | $r^2$=- 0.1676 | r=-0.41 | 0.22 |
| **External Rotation** | $r^2$=- 0.06 | r=-0.24 | 0.19 |
| **Flexion** | $r^2$=- 0.2295 | r=-0.50 | 0.18 |
| **Internal Rotation** | $r^2$=- 0.0635 | r=-0.25 | 0.51 |

### 4.3.4 Comparison of Baseline and Follow-up for Strength Measures

All strength measures were compared for the affected limb for five participants at baseline and follow-up (Table 11). All strength measures were statistically similar at baseline and follow-up ($p>0.05$, Table 11), although differences ranged from -18.8% (where baseline was higher than follow-up), to 32.3% (where follow-up was higher than baseline). Effect sizes were small for abduction, extension, external rotation and flexion (0.24-0.47), and moderate for adduction 0.72. Internal rotation had an insignificant effect size of 0.04.

Table 11: Mean (SD) strength measures for baseline and follow-up (Nm). Percent change represents the increase from baseline to follow-up.

| | Baseline | Follow-up | Percent Change | p-value | Cohen's d |
|---|---|---|---|---|---|
| **Abduction** | 13.80 (± 5.62) | 16.43 (± 5.61) | 19.1% | 0.24 | 0.47 |
| **Adduction** | 14.14 (± 8.10) | 18.72 (± 3.91) | 32.3% | 0.14 | 0.72 |
| **Extension** | 18.60 (± 7.80) | 17.08 (± 4.42) | -8.8% | 0.64 | 0.24 |
| **External Rotation** | 24.53 (± 10.34) | 21.35 (± 3.76) | -14.9% | 0.73 | 0.41 |
| **Flexion** | 15.06 (± 9.19) | 12.69 (± 3.73) | -18.8% | 0.70 | 0.34 |
| **Internal Rotation** | 19.28 (± 8.56) | 19.61 (± 8.22) | 1.7% | 0.48 | 0.04 |

## 4.4 Range of Motion

A relationship between range of motion and DASH scores for affected and unaffected limb was examined. Elevation angles were reported for all measures, except the two rotation angles (were axial rotation was reported).

### 4.4.1 Group comparisons for Range of Motion Tasks

Statistical differences existed between participants with low and high physical function scores for internal rotation ($p = 0.02$). The group with high physical function scores had 1.9 times more internal rotation than those with low physical function scores (Figure 13). It is notable that the group with higher physical function scores had consistently higher range of motion (ranging from 11.6-79.8%). There were no statistical differences between groups for any other range of motion tasks (Figures 14-18), however the effect size for flexion was large (0.94) and all other effect sizes were moderate (ranging from 0.42-0.57) (Table 12).

Table 12: Mean range of motion (SD) for each group (Degrees). Percent change represents the increase from low physical function to high physical function.

| | High Physical Function | Low Physical Function | Percent Change | p-value | Cohen's d |
|---|---|---|---|---|---|
| **Abduction** | 138.39 (± 28.33) | 123.96 (± 25.25) | 11.6% | 0.42 | 0.54 |
| **Extension** | 28.30 (± 18.31) | 20.91 (± 16.94) | 35.4% | 0.53 | 0.42 |
| **External Rotation** | 28.47 (± 28.77) | 15.84 (± 13.07) | 79.8% | 0.40 | 0.57 |
| **Flexion** | 151.49 (± 31.10) | 125.42 (± 24.18) | 20.8% | 0.18 | 0.94 |
| **Internal Rotation** | 38.84 (± 14.34) | 13.32 (± 12.65) | 191.7% | **0.02** | 1.89 |
| **Scapular Plane Abduction** | 139.75 (± 32.38) | 125.16 (± 28.52) | 11.7% | 0.47 | 0.48 |

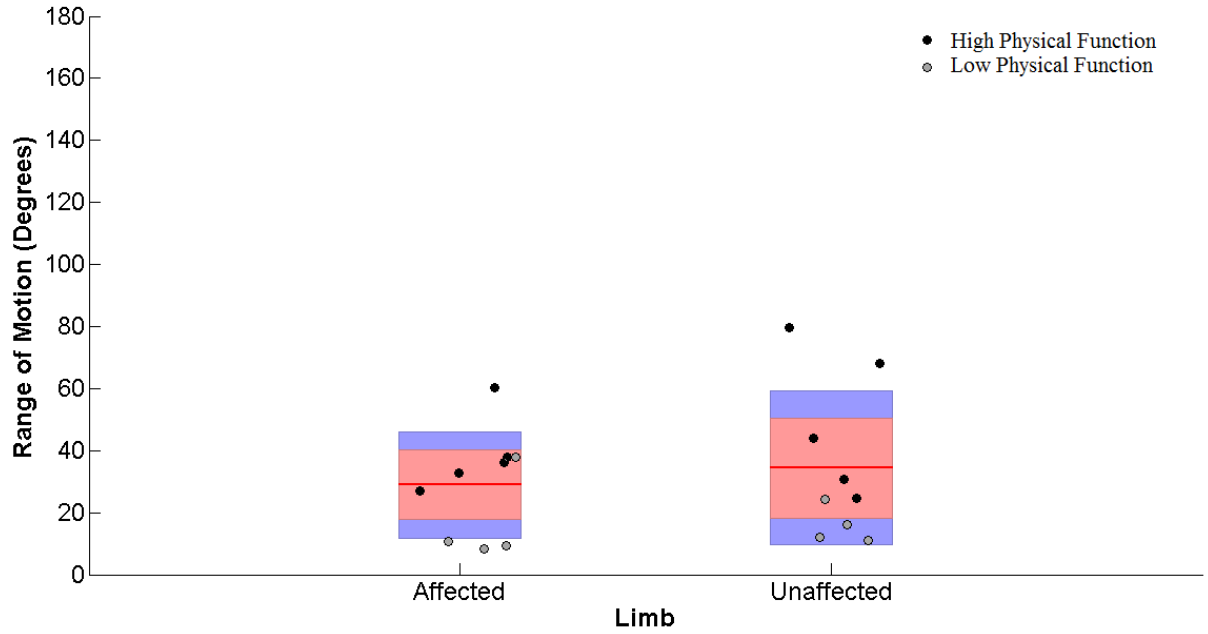


Figure 13: Internal rotation range of motion for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line.

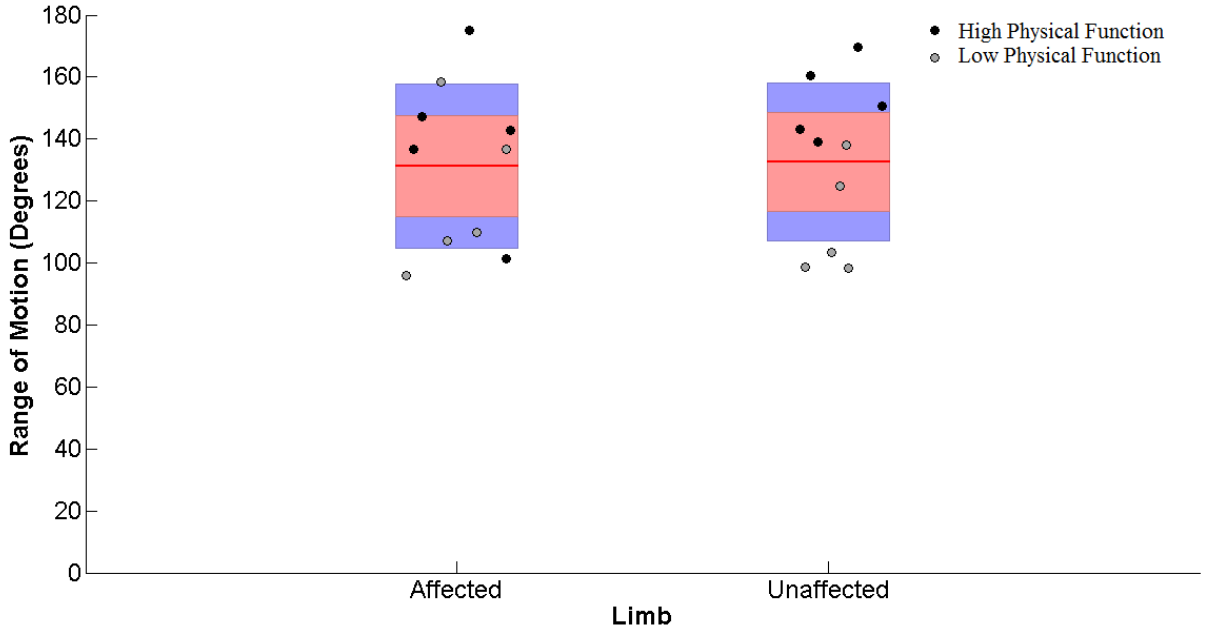


Figure 14: Abduction range of motion for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line.

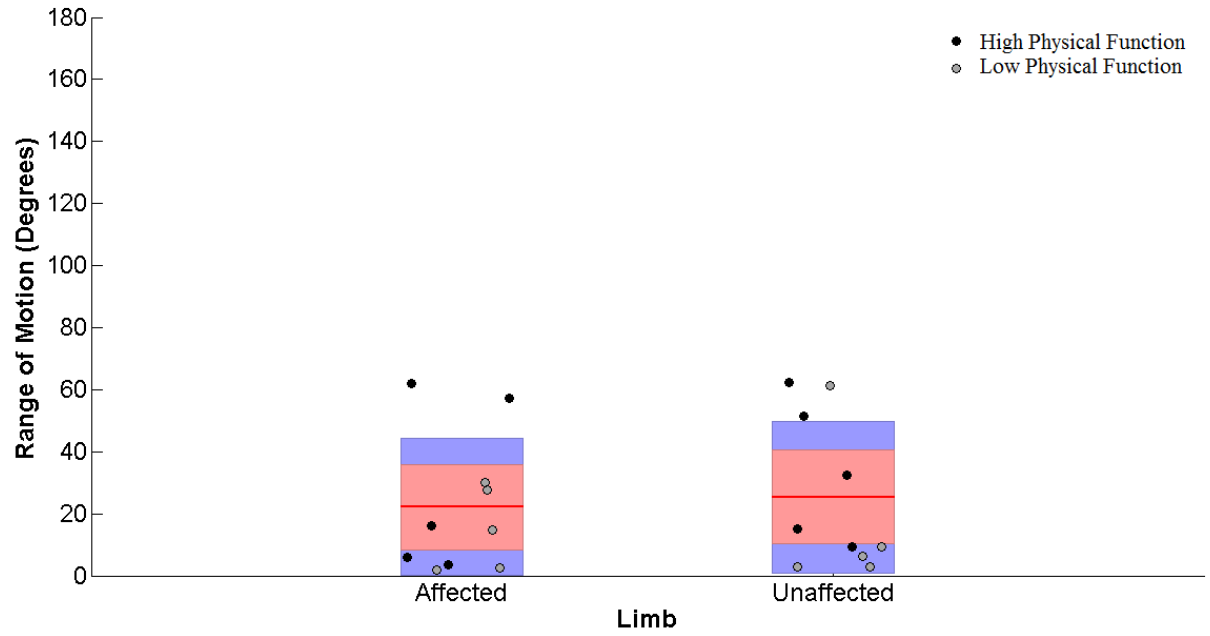


Figure 15: External rotation range of motion for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line.

