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A Comparison of Upper Extremity Function between Female Breast Cancer Survivors and Healthy Controls: Typical Self-report of Function, Motion, Strength, and Muscular Endurance

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A COMPARISON OF UPPER EXTREMITY FUNCTION BETWEEN FEMALE BREAST CANCER SURVIVORS AND HEALTHY CONTROLS: TYPICAL SELF-REPORT OF FUNCTION, MOTION, STRENGTH AND MUSCULAR ENDURANCE

DISSERTATION

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ABSTRACT OF DISSERTATION

A COMPARISON OF UPPER EXTREMITY FUNCTION BETWEEN FEMALE BREAST CANCER SURVIVORS AND HEALTHY CONTROLS: TYPICAL SELF-REPORT OF FUNCTION, MOTION, STRENGTH AND MUSCULAR ENDURANCE

Many women who have experienced breast cancer (BC) report continued impairments in upper extremity (UE) function beyond the time required for normal healing after surgical treatment. Most research supporting this has not made comparisons between survivors of breast cancer (BCS) to a sample of healthy women. This lack of comparison to a healthy cohort prevents an understanding of whether continued deficits in UE function are due to normal aging or the BC treatment.

The purpose of this research was to compare quality of life (QOL) and UE function among long term breast cancer survivors and similar aged women without cancer. Both self-report and objective measurements of UE function were used to create an understanding of UE functional abilities in both populations.

Data on self-reported QOL and UE function, ROM, strength, and muscular endurance were collected on 79 healthy women ages 30-69, stratified by decade. Comparisons between decades and between dominant and non-dominant limbs were made. Findings supported no effect of aging on measures, and that dominance does affect some objective measures of motion, strength, and muscular endurance.

A group of 42 survivors of breast cancer (BCS) were compared to the data from healthy controls on the same measures. BCS reported lower levels of QOL and UE function, and demonstrated less motion and strength than the healthy cohort, particularly when cancer occurred on the non-dominant limb. The values of the measures, however, are not clinically relevant, and reveal that BCS 6 years after treatment recover UE function to levels similar to healthy controls.

In view of a lack of clinically feasible measures of UE muscular endurance, a new test to assess this was designed and implemented: the modified Upper Body Strength and Endurance test (mUBSE). It was believed this new test would be less variable than the

Functional Impairment Test – Hand and Neck, Shoulder, Arm – FIT-HaNSA. Seventeen BCS and 17 matched controls were compared on the mUBSE and FIT-HaNSA. Findings were similar for both tests. Furthermore, BCS who are 6 years post BC treatment appear to recover muscular endurance levels to normal ranges.

KEYWORDS: Breast cancer, quality of life, upper extremity function, range of motion and strength, muscular endurance

Mary Insana Fisher

Student's Signature

6 February 2013

Date

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DEDICATION

This work is dedicated to the many women who have experienced life beyond breast cancer, and helped me understand its implications on a personal level.

To the woman who was my first teacher and the first breast cancer survivor I knew, for her enduring strength amidst life's hurdles, Carmella Insana. She is first and foremost, my mother.

To Shelley Colbert who died from breast cancer while I was working on this project, for the love and care she provided to my children while I pursued this research.

And lastly, to all of the women who participated in my research, for their willingness to give of their time that we might learn in order to improve the quality of life of future breast cancer survivors.

It was through the efforts of these special women that I am successful not only in earning this degree, but gaining a depth of understanding beyond the experience itself.

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An old African proverb states “it takes a village to raise a child.” Similarly, it takes a community to raise a scholar. This dissertation is the culmination of my efforts to develop into a researcher, but it could not be accomplished without the communal help of others whose experience and talents translated into wisdom and support for my growth.

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CHAPTER ONE

Breast cancer is the most common non-skin cancer among women, with a lifetime risk of 1 in 8.[1] Approximately 226,870 women will be diagnosed with breast cancer (BC) in 2012 alone.[2] Over the last 25 years, survival rates have increased to 90%; current estimates are that over 2.5 million women are living with BC.[1] As the number of women living beyond diagnosis and treatment of BC has climbed, the focus of research and intervention is expanding to include quality of life (QOL) issues for survivors.