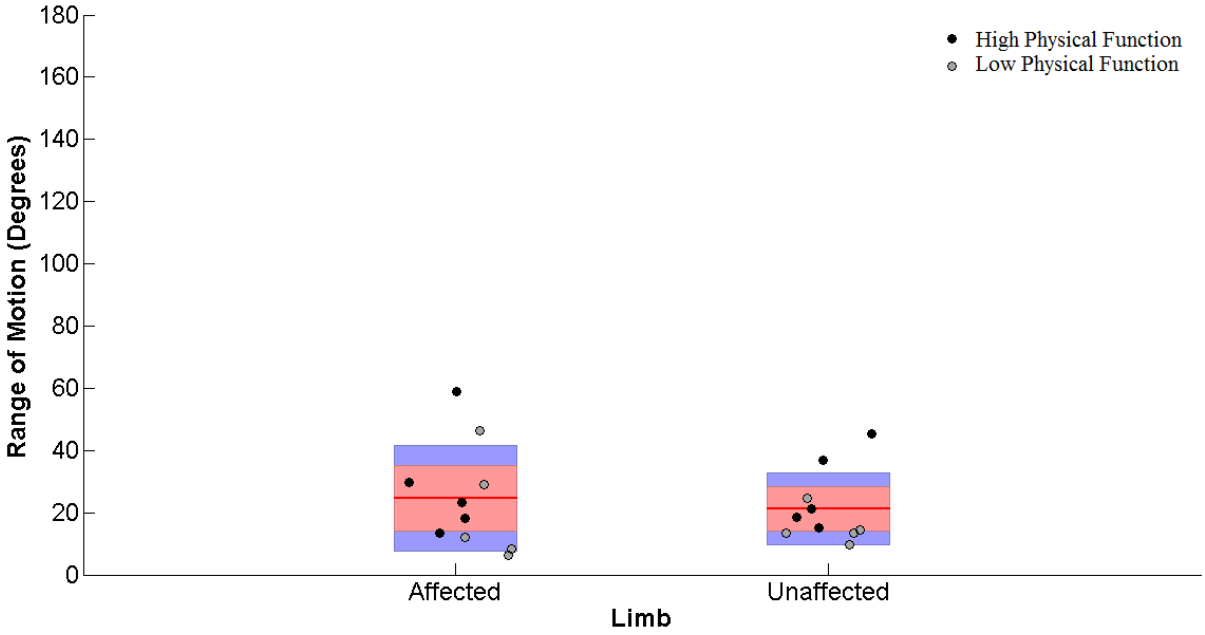


Figure 16: Extension range of motion for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line.

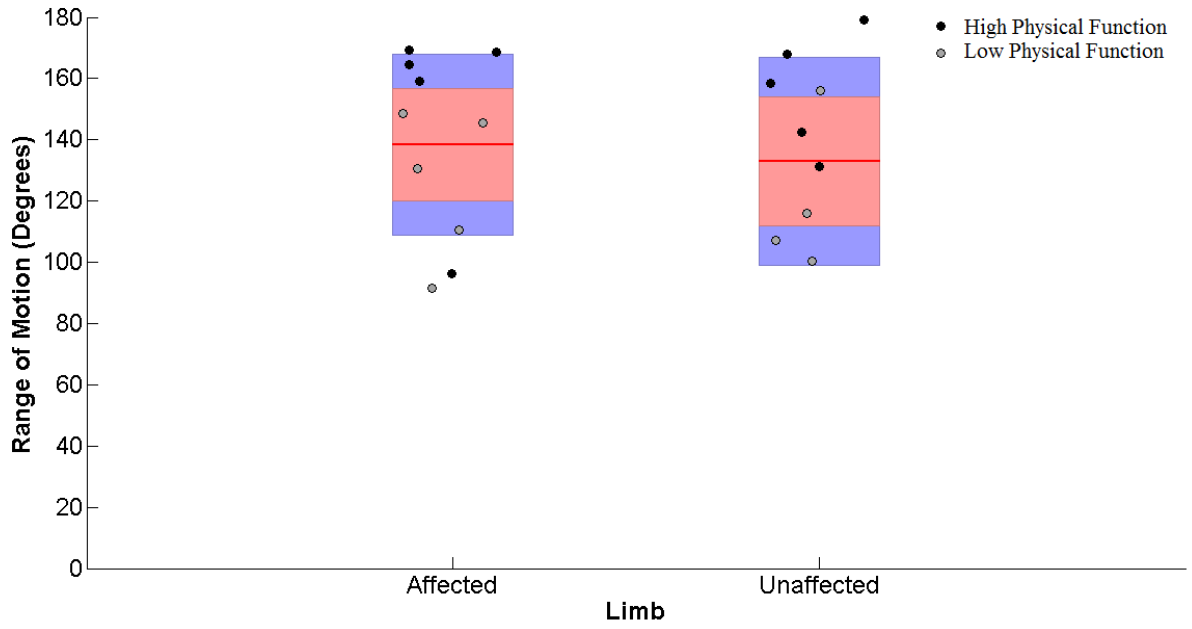


Figure 17: Flexion range of motion for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line.

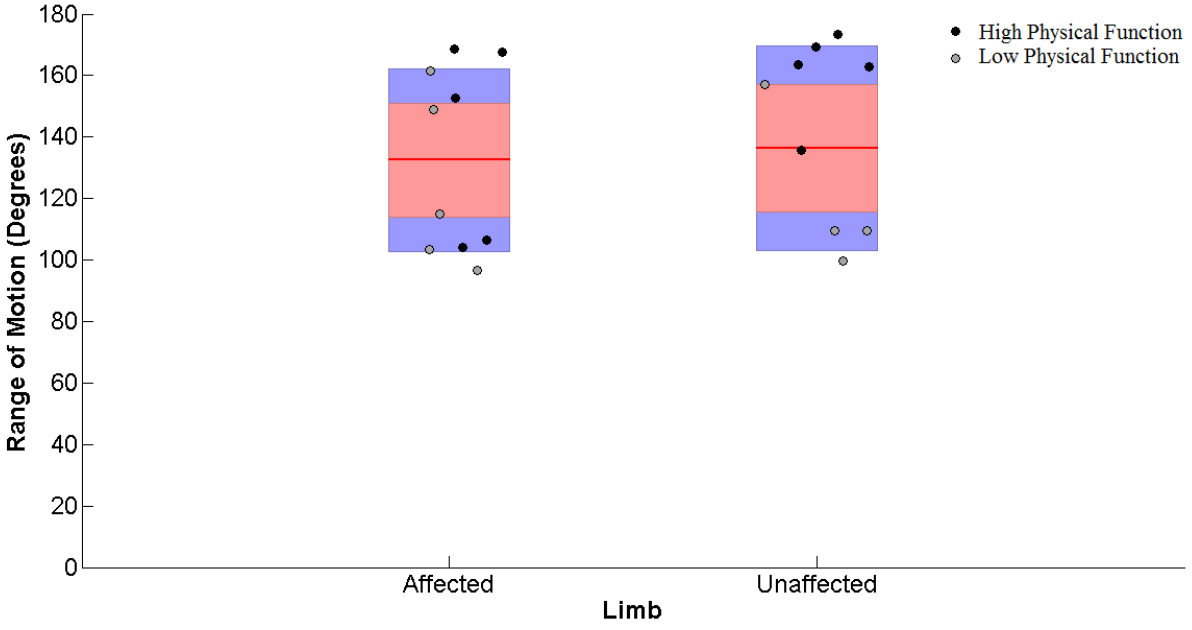


Figure 18: Scapular plane abduction range of motion for both high and low physical function individuals, in both the affected and unaffected limbs. Overall means are indicated with a thick red line.

### 4.4.2 Limb Comparisons for Range of Motion Tasks

There were no statistical differences between affected and unaffected limbs in range of motion ($p > 0.03$). On average, range of motion differed by 5° between affected and unaffected limbs (Table 13). Participants differed between 0 and 40° for range of motion across the different movements collected. However, external rotation had a moderate effect size of 0.42, with a 55% increase in range of motion on the unaffected limb compared to the affected limb (Table 13).

Table 13: Mean range of motion (SD) for each limb (Degrees). Percent change represents the increase from affected limb to unaffected limb.

| | Affected | Unaffected | Percent Change | p-value | Cohen's d |
|---|---|---|---|---|---|
| **Abduction** | 131.17 (± 26.42) | 132.61 (± 25.54) | 1.1% | 0.90 | 0.01 |
| **Extension** | 24.61 (± 17.08) | 21.28 (± 11.44) | -15.63% | 0.91 | 0.14 |
| **External Rotation** | 22.16 (± 23.00) | 34.34 (± 32.99) | 55.0% | 0.34 | 0.42 |
| **Flexion** | 138.46 (± 29.64) | 133.00 (± 34.10) | -4.1% | 0.71 | 0.04 |
| **Internal Rotation** | 26.08 (± 18.54) | 31.02 (± 25.68) | 18.9% | 0.63 | 0.17 |
| **Scapular Plane Abduction** | 132.46 (± 29.78) | 136.36 (± 33.20) | 2.9% | 0.79 | 0.03 |

### 4.4.3 Correlation of DASH Scores and Range of Motion

Several of the fundamental shoulder motions measured had a linear correlation with DASH scores. As previously stated, one participant was excluded from all correlations as their DASH score was identified as an outlier. Internal rotation had the strongest linear, negative relationship ($r = -0.60$, Table 14), such that higher range of internal rotation was associated with lower DASH scores. Flexion and abduction had moderate, negative relationships ($r = -0.45$ and -0.30 respectively). A 4.5° decrease in internal rotation range of motion, a 6.4° decrease in flexion range of motion or a 3.6° decrease in abduction range of motion represented approximately a 5 point increase in DASH scores. Scapular plane abduction had a weak negative relationship with

DASH scores (r = -0.19). Finally, both external rotation and extension were not correlated with DASH scores (r = 0.04 and r = -0.05, respectively).

Table 14: Correlation of range of motion and DASH scores

| | Coefficient of Determination | Correlation Coefficient | p-value |
|---|---|---|---|
| **Abduction** | $r^2$=- 0.0889 | r=-0.30 | 0.44 |
| **Extension** | $r^2$=- 0.0026 | r=-0.05 | 0.90 |
| **External Rotation** | $r^2$=- 0.0015 | r=-0.04 | 0.92 |
| **Flexion** | $r^2$=- 0.2063 | r=-0.45 | 0.22 |
| **Internal Rotation** | $r^2$=- 0.3615 | r=-0.60 | 0.05 |
| **Scapular Plane Abduction** | $r^2$=- 0.0373 | r=-0.19 | 0.62 |

### 4.4.4 Comparison of Baseline and Follow-up for Range of Motion Tasks

All range of motion tasks were compared for five participants at baseline and follow-up (Table 15). Extension range of motion increased by 112% from baseline to follow up (p=0.01, Table 15). All other range of motion tasks were not different at follow up compared to baseline. However effect sizes were moderate for scapular plane abduction, abduction and external rotation range of motion (0.29-0.68), with follow-up increasing by 4.7-44.4% from baseline. Internal rotation decreased by 73.8% from baseline to follow-up (effect size of 0.44) (Table 15).

Table 15: Mean range of motion (SD) for baseline and follow-up (Degrees). Percent change represents the increase from baseline to follow-up.

| | Baseline | Follow-Up | Percent Change | p-value | Cohen's d |
|---|---|---|---|---|---|
| **Abduction** | 141.78 (± 24.34) | 154.83 (± 12.28) | 9.4% | 0.32 | 0.68 |
| **Extension** | 32.24 (± 20.54) | 68.19 (± 15.90) | 111.5% | **0.01** | 1.96 |
| **External Rotation** | 28.03 (± 21.32) | 40.46 (± 33.83) | 44.4% | 0.51 | 0.44 |
| **Flexion** | 151.66 (± 24.87) | 153.26 (± 12.20) | 1.1% | 0.90 | 0.08 |
| **Internal Rotation** | 27.89 (± 16.14) | 20.59 (± 17.16) | -73.8% | 0.51 | 0.44 |
| **Scapular Plane Abduction** | 139.08 (± 31.89) | 145.58 (± 4.64) | 4.7% | 0.66 | 0.29 |

### 4.5 Rating of Perceived Discomfort

Rating of perceived discomfort was analyzed for each group as well as between unaffected and affected limb.

#### 4.5.1 Comparison of groups

There were no differences in RPD ratings of participants with high and low physical function scores during strength trials. Notably, internal rotation strength trials had the largest group difference. Perceived discomfort in the low physical function score group was 3.4/10, compared to 0.8/10 for the high physical function group. All other strength trials showed minimal group differences in reported discomfort.

Statistical differences existed in the RPD between groups with high and low physical function scores for some range of motion trials. For the affected limb, participants in the group with high physical function scores perceived less discomfort during internal rotation and abduction relative to participants in the group with low physical function scores. External rotation, flexion, extension and scapular plane abduction showed no group differences. Overall, the high physical function group rated discomfort of range of motion tasks 0.5/10, while the low physical function group rated these motions 3/10. No differences occurred between groups when using the unaffected limb.

#### 4.5.2 Comparison of limbs

There were no statistical differences in RPD between the affected and unaffected limbs during strength trials. On average, participants rated strength trials with the affected limb 1.5/10, while the unaffected limb was rated 1/10.

Differences existed in range of motion trials between the affected and unaffected limb. Flexion and abduction of the affected limb were perceived with higher discomfort than that of the unaffected limb ($p<0.05$). The unaffected limb was perceived with zero discomfort, while the affected limb averaged from 0.5-2 out of 10. Scapular plane abduction, extension and external and internal rotation showed no bilateral RPD differences.

# 5.0 Discussion

The aim of this research was to quantify the upper limb function of acute breast cancer survivors with respect to strength and glenohumeral range of motion. Comparisons were made between high and low function breast cancer survivors (as determined by questionnaire scores) as well as between the affected and unaffected limbs. Each hypothesis was addressed with experimental data and the results are discussed below, as well as future work and contributions of this research.

## 5.1 Hypotheses

### 5.1.1 Hypothesis One

Hypothesis one stated that participants with higher physical functioning scores would have increased strength. This hypothesis was partially accepted. Increased strength was measured for flexion, extension, abduction and adduction with higher physical function. In all the aforementioned strength measures, a negative correlation existed where participants with increased strength had lower DASH scores.

### 5.1.2 Hypothesis Two

Hypothesis two stated that participants with higher physical functioning scores would have increased range of motion. This hypothesis was partially accepted. This was only the case for internal rotation. Although the group with higher physical function scores generally had increased range of motion, they were not consistently statistically different. However, all other range of motion measurements had moderate to strong effect sizes (0.42-0.94). Negative correlations existed between DASH scores and internal rotation, flexion and abduction where

increased range of motion in these movements correlated with decreased DASH scores (increased physical function).

### 5.1.3 Hypothesis Three

Hypothesis four stated that participants with higher physical functioning scores are more physically active than those with lower physical functioning scores. This hypothesis was partially accepted. Statistically, the two groups were not different when comparing the mean of physical activity in the groups with high and low physical function scores. However, a moderate correlation existed between DASH scores and physical activity, where participants with lower DASH scores (higher physical function scores) were more physically active.

### 5.1.4 Hypothesis Four

Hypothesis six stated that there is no difference between baseline and follow up collections. This hypothesis was partially rejected. All strength measures were unchanged between baseline and follow-up. Only extension range of motion changed. Specifically, extension increased by 112% from baseline to follow-up.

## 5.2 Quality of Life

For the purposes of this thesis, quality of life was defined with respect to physical function. All questionnaires used in this thesis had a score for physical functioning. The questionnaire chosen to represent physical function was the DASH questionnaire. In the current study, average DASH scores were 5 for the group with higher physical functioning and 30.67 for the group with lower physical function.

Quality of life can include representation of individuals function and abilities, with several factors affecting these measures. Surgical methods have showed a relationship to physical function quality of life scores in past studies. Patients who underwent breast conserving

therapy had higher ratings in physical function, social function and work and leisure activities, whereas those who underwent mastectomies reported lower scores for almost all physical function scales (Arndt et al., 2008). Mastectomies are more radical and damages more tissues than that of breast conserving therapy (Dalberg et al., 2010; Nesvold et al., 2008). With this more extensive damage, more side effects become present (such as lymphedema). Due to these complications overall well-being, as well as physical function decrease. With the decrease in function, patients may be unable to return to work, or if they do return, they have to change jobs or miss work. Ratings were also increased when employment was regained and fewer days of work were missed after diagnosis (Howard-Anderson et al., 2012). Overall, the interaction of treatment and quality of life is complicated and several other factors also contribute to function following treatment. DASH scores (as a representation for physical functioning) were correlated with strength (abduction, adduction, flexion and extension) and range of motion (abduction, flexion, internal rotation) measures in the current study. Overall function has had a demonstrated greater impact on quality of life than other factors (i.e. body image) (Kuehn et al., 2000; Rietman et al., 2003; Yang et al., 2010). Regaining function (strength and range of motion) plays an integral role in returning to regular roles. Literature has defined impairment as little as 10° loss of range of motion, and that a minimum of 120° of abduction is necessary to complete daily tasks (Badley et al., 1984; Kuehn et al., 2000). This suggests that survivors with DASH scores above 10 (where the current study was split), have some level of impairment. Following treatment, these decreases in strength and range of motion begin to impair everyday tasks. The roles of strength and range of motion will be explored in sections 5.4 and 5.5 below, respectively.

### 5.3 Characteristics

The demographics of the breast cancer survivor population can influence the effects of treatment and function. Specifically, differing treatments, stage and the limb affected can change the rehabilitation outcomes and capabilities of the survivors afterwards. The breast cancer survivors involved in this study varied in these characteristics; radiation (n=4), chemotherapy (n=1), both chemotherapy and radiation (n=5), dominant limb affected (n=6), stage 1 (n=5), stage 2 (n=3) and stage 3 (n=2). The groups split by DASH scores however, were similar in stage, side affected, surgical intervention, age, height, weight and time since treatment. Although the groups were relatively small, these mitigating factors were evenly split between both groups. Therefore, the possible effects of each of these cannot be explored with respect to the current study. The groups in the current study differed in adjuvant therapy received. The group with higher self-reported physical function received a combination of both chemotherapy and radiation for adjuvant therapy (n=4) and, those with lower self-reported physical function scores often received only radiation therapy (n=4) (Table 6). Each group had one individual who differed on adjuvant therapy. The adjuvant therapies affect the body variously. Radiation therapy is localized and damages local cells surrounding the breast tissue, as well as causes scar tissue between the musculature at the glenohumeral joint leading to adhesions that may affect range of motion (Courneya et al., 2002; Hack et al., 1999; Lauridsen et al., 2008; Markes et al., 2006). On the other hand, chemotherapy manages cancerous cells that may not be detectable, and affects the cells in the whole body (Courneya et al., 2002). Hence, chemotherapy recipients often report decreased arm function, and are less likely to participate in exercise compared to those who do not receive chemotherapy (Markes et al., 2006; Tiezzi et al., 2016). A combination of these treatments may result in symptoms from both. In the current study, the group that received only

radiation had lower physical function scores. This may be because these participants only had one area of their body treated, and were more aware of the deficits in this area. However, the full effects of treatments on physical function have not been fully explored. Treatment is complicated and it can be difficult to isolate which is influencing function. Surgery and adjuvant therapy interact differently for all patients, and it is important to continue to characterize these and interpret their relationship with function.