Activity limitations and participation restrictions among survivors of breast cancer (BCS) can be attributed to physical declines reported on QOL scales. Physical function scores decline the greatest immediately following surgical treatment for breast cancer, but remain below baseline 6-104 weeks after treatment.[3,4] These deficits are greater among women who undergo more involved interventions such as axillary lymph node dissection or mastectomy surgeries, or axillary radiation, than the less invasive lumpectomy or sentinel node biopsy.[5,6]

The link between activity limitations and participation restrictions, and QOL may be explained by changes in upper extremity (UE) function after BC treatment. Full UE function is dependent upon adequate motion, strength, and muscular endurance to complete a particular task.[7] Women diagnosed with BC frequently have upper extremity functional deficits associated with treatment including loss in motion and strength in the arm, resulting in activity limitations.[8-13] Less is known about the extent of change in muscular endurance and its impact on UE function.[14-16]

Self-Report of Function of BCS

Researchers have provided evidence of moderate to high levels of UE self-reported disability among women treated for BC. In a long term study following 188 BCS, the Disabilities of the Arm, Shoulder, and Hand (DASH) was used to determine the extent of upper body functional impairment.[17] Scores of greater than 20 on the DASH were categorized as poor upper body function. At 6 months following BC treatment, 25.6% of BCS scored greater than 20, and at a 6 year follow-up, 21.1% continued to score greater than 20.[17] Other studies examining the self-reported level of UE function have documented mean DASH scores ranging from 24 to 32 in BCS 1-360 months following treatment.[18,19] This continued report of UE functional impairment more than 5 years after BC treatment suggests that this is an issue that the medical community should address during the acute recovery phase to facilitate resumption of normal levels of function.

Understanding how the level of self-reported function among long term BCS compares to a healthy population may clarify whether persistent functional disability is due to BC treatment or occurs with normal aging. One such study which used the DASH to compare self-reported levels of disability of a group of BCS at 6 months following treatment to a healthy control group found significantly more disability in the BC group (19.4±17) than the control group (1.6±1.7).[9] This comparison between BCS and a group of healthy women has not been done for BCS more than 12 months beyond BC treatment. To better understand persistent functional disability however, it is important to know whether the report of disability long term is due to BC treatment or normal aging.

Objective Measures of UE Function among Survivors of BC

Range of motion (ROM) and strength are integral to normal UE function. These objective measures of UE function have been examined in BCS within the first year following diagnosis and treatment. Diminished motion[8,11,14,20] and strength[8,14,16] of the involved extremity have been documented in comparison to the non-involved side. The same limitation exists for these data as the self-reported function in that the changes seen compared to the contralateral limb may not be long term, but rather due to the necessary healing time required following surgical and radiation treatments. Furthermore, limited data exist comparing the UE function among BCS in the short term to a population of healthy controls. One study has compared UE function of 24 BCS less than 6 months from surgical intervention to matched controls, and reported significant but small motion deficits ranging from 5-11°, and moderate strength deficits of greater than 20%.[9] It is unknown if these deficits persist beyond 6 months when compared to a healthy cohort. A study comparing long term BC survivors to a similar population of healthy controls would help to determine whether these deficits are present beyond the first year following BC treatment, and provide information on the long term effects of breast cancer treatment on UE function.

The prevalence of fatigue associated with BC treatments has been as high as 61-99% in all BCS,[21] with 41% of BCS reporting fatigue 2-5 years after diagnosis.[22] This near universal complaint would suggest that muscular endurance has not been restored following BC interventions. Furthermore, diminished muscular endurance can impact UE function.[7] Muscular endurance is an essential component of UE function, yet has been minimally studied among BCS. Two studies have examined muscular endurance of the

involved UE compared to the contralateral limb in BCS. Within the first 6 months of treatment among BCS undergoing surgical treatment, muscular endurance was altered by 20% in the involved limb.[14] In another study of study of 40 BCS with a mean duration since treatment of 28 months, no deficits in muscular endurance were found in the involved extremity when compared to the non-involved side.[16] These findings suggest that BCS recover muscular endurance over time however, this latter study may have biased recruitment of muscle fibers toward fast twitch, calling into question whether the test actually assessed muscular endurance. More importantly, neither study made a comparison to a healthy population; therefore a determination cannot be made whether an inequality in muscular endurance is due to an inherent difference between arms, due to aging, or is a result of pathology.