Body fat percentage may also play a large role in function of breast cancer survivors. In the current study body fat percentage had a large effect size (Table 7). High physical functioning survivors had approximately 8% lower body fat, compared to the low physical function individuals. Individuals with higher percent body fat (and lower lean muscle mass) have decreased range of motion and strength (Park et al., 2010; Zoico et al., 2004). It is possible that due to the increased body fat these individuals already had reduced strength and range of motion, prior to treatment. Lower functioning individuals may have had less strength and range of motion prior, which further decrease with treatment. Future work to compare lean mass of the arm may provide insight as to whether a decrease in strength compared to muscle mass has occurred, and provide context into these lower strengths.

### 5.4 Strength

The effect of strength on quality of life (as determined by DASH scores) was explored through comparison of two groups and correlation. When separating participants into groups of high and low physical function scores strength was 32 to 52% higher, in the group with high physical function scores compared to the group with low physical function scores for all strength measures except internal or external rotation. Additionally, the strongest correlation occurred with flexion strength (r=-0.50), than adduction (r=-0.48), followed by abduction (r=-0.45), and

finally extension (r=-0.41). Internal and external rotation strength were not correlated with DASH scores.

Correlations have been used in recent analyses to determine relationships between shoulder girdle strength and disability of the arm. Both the Pennsylvania shoulder score (PSS) and DASH score had moderate – strong correlation values for abduction, adduction and flexion (r-values ranging from -0.48 to -0.64) with the strongest Pearson correlation coefficient in adduction (Harrington et al., 2013), similar to the current findings. Two major functions of the pectoralis major are flexion and horizontal adduction. It is likely that the combination of treatments damaged the pectoralis major, causing greater functional disability, and thus decreased strength. In the current study these two exertions displayed significant group strength differences as for both group with low physical function scores (increased disability and decreased QOL) had lower strength. Harrington et al. (2011), reported that breast cancer survivors had 20-31% less strength in all shoulder girdle strength measures compared to healthy aged matched controls (Harrington et al., 2011). The participants in the group with high physical function scores in the current study had similar abduction strength values (16.5Nm) to the healthy aged matched controls (~20Nm), whereas the participants with low physical function scores had similar abduction strength (12.3Nm) compared to the breast cancer survivor group (~10Nm) (Harrington et al., 2011). The two groups in Harrington et al (2011) had significant differences in DASH scores, with the healthy aged matched controls having lower DASH scores, and PSS scores. These two findings suggest that those with decreased strength perceive daily tasks as more difficult and present with more disability.

Bilateral strength differences have limited documentation, but indicate a decrease in the affected limb, or no change. In the current study there were no significant differences in strength

between the limbs (~5%). Our findings are similar to a previous study, which found differences of 4-7% in extensors, protractors and retractors, with no difference in flexion strength (Merchant et al., 2008). Although different strength measures were investigated, the magnitude of change was similar between the two studies. Two implications arise: first, 23 participants were included in the study completed by Merchant et al (2008). In the current study, 10 participants were included for analysis, with a similar percent difference. With decreased power, these small changes were not significant (effect size 0.002-0.08). With both studies finding small changes in strength, it is likely that the effect of treatment is not isolated to just the tissue surrounding the breast.

Breast cancer survivors may have generally lower strength compared to the population. Strength of a $50^{th}$ percentile female adult was calculated as 25.6-44.6Nm using 3DSSPP software (3DSSPP, University of Michigan, Ann Arbor, MI). When compared to a $50^{th}$ percentile adult female, participants in the current study had lower strength in all fundamental shoulder motions (Figures 7-12). It has been shown however, there is a loss of skeletal muscle mass due to aging (Janssen et al., 2002) leading to a decrease in strength (Hughes et al., 1999), which is not accounted for in the strength prediction. In addition to aging, these lower strengths are likely caused by the effects of various treatments. Compared to healthy women, patients who receive chemotherapy had 25% lower strength in lower extremities and 12–16% in upper extremities (Klassen et al., 2017). As stated above, there were no differences in strength between affected and unaffected limbs in the current study. As strength is decreased in the entire body, it is plausible that it affects both limbs similarly. Further, differences in strength may also be affected by hand dominance. Grip strength is altered between 10-30% due to hand dominance (Incel et al., 2002). Although grip strength is a combination of strength from the hand, wrist, forearm,

elbow, upper arm and shoulder, these differences exist in the muscles of the entire limb. With these considered, the modest differences between limbs in the current study can be a combination of dominance, and chemotherapy treatment side effects. Future work to compare to healthy age-matched controls will help contextualize these results and provide insight on whether the survivor population has generally lower baseline strength, accounting for the effects of aging.

### 5.5 Range of Motion

The current study identified several correlations between DASH scores and specific shoulder ranges of motion. Three of the six motions had moderate negative correlations: internal rotation ($r = 0.60$), flexion ($r = -0.45$) and abduction ($r = -0.30$). When divided into groups, the group with higher physical function scores had 192% more internal rotation (~25°) than the group with low physical function scores. However, although not significant the group with high physical function scores had 12-88% more range of motion than the group with low physical function scores across the other five movements (effect sizes 0.48-0.94).

Range of motion recovery differs between survivors, and therefore the effects on quality of life can vary. The current study measured 8-25° (between groups) and 0-13° difference between limbs (on average) in support of previous literature. Reductions in range of motion of the affected limb in 1-67% of survivors have been identified (Lee et al., 2008). Impairment is defined as a reduction in range of motion of 10° or more (Kuehn et al., 2000). In extension, flexion, and internal/external rotation 90% of normal range of motion was recovered within 1 year of surgery. However, in abduction 75% of survivors recovered only 60-80% of normal range of motion (Garusi et al., 2016). These differences in range of motion may be modest, but combined with additional symptoms can have lasting effects and decrease productivity. Approximately ¾ of women who returned to work presented with additional symptoms reducing

their capacity to perform at the workplace (Quinlan et al., 2009). As previously stated, quality of life ratings were increased when employment returned to normal (Howard-Anderson et al., 2012). The combination of decreased range of motion, therapy effects, and strength differences, may have a large influence that results in lower physical function.

The correlation between physical function scores and range of motion occurs for several movements. Spinelli et al (2016) used PSS scores and glenohumeral range of motion to correlate shoulder pain and disability with function. Glenohumeral external rotation during weighted and unweighted reaching were moderately correlated ($r = 0.53$-$0.57$) with the PSS-function sub-scale (Spinelli et al., 2016). Interestingly, pure external rotation was uncorrelated with DASH scores in the current study. Although changes may not be apparent in the comparison of range of motion, it is possible that compensatory strategies might be taken by those individuals who self-reported lower function to avoid painful motions.

Range of motion differences vary across the population and can have effects on daily tasks. No differences existed between affected and unaffected limbs in range of motion in the current study. Participants differed between 0 and 40° across the movements collected. However, on average range of motion differed by ~5° between affected and unaffected limbs, representing 0-55% difference in range of motion. However, several studies have reported restrictions in range of motion in this population. Previous research found restrictions of 10-21° in abduction (Kuehn et al., 2000; Reitman et al., 2004) and 5-12° in forward flexion (Kuehn et al., 2000; Reitman et al., 2004) between affected and unaffected limbs. When comparing pre and post-surgery, flexion and abduction impairments are similar, with affected limb presenting with 5 and 16° reduction in range of motion, respectively (Rietman et al., 2006). However, no glenohumeral motion differences occurred between women with breast cancer (affected arm) and healthy

controls during several activities (Spinelli et al., 2016). These, however were only comparing a few functional tasks (i.e. reaching with/without weight and combing hair). In the current study, more discomfort was reported in the affected limb during flexion and abduction range of motion tasks (0.5-2 out of 10) compared to the unaffected limb (0/10). Among other functions, pectoralis major is an agonist in glenohumeral flexion, and an antagonist in abduction. The surgical damage that was sustained by muscle, radiation and/or overall damage from chemotherapy produces scar tissue and adhesions (Lauridsen et al., 2008; Markes et al., 2006). It is possible that this damage is not extensive enough to limit range of motion, but could make these movements painful.

Treatment type can influence range of motion. Patients with breast conserving therapy reported reductions in range of motion between 33 and 39% of the time. Increases in reduction in range of motion occurring following mastectomies, or radiation treatment may occur up to 77% of the time (Ebaugh et al., 2011; Harrington et al., 2013; Lauridsen et al., 2008; Nesvold et al., 2008; Sugden et al., 1998; Thompson et al., 1995). Although minimal differences were found between the affected and unaffected limb in the current study, the patients with more extensive treatment were associated with less reduced range of motion capability. The group with self-reported high physical function scores received a combination of radiation and chemotherapy (4 of 5 participants) and had 12-192% (effect sizes 0.48-1.89) more range of motion than the group with low physical function scores receiving just radiation therapy (4 of 5 participants). These treatments increase scar tissues and adhesions. It is possible that the self-reported restrictions indicated by patients relate to scar tissue and adhesions present after they receive treatment.