Problem

Quality of life is often compromised following breast cancer treatment in the short term, and is commonly associated with UE functional deficits. Long term deficits in motion and strength have been reported following treatment for BC, although the prevalence of deficits declines from the short term.[10,12,15,20] Furthermore, questions arise regarding the extent of the deficits which persist beyond the first year after treatment and how these may affect overall UE function, but it is reasonable to expect these deficits are sustained in the long term to some degree. No study has directly compared healthy women to BCS using objective measures of upper body motion, strength, or muscular endurance at 12 months or more after surgical intervention. Comparison to a healthy population allows a determination whether UE deficits are due to cancer and subsequent treatments, or due to the natural aging process.

Purpose

The primary purpose of this research is to compare quality of life and UE function among long term breast cancer survivors and similar aged women without cancer. Both self-report and objective measurements of UE function are used to create an understanding of UE functional abilities in both populations.

Hypotheses

1a) Self-report of QOL and UE function will be lower among a group of BCS compared to healthy controls of the same age.

1b) Motion, strength, and muscular endurance will be less on the involved limb in women with BC compared to same limb in women without BC.

1c) Motion, strength, and muscular endurance will be less on the involved limb than the non-involved limb in women treated for BC.

The second purpose is to determine if UE function declines across the normal aging process, and whether ROM, strength, and muscular endurance differ based on limb dominance.

Hypotheses

2a) Motion, strength, and endurance measurements will decline with aging among a healthy population of women stratified by decade from 30's to 60's.

2b) The dominant limb of healthy women ages 30-69 will demonstrate greater strength and muscular endurance than the non-dominant limb.

2c) The dominant limb of healthy women ages 30-69 will demonstrate decreased shoulder mobility than the non-dominant limb.

The third aim of this dissertation is to investigate and compare clinical measures of muscular endurance in order to identify a measure that has good responsiveness and minimal ceiling effects.

Hypothesis

3) The modified Upper Body Strength and Endurance test (mUBSE) will be a less variable measure of muscular endurance than the FIT-HaNSA.

Operational Definitions

For the purposes of this study, the following definitions were used:

Estimated 1 repetition maximum (1RM) is a submaximal repetition test used to determine a 1RM value. Each participant was given a heavy load, and the number of repetitions correctly performed was counted. The estimation is based on the following formula where x is the number of repetitions completed:[23]

$$\text{Estimated 1RM} = \text{weight lifted}/(1.0278-.0278x)$$

Short term effects are deficits in self-reported QOL and UE function, shoulder motion, strength, muscular endurance, present immediately after surgical treatment and which resolve within 12 months.

Long term effects are said deficits lasting greater than 12 months.

Outcome measures:

Range of Motion: Range of motion measured with a goniometer has adequate to good intra-rater reliability,[24] reported by various authors with ICCs ranging .53-.98.[25,26] Goniometric landmarks were used in this study, however, measurement of shoulder flexion, external rotation, and hand behind back (HBB) was be completed using digital photography and software to calculate angles and distances. The (HBB) measure is the

distance in centimeters from the C7 spinous process to the spinous process in line with the tip of the thumb when the hand is reached behind the back as high as possible.[27]

Strength: Strength of shoulder flexors, internal and external rotators as measured with a mean maximal voluntary isometric contraction (MVIC) using hand-held dynamometry was completed.[7] Strength was then normalized to body weight and reported as a percentage of body weight in order to make comparisons among individuals clearer.

Muscular Endurance: One measure of muscular endurance is Functional Impairment Test - Hand, and Neck, Shoulder, Arm (FIT-HaNSA),[28,29] which measures the duration of UE lifting and manipulation tasks. A second test of muscular endurance used is a modified Upper Body Strength and Endurance Test (mUBSE), patterned after the Upper Body Strength and Endurance Test.[14,15] In the mUBSE, the participant repetitively lifted 50% of her estimated 1RM until one of 4 stopping criteria were met:

1. Participant could no longer continue lifting weight
2. Participant could not reach her maximum high point of elevation 2 times consecutively
3. Participant could not maintain cadence of lift (2 beats up/2 beats down)
4. Participant demonstrated extremely poor form of lift

The number of repetitions and the duration of the test in seconds for each limb were recorded.

<u>Assumptions:</u>

1. All participants accurately reported no current (within the last 6 months) shoulder, cervical or thoracic pathology.

2. All participants accurately reported no surgery to the shoulder, cervical or thoracic spines, other than that related to BC treatment.
3. All BCS underwent a mastectomy and/or axillary lymph node dissection and/or axillary radiation.
4. All participants gave their best effort during measurements of strength, motion, and muscular endurance.
5. All participants accurately completed self-report questionnaires.

Limitations:

1. No BCS in their fourth decade were recruited.
2. Some participants in the study may have been exposed to physical therapy intervention in the past, and as a result may have performed differently than those who had no previous physical therapy.
3. The investigators were not blinded to group during data collection, and the primary investigator was not blinded to group during data analysis.
4. Primary recruitment of participants was through BC support groups, possibly biasing this sample toward a group of women with higher levels of support or resources.

Delimitations

1. The healthy control group consisted of females, ages 30-69, with an ability to read and write English.
2. The BCS group was limited to females, ages 30-69 who had been diagnosed with BC and completed surgical treatment at least one year prior to enrollment.

Surgical treatment must have included at least one of the following: mastectomy, axillary lymph node dissection, or axillary radiation.

3. All participants were excluded if they had recent (6 month) history of shoulder, cervical or thoracic spine pathology diagnosed by a physician, or any history of shoulder, cervical or thoracic surgery.
4. Breast Cancer Survivors were excluded if the surgical treatment of BC was limited to breast conserving therapy (lumpectomy), or sentinel node biopsy, or local (tumor bed) radiation.

CHAPTER TWO

Current literature related to understanding upper extremity (UE) function and evidence of UE function among survivors of breast cancer (BCS) is the focus of Chapter Two. The first section presents evidence supporting UE function as an aspect of, and having an effect upon, quality of life (QOL). The link between UE function and QOL within the framework of the International Classification of Functioning, Disability and Health (ICF) will be established. The second section presents methods to measure UE function, including subjective and objective measurements. The emphasis is on clinical measurements rather than laboratory techniques as these will better inform clinical practice. Lastly, the need for measuring UE function in survivors of breast cancer (BCS) is presented with evidence outlining the understanding of UE function in long term BCS.

Introduction

Breast cancer (BC) is the most commonly diagnosed non-skin cancer among women, with 2012 estimates at more than 280,000 new cases of both invasive and in situ cancer.[30] With a lifetime risk of 1 in 8 women being diagnosed with BC, greater than 67% of these cases, will be among women between the ages of 44 and 74.[31] Survival rates have increased 15% in the last 25 years, and currently approach 90%.[31] The number of women diagnosed with and surviving BC has placed prevalence estimates at 2.8 million women.[31] The focus of treatment for BC has broadened from simply focusing on the cancer itself to ensuring a return to a QOL similar to the pre-cancer diagnosis time point.

The World Health Organization's ICF[7] is a framework to measure and describe health and disability, and the impact of health conditions on abilities of an individual, within a context of environmental and social structures. The presentation of health and

disability within this context of specific domains is the way in which the ICF codifies the impact of disability on QOL. ICF body structure and function domains comprise parameters of UE function, including motion, strength, and muscular endurance.[7] Impairments in any of one of these three areas can result in limitations in activity and restrictions in participation, also outlined in the ICF.[7] The mobility domain under activities and participation constructs of the ICF lists carrying, moving, and handling of objects and the self-care domain includes abilities related to washing, toileting, dressing, eating and drinking.[7] All of these tasks require functional abilities of the UE; the inability to carry-out tasks within these domains can result in lower reported QOL.