### 5.6 Limitations

The work reported in this thesis should be considered within the scope of the various limitations. First, a limited number of participants participated in this study. With the strict

inclusion criteria and special population, recruitment was challenging. Figure 1 demonstrates the successful recruitment strategies as well as the number of participants excluded. The small sample size leads to a lack of power in analysis that was further depleted when groups were separated. However, this allows us to explore this population and the many characteristics that may differ between individuals. Second, in the strength and range of motion trials only one trial was taken for each task. Although this is not ideal for repetition, various protocols were adopted to ensure these trials accurately represented participant's maximums, and to avoid fatigue and pain for future trials. Pilot participants indicated increased fatigue following strength trials, as well as total protocol taking too long (i.e. ~5 hours in length). With a special population, the protocol was reduced to mitigate the fatigue and length of the session. Additionally, physical function, as well as physical activity were both determined through the use of questionnaires. Both require self-reporting from participants and are therefore subjective measures. However, these measures represent a portion of participants' lives that can be difficult to interpret with objective measures and allow us to explore the differences they experience outside of the laboratory setting. Range of motion tasks followed strength trials for all collections, and therefore the possibility exists that order effects were present within the range of motion tasks following maximal strength trials. Finally, strength can be contextualized with respect to body composition. Although not analyzed in this thesis, taking into account lean muscle mass may mitigate any impacts dominance may have had on strength measures.

### 5.7 Future Work

Future work will aim to continue to quantify the abilities of breast cancer survivors. First, glenohumeral and scapular kinematics, as well as muscular activity, during various activities of daily living will be analyzed. This will provide more direct insight into the function of these

individuals, as well as possible adaptions to complete these tasks. Additionally, with additional data, further analysis of the effects of usual care (in a 4 month period) can take place. Finally, as a part of a larger scope, 2 more groups of individuals will be collected. First, another group of breast cancer survivors will participate in a 4-month exercise program. Healthy aged-matched controls will be the final group. This will allow for a more comprehensive evaluation of breast cancer survivor function (range of motion, strength, muscular activity and scapular kinematics). Comparisons can be made between survivors' strength and range of motion to healthy age-matched controls. Finally, an evaluation of a 4-month exercise program on function can be completed.

### 5.9 Contributions

This thesis explores the differences in breast cancer survivors. First, this work will add to the limited literature on the acute breast cancer survivor population. Various characteristics were explored, with focus on strength and range of motion. Limited differences were found in the current study between affected and unaffected limbs, indicating an overall decrease in function in breast cancer survivors. Additionally, previous evidence indicated that survivors with lower self-reported physical function scores have lower strength and range of motion. However, differences between groups with high and low physical function scores were previously undocumented. The current work quantified the differences between these two groups. In previous literature, strength, range of motion and muscular activity have been reported for all survivors as a whole. These variables have been inconclusive throughout literature. By separating survivors into two separate groups, the deficit experienced by some may be more accurately quantified and interpretation of specific deficits can be clarified. Furthermore, these variables have not been evaluated in a group of acute breast cancer survivors. By targeting the period following treatment

we are able to better evaluate strength and range of motion with minimal mitigation from other treatment sources (such as physiotherapy or massage).

# 6.0 Conclusions

This thesis evaluated strength and range of motion in a breast cancer survivor population. Comparisons were made between affected and unaffected limb as well as between participants with high and low physical function scores. Additionally, several participants were evaluated before and after a period of usual care. The following conclusions result:

1. Participants with higher physical functioning scores exhibit increased strength in flexion, extension, abduction and adduction.
2. Flexion, extension, abduction and adduction strength in the affected limb show moderate correlation with physical function (DASH) scores.
3. No differences exist between affected and unaffected limbs in strength or range of motion.
4. Participants with higher physical functioning scores exhibit increased internal rotation range of motion.
5. Internal rotation, flexion and abduction range of motion in the affected limb show moderate correlation with physical function (DASH) scores.
6. Physical functioning scores were moderately associated with physical activity: those who were more active had higher physical functioning scores.

Acute breast cancer survivors have had minimal exploration. It is important to consider the immediate effects of treatment to strength and range of motion. With minimal differences between affected and unaffected limb in the current study, but overall less strength compared to the $50^{th}$ percentile female strength abilities, function of both limbs should be considered. Several factors, such as physical activity and body fat percentage had large effect sizes and indicate that with a higher sample size, the influence of these variables on function can be

more thoroughly explored. Finally, this thesis has shown that there are differences in high and low functioning breast cancer survivors. These differences indicate that treatment affects individuals differently and these groups should be separated to better document the deficits in the low physical functioning individuals.

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# Appendix A: Supplementary Materials

Attached are the documents and questionnaires used in the collection of this thesis.

### Information Consent Form

**Title of Project:** Longitudinal evaluation of upper limb functional capacity and body composition in breast cancer survivors

**Investigators:**
Marina Mourtzakis and Clark Dickerson, PhD
Department of Kinesiology, University of Waterloo
(519) 888-4567 Exts. 38549 and 37844

**Student-Investigator**:
Jackie Maciukiewicz MSc Candidate, Department of Kinesiology
**Research Assistant:**
Alicia Nadon, MSc., Department of Kinesiology

**Purposes of this Study:**

While 5-year breast cancer survivorship is 88% in Canada, up to 72% of breast cancer survivors (BCS) have upper limb impairments that remain following treatment. This can severely diminish quality of life, reducing the ability to complete activities of daily living (ADL) and successfully return to work. It is currently unknown which ADL tasks and arm postures pose the biggest problem for BCS, as prior studies have focused on coarse clinical measures. A refined definition of these deficits will provide critical information to aid in the development of targeted survivorship programs. In this project, we will assess functional impairment by measuring body composition, quality of life, and shoulder strength, range of motion, joint movement and muscular demands during ADL. This is one of the first studies that objectively looks at and quantitates shoulder function in breast cancer survivors. Understanding upper limb impairment in BCS will allow development of more specific and effective strategies to improve short- and long-term outcomes for BCS. These evidence-based strategies will be incorporated into existing

survivorship guidelines for breast cancer patients and clinical decision makers. The purpose of this study is:

- to describe the upper limb impairment of breast cancer survivors in terms of body composition, kinematics, muscle activation and strength, and to relate these physical measures with objective and subjective measures of function and quality of life during ADL and work
- finger prick to determine HbA1c (glycated haemoglobin) will allow for investigation into changes in average blood sugar levels over a period of 3 months.

**Who Can Participate:**

Participants in this study should be at least 3 months but less than two years post-treatment. They may have had Stage I to IIIa cancer, received any form of radiation therapy or chemotherapy, have undergone any form of surgical procedure for breast cancer removal, and have had any form of breast cancer pathology. Participants cannot have had bilateral cancer, metastases, barium swallow within previous 3 weeks of participation, women who are or suspect they are pregnant, or have had upper arm dysfunction prior to cancer treatments. Please note, only the female gender are being recruited for this study, as breast cancer is very rare among men (~1% prevalence) and the potential impairments we are describing have different characteristics across genders.

***Procedures Involved in this Study:***

The total in-lab time commitment for the participant will amount to approximately 4 hours; two 2 hour collections are required, with a 16 week duration between each.

*Participant Information and Body Composition*

- ✓ Medical History: cancer type, treatment (surgery, chemotherapy, radiation and hormonal therapy), chronic conditions, medications, and any musculoskeletal injury that may limit performance
- ✓ Anthropometric Measures (10 minutes): Measurements of standing height, weight and waist circumference will be taken.
- ✓ FACT-B quality-of-life survey (10 minutes): This survey asks you to respond to questions using a rating scale for such things as your physical well-being (e.g., I have a lack of energy, I have nausea, I have pain). *You may, at any time, choose not to answer some or all of the questions by leaving them blank.*
- ✓ RAND 36-Item Health Survey Questionnaire (10 minutes) : This survey asks you to respond to questions using a rating scale for such things as your physical well-being and your physical functioning (e.g., During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?)

- ✓ DASH Questionnaire (10 minutes): This questionnaire asks you to respond to questions about symptoms related to your arm, shoulder, and hand as well as your ability to perform certain activities in the past week. (e.g. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder, or hand problem?)

- ✓ DXA- Dual-Energy X-Ray Absorptiometry (20 minutes): The DXA will be used to precisely measure lean tissue mass as well as body fat for the whole body and for specific regions of the body. There is a very low dose of radiation emitted, which is 200 times less than the limit for exposure to the general public (i.e. the radiation emitted from the scanner is 0.012 mSV/DXA scan, where the maximal trivial dose is 5mSV/year for the general public. This is a very low dose of radiation emitted which is 200 times less than the limit for trivial exposure (and less than the amount of radiation you would be exposed to on a transatlantic flight). This test requires that you put on a hospital gown, remove all jewellery and lie on an X-ray bed. A certified Medical X-Ray Technologist (MRT) will conduct the scan. If you have had barium swallow in the past 3 weeks, you will not be eligible for the DXA scan. You will be asked if you are taking oral contraceptives and if you are pregnant or if you suspect that you are pregnant. The potential risks associated with radiation exposure to an unborn fetus are unknown. Thus, if you are pregnant, you will not be eligible for this assessment or study.

- ✓ Bioelectrical Impedance Analysis (BIA) (5 minutes): To measure your body composition, you will be asked to void your bladder before the assessment. Two disposable adhesive electrodes will be placed on your foot (one above the middle toe and one on the ankle) and 2 on your hand (one on the middle finger and one on the wrist). The skin will be cleaned with rubbing alcohol before placing the disposable electrodes. If you are allergic to rubbing alcohol, please indicate this to the researcher and the skin will be cleaned with water instead. The 4 electrodes will be connected to the cables where the signal is sent and received. If you have a pacemaker; this test will not be performed. Otherwise, there are no risks involved in this assessment.

- ✓ HbA1c Finger Prick (3 minutes): To measure your average blood glucose levels over the previous few months, we will do a finger prick analysis for glycolated haemoglobin using the HbA1c test. A trained phlebotomist (wearing disposable nitrile/vinyl gloves) will perform the test, in which you will provide one finger to prick. The finger will be wiped with rubbing alcohol, and pricked with a small device containing a lancet. If you are uncomfortable the procedure and/or allergic to alcohol wipes, you do not have to participate. In some cases, bruising or discomfort can result from the finger prick.

*Physical Activity and Rehabilitation Frequency Assessment*

- ✓ Godin Leisure Time Activity Questionnaire (5 minutes): In addition to each lab collection, you will receive (via preferred method – email or phone) this questionnaire once per month, which asks you to describe your level of physical activity in the 7 days prior. Four additional questions will evaluate the frequency of your rehabilitation visits.

*Biomechanical Shoulder Assessment*

- ✓ Biomechanical Shoulder Assessment (120 minutes): In order to systematically evaluate your shoulder function to describe upper limb capacities and dysfunctions in breast cancer survivors, we will perform a biomechanical assessment of your upper arm. This assessment includes arm motion, muscle coordination, and strength during activities of daily life and work

activities. The preparation and testing protocol that will be done in the laboratory is outlined below.

**Participant Preparation**

It is recommended that participants are dressed in comfortable athletic or workout attire. A sleeveless shirt is required for the biomechanical shoulder assessment. Participants should avoid wearing clothing that has any metal or reflective pieces on it.

*EMG Preparation:* EMG preparation will be performed by a female graduate student with 3 years of experience with surface EMG. She has had both apprenticeship training from her supervisor as well as formal course training in a UW graduate program.

Prior to electrode placement, any hair in the placement area is shaved. The removal of hair enhances the signal and makes the removal of the electrode easier. A new disposable razor is used for each participant. Over 1000 participants have undergone this procedure in the Kinesiology department, and to date no participants have been cut. All shaving and electrode placements will be done by females. The skin areas for electrode placement are wiped with isopropyl alcohol and then the electrodes are placed on the skin.

Eight surface adhesive bipolar electrodes will be placed on the skin over 8 muscles on each arm (therefore 16 muscles total). One additional electrode will be placed on the sternum as a ground electrode. On occasion the electrodes can leave a mark after removal. Usually, these marks disappear within hours or within two days. Should the irritation/redness last longer than 3 days, please contact your physician.

You will then be asked to perform 14 maximal exertions that require full muscular effort for a total of five seconds each. Two rounds of each of these maximal voluntary muscle exertions will be performed for each muscle group. There will be 2 minutes rest in between each MVC in order to prevent fatigue. You will then be asked to lie down on a bench while remaining as relaxed and still as possible. This resting EMG trial will be used to remove bias in the signal.

On completion of the session the electrodes are removed and the skin is rubbed with isopropyl alcohol to remove any residual gel or adhesive material left behind from the electrodes.

*Motion capture preparation :* Three-dimensional kinematics will be recorded using an 8-camera (2 MP) optoelectronic Vicon MX20+ motion tracking system (sampling rate 50 Hz) (Vicon, Oxford, UK). Thirty-nine reflective markers will be placed on the skin (adhesive backing) over the upper limbs, scapulae, thorax, head, and pelvis. The cameras will track these reflective markers, and these will be used to calculate joint angle. Some participants may experience mild skin irritation/redness from the tape used to attach the instrumentation to the skin. This is similar to the irritation that may be caused by a bandage and typically fades within 1-3 days. Should the irritation/redness last longer than 3 days, please contact your physician.

**Experimental Protocol**

*Strength Trials:* We will then measure isometric joint moment positions of the shoulder. Maximal voluntary force will be assessed at the hand using a 6 degree of freedom force transducer (FS6-500, AMTI); three 5 second trials will be performed for a total of 24 per participant. You will be pushing against a force transducer that will record how hard you push with your arm in four different positions. We will repeat the trials for both arms. At least two minutes rest will be given between trials to avoid fatigue.

*Shoulder Range of Motion (ROM):* You will then be asked to move through a selection of active shoulder ROM positions. Movement (abduction, flexion, extension, and rotation of the shoulder) in each anatomical plane will be recorded using motion capture cameras.

*Performance of Activities of Daily Living:* You will then be asked to perform a series of activity of daily living (ADL) tasks (12 in total). Examples of these are bra fasten, pour water from pitcher, push/pull, and forward reach. You will perform each task twice with both arms, however some require both hands and will only need two trials. You will be given at least two minutes rest between trials to avoid fatigue. A total of 40 trials will be collected.

*Rating of Perceived Exertion:* Following the completion of each ADL task, you will be asked to rate your perceived exertion (RPE) on a calibrated, modified continuous Borg CR-10 scale for the neck, as well as each shoulder, elbow, wrist, and hand. At any point during the study, participants should advise the researcher if any of the movements or activities are causing discomfort or pain.

***Incidental Findings***

*DXA:* In addition to providing us with a measure of fat mass and lean mass, the DXA scan also estimates whole body and regional bone mineral content. The procedure for the DXA scan that we perform is not meant to accurately assess bone mineral density, however, the bone mineral density results that we collect from the DXA scan may provide a crude indication of potential measures of bone mineral density (i.e. whether one may have lower bone mineral density than for someone their age). It is your decision if you would like to be notified if we find that your bone mineral density if below what is considered normal. After receiving notification of your bone mineral density, we encourage you to share this information with your physician to discuss whether you should undergo a bone scan to more accurately measure your bone mineral density.

Do you wish to be notified if we find your bone mineral density to be below what is considered normal?

- ☐ I do wish to be notified if my bone mineral density is below what is considered normal.
- ☐ I do not wish to be notified if my bone mineral density is below what is considered normal.

***Confidentiality and Security of Your Information and Data:***

To ensure the confidentiality of your data, you will be identified by a participant identification code known only to members of the research team. Your information will be stored in a locked

office at the Lyle Hallman building (0603) and Burt Matthews Hall (1404 and 1044) at the University of Waterloo. The information will be stored for a minimum of 25 years. Data will also be encrypted and stored on a password-protected computer and server.

The data may need to be inspected from time to time for quality assurance (to make sure the information being used in the study is accurate) and for data analysis (to do statistical analysis that will not identify you). The following organizations may do this inspection: the University of Waterloo Research Ethics Committee and other members of the research team (including monitors or auditors) as required, ensuring the safety of participants and the quality of data.

Photographs and video recordings will be taken during the study, if you give consent to do so. These photographs or video recordings will be focused on the upper body and arm, but will not be focused on facial features. These photos and recordings are useful to verify the movement information recorded by the researchers, and may be helpful in teaching purposes such as when presenting the study results in a scientific presentation or publication. Any facial features or other distinguishing features that are visible in photos or recordings used for these above mentioned purposes will be blotted out to remove distinguishing features and maintain your confidentiality.

***Questions and Ethics Clearance:***

If you have any further questions or want any other information about this study, please feel free to contact:

Marina Mourtzakis, PhD, Department of Kinesiology 888-4567 Ext.38459

Clark Dickerson, PhD, Department of Kinesiology 888-4567 Ext. 37844

This project has been reviewed by, and received ethics clearance through, a University of Waterloo Research Ethics Committee (ORE # 21124). If you have any questions, you may contact the Chief Ethics Officer, Office of Research Ethics, at 519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

***Remuneration:***

You will be provided with a $50 gift card in appreciation for their participation in this study. The amount received is taxable. It is your responsibility to report this amount for income tax purposes.

***Changing Your Mind about Participation***

Participation is voluntary. You may withdraw from the study at any time without penalty. To do so, indicate this to a member of the team by saying, “I no longer wish to participate”. You may choose to have your data destroyed, or with your permission, your data will be used for the study. Please note, if you choose to withdraw at any time during the first session or before the start of the second session, you will receive a $25 gift card as part of remuneration.

***Consent to Participate***

By signing this consent form, you are not waiving your legal rights or releasing the investigators (Professor Marina Mourtzakis and Professor Clark Dickerson) or involved institution (University of Waterloo) from their legal and professional responsibilities.

☐ I agree to take part in a research study being conducted by Professor Marina Mourtzakis and Professor Clark Dickerson of the Department of Kinesiology, University of Waterloo.

☐ I consent to the finger prick (HbA1c) test

I have made this decision based on the information I have read in the Information letter. All the procedures, any risks and benefits have been explained to me. I have had the opportunity to ask any questions and to receive any additional details I wanted about the study.

If I have questions later about the study, I can ask one of the researchers (Professor Marina Mourtzakis, 519-888-4567 Ext. 38549; Professor Dickerson, 519-888-4567 Ext. 37844). I understand that I may withdraw from the study at any time without penalty by telling the researcher.This project has been reviewed by, and received ethics clearance through, a University of Waterloo Research Ethics Committee (ORE # 21124). If you have any questions, you may contact the Chief Ethics Officer, Office of Research Ethics, at 519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

_____ _____

Printed Name of Participant Signature of Participant

_____ _____

Dated at Waterloo, Ontario Witnessed

***Consent to Use Video and/or Photographs***

Sometimes a certain photograph and/or part of a video recording clearly shows a particular feature or detail that would be helpful in teaching or when presenting the study results in a scientific presentation or publication. If you grant permission for photographs or video recording in which you appear to be used in this manner, please complete the following section. Please note that any facial features will be blotted out so that you will not be identifiable.I agree to allow video and/or photographs to be used in teaching or scientific presentations, or published in scientific journals or professional publications of this work without identifying me by name. I understand that I retain the right to withdraw my consent to be video recorded or photographed at any time, and that existing video or photos may be destroyed at my request. There will be no penalty to me if I choose to refuse this consent.

_____ _____

Printed Name of Participant Signature of Participant

_____ _____

Dated at Waterloo, Ontario Witnessed

**Participant Information Form**

Participant ID: _____

**DIAGNOSIS INFORMATION**

Date of Diagnosis: _____

Type of Breast Cancer: _____

Stage of Breast Cancer: _____

**TREATMENT INFORMATION**

**Radiation Therapy:**

a. Start date: _____

b. Frequency (i.e. everyday, every other day etc): _____

c. Duration of therapy: _____

d. Date of last radiation dose: _____

**Surgery:**

a. Date of surgery(ies):_____

b. Type of surgery (lumpectomy vs mastectomy vs other): _____

c. Side (R, L or both): _____

**Chemotherapy***:*

a. Start date:_____

b. Total cycles:_____

d. Date of treatments (e.g. Every Wednesday for 6 weeks):

_____

_____

e. Chemotherapy Drugs (if known):_____

_____

f. Did you have a PICC or port-a-cath? _____

g. If yes, when was it removed? _____

h. Did you experience any pain or discomfort with it?