Physical function is one aspect of QOL. Most QOL measures include a physical functioning subscale within the tool. The physical well-being subscale on the Functional Assessment of Cancer (FACT-G)[32] includes questions related to abilities to meet the needs of family members. The FACT-B[33] has an additional nine items specific to BCS, one of which focuses on arm swelling, or lymphedema, as a result of BC treatment. Interference in the ability to use the UE to complete daily tasks can result in lower levels of QOL whether from the impact of lymphedema, or impairments related to motion, strength, or muscular endurance.[3,34]

Given the potential for UE disability following BC treatment and its possible impact on QOL, it is necessary to identify impairments in physical functioning so they can be effectively addressed. The purpose of this paper is to: (1) review how UE function is measured, with an emphasis on measures with clinically feasibility; and, (2) identify the reported levels of UE function in long term BCS.

Typical Measures of UE Function

To accurately understand UE functional abilities, a comprehensive assessment of the different components of function is required. Complete assessment includes measuring self-reported function, as well as taking objective measures of range of motion (ROM), strength, and muscular endurance. These measurement tools must be valid and reliable to gain a thorough clinical view of UE function. The following section focuses on methods of measurement for each component of UE function, and presents evidence related to validity and reliability of the measures.

Self-report of UE Function

Clinically, self-report measures are commonly used to describe UE function and provide the clinician with important information about an individual's perception of abilities. Although numerous validated scales have been designed for the UE, those used in BC research include the Disabilities of the Arm, Shoulder and Hand (DASH),[35] the Penn Shoulder Score,[36] and the Constant Murley Shoulder Score.[37] Another potentially useful scale which has not been used in BC research is the Upper Extremity Functional Index (UEFI).[38] Each of these scales includes specific functional activities on which an individual rates her level of difficulty performing a task. Of these, only the DASH and the UEFI provide a framework for assessing function based on ICF constructs, therefore providing an understanding UE function within this contextual framework.

The DASH is a reliable and valid[39,40] 30 question disability scale which is commonly reported in BC research studies. The DASH scale is scored 0-100, with lower scores indicating less disability. Two studies have examined the items on the DASH in relation to the ICF framework and have found good association to the body

functions and the activities and participation components of the ICF.[41,42] Intraclass correlation coefficients (ICC) for test-retest reliability range from .77-.98,[39,43] and both construct and convergent validity was established with 3 other shoulder scales: the American Shoulder and Elbow Surgeons Score, the Simple Shoulder Test, and the Shoulder Pain and Disability Index.[43,44] Normative data for the DASH have been established for the general United States population using a sample of 1706 participants, with a mean of 10.1±14.68 reported.[45] The effects of age, gender, and type of employment on DASH scores were examined in a study of 716 employed adults in Germany, a country with similar a socioeconomic makeup to the United States.[46] DASH scores increased with age, were higher among women than men (14.3±14.9 and 11.6±15.8, respectively), and among manual laborers as compared to non-manual laborers (15.7±17.2 and 937±12.5, respectively).[46]

The Upper Extremity Functional Index (UEFI) has not been used in published research to assess self-reported arm function among BCS; however, it was designed with the current ICF model as a guide.[38] This 20 question scale scores specific functional tasks on level of difficulty, from 0 (i.e. extremely difficult) to 4 (i.e.no difficulty). A total of 100% indicates full UE function. The UEFI has a test-retest reliability of ICC=.95, and good convergent validity with the Upper Extremity Functional Score (r=.82).[38] The questions on this scale pertain specifically to the involved extremity, differing from the DASH which asks about the level of difficulty in completing a task, regardless of whether the pathological limb is involved in the task.

Objective Measures UE Function: ROM, Strength, and Muscular Endurance

Objective measures of UE function include range of motion (ROM), strength, and muscular endurance. Methods to quantify these measures include both laboratory and clinical methods. Commonly used clinical tests are reviewed, as well as those less common but which provide objective and accurate measures.

Range of motion in the clinic is frequently measured using several different methods: goniometry, photography, and inclinometry. Goniometry provides the clinician with an inexpensive but reliable method to document motion. In a study of 50 participants referred to physical therapy, both intra- and inter-rater reliability were examined for all shoulder motions.[25] In particular, shoulder flexion motion demonstrated better intra-rater reliability (ICC = .98) than inter-rater reliability between 2 testers (ICC = .89), although both methods demonstrated good reliability.[25] In a smaller study of 8 participants and four raters, the inter-rater reliability of shoulder flexion measured with a goniometer was lower (ICC=.69), with a standard error of measurement of 25°.[26] This lower reported ICC value suggests that reliability between more than 2 testers is more difficult to ensure.

Still photography of a joint presents another option for measuring ROM. By applying a goniometer on the photo to measure motion, or using specialized software to measure angles and distances, an exact measurement can be made. In a study examining the reliability of five methods of measuring shoulder ROM, photography with a goniometer demonstrated moderate[24] inter-rater reliability for shoulder flexion (ICC = .73).[26] When comparing the inter-rater reliability of the goniometer to photographic measurement, the ICCs are similar, but photography appears to have a slightly higher

value, suggesting that it may be beneficial to use this method to reduce error in an environment where multiple clinicians are involved in care.

Inclinometry provides the clinician with another method to measure ROM. The intra-rater reliability of inclinometry is reportedly better than goniometry with ICC= .90-.95.[47] However, inter-rater reliability of inclinometry has greater variability as compared to goniometry with reported ICCs ranging from .28-.90, and differences of measurement between observers exceeding 10°.[47] These findings suggest that inclinometry is best used by a single examiner rather than in a situation where more than one tester is involved.

Measuring internal rotation ROM with a goniometer can result in lower inter-rater reliability (ICC = .50-.66)[48] because controlling for scapular motion is difficult. In this situation, internal rotation ROM measures are often performed in a clinically functional manner by having an individual reach her hand up behind her back. This Hand Behind Back (HBB) measure is not a true measure of shoulder internal rotation because it incorporates glenohumeral extension, scapular retraction, downward rotation and elbow flexion.[49,50] However, it does mimic many UE functional motions including dressing, reaching into back pockets, or reaching behind, and so is a useful clinical tool for determining whether a limitation may impact functional activities. Furthermore, concerns over low inter-rater reliability can be addressed by using photography to capture the motion with one individual measuring the motion.

In a clinical setting, strength is frequently measured using manual muscle testing (MMT). MMT is a subjective method of grading force of resistance on a 0-5 point scale, where 0 is no evidence of muscle activity, 3 is full anti-gravity motion without resistance, and a 5 is full anti-gravity motion with maximal resistance.[51] Intra-rater reliability of

MMT has been reported as high as ICC=.98 for shoulder abduction in a study of 11 participants. [52] Inter-rater reliability is lower; in another study of 11 participants measuring deltoid strength, the reported kappa was .62.[53] An additional but important limitation of MMT is the inability to provide a specific level of force production which can be objectively tested and retested over time. Dynamometry can provide a reliable objective measure of the level of strength where MMT does not.

Dynamometry has traditionally been reserved for laboratory research; however, the development of hand-held dynamometry (HHD) provides the clinician with a method to objectively measure strength. Concurrent validity of HHD with isokinetic dynamometers has been established.[54] The reliability of HHD for UE strength testing has also been established in multiple studies with ICCs ranging from .82-.97.[55-57] Some studies have suggested that the counterforce provided by the examiner can influence accuracy in measurement. Two studies investigating gender effects in HHD measures reported that female testers have lower levels of inter-rater reliability than males as greater stabilization is needed for larger muscle groups.[58,59] This problem of an adequate counterforce can be alleviated by using a consistent stabilization force such as a strap or a brace.[60,61] Normative data and reference values for hand-held dynamometry have been established and are available for comparisons.[62,63]

Muscular endurance is an essential component of UE abilities, but because few clinical measures exist, it is not often tested. A newer test of muscular endurance is the Functional Impairment Test – Hand and Neck, Shoulder, Arm (FIT-HaNSA).[29] This test examines the ability of an individual to sustain an activity over time in 3 sub-tests of repetitive UE use. These sub-tests include repetitive lifting at chest height, above head,

and an overhead manipulation task. The FIT-HaNSA has demonstrated good reliability (ICC=.79-.97)[28,29] and convergent validity with self-report scales (*r*=.71-.76),[28,29] yet no normative values for this test have been reported.