_____

**Other treatment information** (immune therapy, hormonal therapy, etc.):

_____

_____

_____

**PHYSICAL ACTIVITY**

Are you currently physically active? (meet Canada's P.A. Guidelines) ☐Yes ☐ No

**Current Physical Activity**

i.e. lifting weights, cardiovascular activity, recreational or other unstructured physical activities that are part of daily life/job?

- 
- 

**Previous Physical Activity**

List any activities/exercise performed in the past. How long ago? Give brief details regarding activity.

- 
- 

**Physiotherapy and Exercise Prescription**

Have you ever been to a physiotherapy or other allied health professional for treatment regarding your arm or shoulder? _____

If yes, how long did you receive treatment? _____
What did the treatment involve? _____

Have you ever received an exercise program specifically for your arm or shoulder? _____
If yes, how long did you do the program for? _____
Are you still currently doing the program? _____

Do you have any difficulty in completing daily tasks? Yes / No
a. If yes, what tasks di you have trouble doing (e.g., reach overhead, lifting)?:
_____
Do you often feel tightness in the chest or shoulder of your affected arm? Yes / No
If yes:
Does this occur at a certain time of day or after a certain activity (i.e., morning, night, after exercise)?
_____
Does anything help ease the tightness (i.e., certain exercises, medications)?
_____
Do you experience the following in the chest/shoulder/arm of affected side?
1. Pain_____
2. Swelling_____
3. Decreased range of motion_____
4. Weakness_____
5. Cording_____
6. Numbness_____
7. Other? Please describe.

Did you have any shoulder or arm injuries before cancer? Please describe.

**CHECKLIST FOR SIGNS AND SYMPTOMS OF DISEASE**

| Condition | Yes | No | Comments |
|---|---|---|---|
| **Cardiovascular** | | | |
| Hypertension | ☐ | ☐ | |
| Hypercholesterolemia | ☐ | ☐ | |
| Heart Condition | ☐ | ☐ | |
| Fainting/dizziness | ☐ | ☐ | |
| Chest pain | ☐ | ☐ | |
| **Pulmonary** | | | |
| Asthma | ☐ | ☐ | |
| Bronchitis | ☐ | ☐ | |
| Emphysema | ☐ | ☐ | |
| **METABOLIC** | | | |
| Diabetes | ☐ | ☐ | |
| Excess weight changes | ☐ | ☐ | |
| Thyroid disease | ☐ | ☐ | |
| **MUSCULOSKELETAL** | | | |
| Osteoporosis | ☐ | ☐ | |
| Arthritis | ☐ | ☐ | |
| Low back pain | ☐ | ☐ | |
| Swollen joints | ☐ | ☐ | |
| Orthopedic pain | ☐ | ☐ | |
| Artificial joints | ☐ | ☐ | |

**OTHER**

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

**PRESENT MEDICATIONS** (name, dose, frequency: i.e. Aspirin/325 mg/ 1 daily)

| Name | Dose | Frequency | Comments |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## Supplement 3 – Amendment

**Godin Leisure-Time Exercise Questionnaire**

1. During *the past 7 days (week),* how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time (write appropriate number on each line).

**Times per Week**

a) STRENUOUS EXERCISE _____

(HEART BEATS RAPIDLY)

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

b) MODERATE EXERCISE _____

(NOT EXHAUSTING)

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

c) MILD EXERCISE _____

(MINIMAL EFFORT)

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snowmobiling, easy walking)

2. During *the past 7 days (week),* in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)? Please check one.

1. Often _____ 2. Sometimes _____ 3. Rarely/Never _____

**Rehabilitation Assessment**

1. Do you have an additional health practitioner or rehabilitation specialist (chiropractor, physical therapist, naturopath, other)?

_____

2. If yes, how often did you visit a health practitioner or rehabilitation specialist in the past 7 days (week)?

_____

3. Do you continue to do exercises prescribed by a specialist in your own home?

_____

4. If yes to # 3, how many times in the last 7 days (week) did you perform those exercises?

**The Rand SF 36 Quality of Daily Living Questionnaire**

**PT#** _____ **Session#**_____ **Date**_____

The following questionnaire asks questions to gain insight into a picture of your daily health. For each question, please **circle one number** that most appropriately describes your situation. Please let us know if you have any questions throughout.

1. In general, would you say your health is :
   Excellent 1
   Very Good 2
   Good 3
   Fair 4
   Poor 5
2. Compared to one year ago, how would you rate your health in general, now:
   Much better now than one year ago 1
   Somewhat better now than one year ago 2
   About the same 3
   Somewhat worse than one year ago 4
   Much worse now than one year ago 5

The following items are about activities you might do during a typical day. Does **your health now limit you** in these activities? If so, how much?

| | Yes, Limited a Lot | Yes, Limited a Little | No, Not limited at All |
|---|---|---|---|
| 3. **Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports | [1] | [2] | [3] |
| 4. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf | [1] | [2] | [3] |
| 5. Lifting or carrying groceries | [1] | [2] | [3] |
| 6. Climbing **several** flights of stairs | [1] | [2] | [3] |
| 7. Climbing **one** flight of stairs | [1] | [2] | [3] |
| 8. Bending, kneeling, or stooping | [1] | [2] | [3] |
| 9. Walking **more than a mile** | [1] | [2] | [3] |
| 10. Walking **several blocks** | [1] | [2] | [3] |
| 11. Walking **one block** | [1] | [2] | [3] |
| 12. Bathing or dressing yourself | [1] | [2] | [3] |

During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities **as a result of your physical health**?

| | Yes | No |
|---|---|---|
| 13. Cut down the amount of time you spent on work or other activities | 1 | 2 |
| 14. **Accomplished less** than you would like | 1 | 2 |
| 15. Were limited in the **kind** of work or other activities | 1 | 2 |
| 16. Had **difficulty** performing the work or other activities (for example, it took extra effort) | 1 | 2 |

During the **past 4 weeks,** have you had any of the following problems with your work or other regular daily activities **as a result of any emotional problems** (such as feeling depressed or anxious)?

| | Yes | No |
|---|---|---|
| 17. Cut down the **amount of time** you spent on work or other activities | 1 | 2 |
| 18. **Accomplished less** than you would like | 1 | 2 |
| 19. Didn't do work or other activities as **carefully** as usual | 1 | 2 |

20. During the **past 4 weeks,** to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

| | |
|---|---|
| Not at all | 1 |
| Slightly | 2 |
| Moderately | 3 |
| Quite a bit | 4 |
| Extremely | 5 |

21. How much **bodily** pain have you had during the **past 4 weeks**?

| | |
|---|---|
| None | 1 |
| Very mild | 2 |
| Mild | 3 |
| Moderate | 4 |
| Severe | 5 |
| Very severe | 6 |

22. During the **past 4 weeks,** how much did **pain** interfere with your normal work (including both work outside the home and housework)?

| | |
|---|---|
| Not at all | 1 |
| A little bit | 2 |
| Moderately | 3 |
| Quite a bit | 4 |
| Extremely | 5 |

These questions are about how you feel and how things have been with you **during the past 4 weeks**. For each question, please give the one answer that comes closest to the way you have been feeling.
How much of the time during the **past 4 weeks** . . .

| | All of the Time | Most of the Time | A Good Bit of the Time | Some of the Time | A Little of the Time | None of the Time |
|---|---|---|---|---|---|---|
| 23. Did you feel full of pep? | 1 | 2 | 3 | 4 | 5 | 6 |
| 24. Have you been a very nervous person? | 1 | 2 | 3 | 4 | 5 | 6 |
| 25. Have you felt so down in the dumps that nothing could cheer you up? | 1 | 2 | 3 | 4 | 5 | 6 |
| 26. Have you felt calm and peaceful? | 1 | 2 | 3 | 4 | 5 | 6 |
| 27. Did you have a lot of energy? | 1 | 2 | 3 | 4 | 5 | 6 |
| 28. Have you felt downhearted and blue? | 1 | 2 | 3 | 4 | 5 | 6 |
| 29. Did you feel worn out? | 1 | 2 | 3 | 4 | 5 | 6 |
| 30. Have you been a happy person? | 1 | 2 | 3 | 4 | 5 | 6 |
| 31. Did you feel tired? | 1 | 2 | 3 | 4 | 5 | 6 |

32. During the **past 4 weeks,** how much of the time has your **physical health or emotional problems** interfered with your social activities (like visiting with friends, relatives, etc.)?

| | |
|---|---|
| All of the time | 1 |
| Most of the time | 2 |
| Some of the time | 3 |
| A little of the time | 4 |
| None of the time | 5 |

How TRUE or FALSE is <u>each</u> of the following statements for you.

| | Definitely True | Mostly True | Don't Know | Mostly False | Definitely False |
|---|---|---|---|---|---|
| 33. I seem to get sick a little easier than other people | 1 | 2 | 3 | 4 | 5 |
| 34. I am as healthy as anybody I know | 1 | 2 | 3 | 4 | 5 |
| 35. I expect my health to get worse | 1 | 2 | 3 | 4 | 5 |
| 36. My health is excellent | 1 | 2 | 3 | 4 | 5 |

# Disabilities of the Arm, Shoulder and Hand

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | UNABLE |
|---|---|---|---|---|---|
| 1. Open a tight or new jar. | 1 | 2 | 3 | 4 | 5 |
| 2. Write. | 1 | 2 | 3 | 4 | 5 |
| 3. Turn a key. | 1 | 2 | 3 | 4 | 5 |
| 4. Prepare a meal. | 1 | 2 | 3 | 4 | 5 |
| 5. Push open a heavy door. | 1 | 2 | 3 | 4 | 5 |
| 6. Place an object on a shelf above your head. | 1 | 2 | 3 | 4 | 5 |
| 7. Do heavy household chores (e.g., wash walls, wash floors). | 1 | 2 | 3 | 4 | 5 |
| 8. Garden or do yard work. | 1 | 2 | 3 | 4 | 5 |
| 9. Make a bed. | 1 | 2 | 3 | 4 | 5 |
| 10. Carry a shopping bag or briefcase. | 1 | 2 | 3 | 4 | 5 |
| 11. Carry a heavy object (over 10 lbs). | 1 | 2 | 3 | 4 | 5 |
| 12. Change a lightbulb overhead. | 1 | 2 | 3 | 4 | 5 |
| 13. Wash or blow dry your hair. | 1 | 2 | 3 | 4 | 5 |
| 14. Wash your back. | 1 | 2 | 3 | 4 | 5 |
| 15. Put on a pullover sweater. | 1 | 2 | 3 | 4 | 5 |
| 16. Use a knife to cut food. | 1 | 2 | 3 | 4 | 5 |
| 17. Recreational activities which require little effort (e.g., cardplaying, knitting, etc.). | 1 | 2 | 3 | 4 | 5 |
| 18. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.). | 1 | 2 | 3 | 4 | 5 |
| 19. Recreational activities in which you move your arm freely (e.g., playing frisbee, badminton, etc.). | 1 | 2 | 3 | 4 | 5 |
| 20. Manage transportation needs (getting from one place to another). | 1 | 2 | 3 | 4 | 5 |
| 21. Sexual activities. | 1 | 2 | 3 | 4 | 5 |

# DISABILITIES OF THE ARM, SHOULDER AND HAND

| | NOT AT ALL | SLIGHTLY | MODERATELY | QUITE A BIT | EXTREMELY |
|---|---|---|---|---|---|
| 22. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups? *(circle number)* | 1 | 2 | 3 | 4 | 5 |

| | NOT LIMITED AT ALL | SLIGHTLY LIMITED | MODERATELY LIMITED | VERY LIMITED | UNABLE |
|---|---|---|---|---|---|
| 23. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? *(circle number)* | 1 | 2 | 3 | 4 | 5 |

Please rate the severity of the following symptoms in the last week. *(circle number)*

| | NONE | MILD | MODERATE | SEVERE | EXTREME |
|---|---|---|---|---|---|
| 24. Arm, shoulder or hand pain. | 1 | 2 | 3 | 4 | 5 |
| 25. Arm, shoulder or hand pain when you performed any specific activity. | 1 | 2 | 3 | 4 | 5 |
| 26. Tingling (pins and needles) in your arm, shoulder or hand. | 1 | 2 | 3 | 4 | 5 |
| 27. Weakness in your arm, shoulder or hand. | 1 | 2 | 3 | 4 | 5 |
| 28. Stiffness in your arm, shoulder or hand. | 1 | 2 | 3 | 4 | 5 |

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | SO MUCH DIFFICULTY THAT I CAN'T SLEEP |
|---|---|---|---|---|---|
| 29. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)* | 1 | 2 | 3 | 4 | 5 |

| | STRONGLY DISAGREE | DISAGREE | NEITHER AGREE NOR DISAGREE | AGREE | STRONGLY AGREE |
|---|---|---|---|---|---|
| 30. I feel less capable, less confident or less useful because of my arm, shoulder or hand problem. *(circle number)* | 1 | 2 | 3 | 4 | 5 |

**DASH DISABILITY/SYMPTOM SCORE** = $\left[\frac{(\text{sum of n responses})}{n} - 1\right] \times 25$, where n is equal to the number of completed responses.

**A DASH score may <u>not</u> be calculated if there are greater than 3 missing items.**

# DISABILITIES OF THE ARM, SHOULDER AND HAND

## WORK MODULE (OPTIONAL)

The following questions ask about the impact of your arm, shoulder or hand problem on your ability to work (including home-making if that is your main work role).

Please indicate what your job/work is:_____

❒ I do not work. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week. Did you have any difficulty:

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | UNABLE |
|---|---|---|---|---|---|
| 1. using your usual technique for your work? | 1 | 2 | 3 | 4 | 5 |
| 2. doing your usual work because of arm, shoulder or hand pain? | 1 | 2 | 3 | 4 | 5 |
| 3. doing your work as well as you would like? | 1 | 2 | 3 | 4 | 5 |
| 4. spending your usual amount of time doing your work? | 1 | 2 | 3 | 4 | 5 |

## SPORTS/PERFORMING ARTS MODULE (OPTIONAL)

The following questions relate to the impact of your arm, shoulder or hand problem on playing *your musical instrument or sport or both*. If you play more than one sport or instrument (or play both), please answer with respect to that activity which is most important to you.

Please indicate the sport or instrument which is most important to you:_____

❑ I do not play a sport or an instrument. (You may skip this section.)

Please circle the number that best describes your physical ability in the past week. Did you have any difficulty:

| | NO DIFFICULTY | MILD DIFFICULTY | MODERATE DIFFICULTY | SEVERE DIFFICULTY | UNABLE |
|---|---|---|---|---|---|
| 1. using your usual technique for playing your instrument or sport? | 1 | 2 | 3 | 4 | 5 |
| 2. playing your musical instrument or sport because of arm, shoulder or hand pain? | 1 | 2 | 3 | 4 | 5 |
| 3. playing your musical instrument or sport as well as you would like? | 1 | 2 | 3 | 4 | 5 |
| 4. spending your usual amount of time practising or playing your instrument or sport? | 1 | 2 | 3 | 4 | 5 |

**SCORING THE OPTIONAL MODULES:** Add up assigned values for each response; divide by 4 (number of items); subtract 1; multiply by 25.
**An optional module score may <u>not</u> be calculated if there are any missing items.**

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## FACT-B (Version 4)

Below is a list of statements that other people with your illness have said are important. **Please circle or mark one number per line to indicate your response as it applies to the past 7 days.**

| | PHYSICAL WELL-BEING | Not at all | A little bit | Some-what | Quite a bit | Very much |
|---|---|---|---|---|---|---|
| GP1 | I have a lack of energy | 0 | 1 | 2 | 3 | 4 |
| GP2 | I have nausea | 0 | 1 | 2 | 3 | 4 |
| GP3 | Because of my physical condition, I have trouble meeting the needs of my family | 0 | 1 | 2 | 3 | 4 |
| GP4 | I have pain | 0 | 1 | 2 | 3 | 4 |
| GP5 | I am bothered by side effects of treatment | 0 | 1 | 2 | 3 | 4 |
| GP6 | I feel ill | 0 | 1 | 2 | 3 | 4 |
| GP7 | I am forced to spend time in bed | 0 | 1 | 2 | 3 | 4 |

| | SOCIAL/FAMILY WELL-BEING | Not at all | A little bit | Some-what | Quite a bit | Very much |
|---|---|---|---|---|---|---|
| GS1 | I feel close to my friends | 0 | 1 | 2 | 3 | 4 |
| GS2 | I get emotional support from my family | 0 | 1 | 2 | 3 | 4 |
| GS3 | I get support from my friends | 0 | 1 | 2 | 3 | 4 |
| GS4 | My family has accepted my illness | 0 | 1 | 2 | 3 | 4 |
| GS5 | I am satisfied with family communication about my illness | 0 | 1 | 2 | 3 | 4 |
| GS6 | I feel close to my partner (or the person who is my main support) | 0 | 1 | 2 | 3 | 4 |
| Q1 | *Regardless of your current level of sexual activity, please answer the following question. If you prefer not to answer it, please mark this box* ☐ *and go to the next section.* | | | | | |
| GS7 | I am satisfied with my sex life | 0 | 1 | 2 | 3 | 4 |

## FACT-B (Version 4)

**Please circle or mark one number per line to indicate your response as it applies to the past 7 days.**

| | EMOTIONAL WELL-BEING | Not at all | A little bit | Some-what | Quite a bit | Very much |
|---|---|---|---|---|---|---|
| GE1 | I feel sad | 0 | 1 | 2 | 3 | 4 |
| GE2 | I am satisfied with how I am coping with my illness | 0 | 1 | 2 | 3 | 4 |
| GE3 | I am losing hope in the fight against my illness | 0 | 1 | 2 | 3 | 4 |
| GE4 | I feel nervous | 0 | 1 | 2 | 3 | 4 |
| GE5 | I worry about dying | 0 | 1 | 2 | 3 | 4 |
| GE6 | I worry that my condition will get worse | 0 | 1 | 2 | 3 | 4 |

| | FUNCTIONAL WELL-BEING | Not at all | A little bit | Some-what | Quite a bit | Very much |
|---|---|---|---|---|---|---|
| GF1 | I am able to work (include work at home) | 0 | 1 | 2 | 3 | 4 |
| GF2 | My work (include work at home) is fulfilling | 0 | 1 | 2 | 3 | 4 |
| GF3 | I am able to enjoy life | 0 | 1 | 2 | 3 | 4 |
| GF4 | I have accepted my illness | 0 | 1 | 2 | 3 | 4 |
| GF5 | I am sleeping well | 0 | 1 | 2 | 3 | 4 |
| GF6 | I am enjoying the things I usually do for fun | 0 | 1 | 2 | 3 | 4 |
| GF7 | I am content with the quality of my life right now | 0 | 1 | 2 | 3 | 4 |

## FACT-B (Version 4)

**Please circle or mark one number per line to indicate your response as it applies to the <u>past 7 days</u>.**

| | **ADDITIONAL CONCERNS** | **Not at all** | **A little bit** | **Some-what** | **Quite a bit** | **Very much** |
|---|---|---|---|---|---|---|
| B1 | I have been short of breath | 0 | 1 | 2 | 3 | 4 |
| B2 | I am self-conscious about the way I dress | 0 | 1 | 2 | 3 | 4 |
| B3 | One or both of my arms are swollen or tender | 0 | 1 | 2 | 3 | 4 |
| B4 | I feel sexually attractive | 0 | 1 | 2 | 3 | 4 |
| B5 | I am bothered by hair loss | 0 | 1 | 2 | 3 | 4 |
| B6 | I worry that other members of my family might someday get the same illness I have | 0 | 1 | 2 | 3 | 4 |
| B7 | I worry about the effect of stress on my illness | 0 | 1 | 2 | 3 | 4 |
| B8 | I am bothered by a change in weight | 0 | 1 | 2 | 3 | 4 |
| B9 | I am able to feel like a woman | 0 | 1 | 2 | 3 | 4 |
| P2 | I have certain parts of my body where I experience pain | 0 | 1 | 2 | 3 | 4 |