Another clinical muscular endurance test is the Upper Body Strength and Endurance Test (UBSE).[14] In the UBSE, the participant completes a combination upright row/shoulder press motion repeatedly as resistance is incrementally increased. The test is discontinued when the participant can no longer perform the motion correctly, keep a specific pace, or stops. The psychometric properties of the UBSE have not been investigated, but this test has been used to examine muscular strength and endurance in a population of BC survivors.[14,15]

Recommended Clinical Measures of UE Function

Using valid and reliable tools to measure UE function is important to accurately assess functional abilities. Those self-report measures of UE function that meet these criteria include the Penn Shoulder Score (PSS),[64] the Constant Murley Shoulder Score (CSS),[65] and the Disabilities of the Arm, Shoulder, Hand (DASH).[39,43,44] Although any of these measures could be used, the DASH has been validated in multiple populations[39,40,43,46] and may be a more versatile tool for clinical use. Reliable and objective clinical measures include goniometry, including photography, or inclinometry for ROM, and hand held dynamometry for objectifying strength. Muscular endurance should be a component of clinical assessment of UE function, yet few valid and reliable tools are available to the clinician. The FIT-HaNSA is one such tool which could be incorporated into evaluation. By using a combination of measures, the clinician gains a clear understanding of UE functional abilities.

UE Function Among Breast Cancer Survivors

Treating BC can involve extensive surgery to the anterior chest and axillary regions, which may impact UE function. Women who undergo mastectomies and axillary lymph node dissection have higher levels of UE morbidities than women who undergo breast conserving surgery and sentinel node biopsies.[6,10,11,66,67] Axillary radiation treatment can result in further declines of UE function.[68,69] This section will review the literature related to the extent of UE disability and recovery of functional abilities in within and after the first year of treatment.

UE Function 0-12 months following BC Treatment

Many women treated for BC report that they do not recover to their pre-diagnosis level of UE function within the first year after treatment. In a study of 188 BCS 6 months after treatment, 25.6% report Disabilities of the Arm, Shoulder and Hand (DASH) scores of greater than 20.[17] In another study, significantly higher DASH scores were recorded by 24 BCS less than one year from treatment compared to matched controls.[9] Other studies using non-standardized self-report questionnaires confirm the loss of UE function for this population.[10,70-72] These self-reports of UE functional loss may be the result of impairment in the components of UE function, including ROM, strength, and muscular endurance, which occur after BC treatment.

Joint ranges of motion and muscle strength levels have been examined in BCS following surgical and adjuvant treatment. Diminished motion[11,14,20] and strength[8,14,16] of the involved extremity have been documented in the first year after BC treatment. Deficits of up to 10% of flexion motion and 20% of elevation strength are reported when compared to the contralateral limb.[8,14] When examining deficits compared to age

matched controls, limited data exist. In a comparison of 24 BCS within 6 months of treatment to matched controls, shoulder flexibility deficits ranged from 7-12%, and strength deficits reported were up to 27%.[9] It is necessary to compare the ROM and strength of BCS more than one year following treatment to a population of healthy controls to determine if problems persist beyond the healing stage in the first year.

One study has examined muscular endurance of the involved UE compared to the contralateral limb in BCS within 12 months of diagnosis. Another study examining endurance used the Upper Body Strength and Endurance test (UBSE) to record the weight of the last successfully completed stage in a progressive resistance lifting task.[14] In contrast to the shoulder press task, the involved limb in the UBSE study showed a 20% deficit in muscular endurance compared to the non-involved limb among BCS 6 months following surgical treatment.[14] In the shoulder press task, the use of 90% of 1RM may bias fast twitch fibers and therefore might not accurately reflect muscular endurance. The UBSE measures the maximum weight lifted over time, rather than noting duration of activity, which is the accepted unit of measure for endurance. These inconsistencies in results do not provide a clear understanding of muscular endurance among BCS.

Impairments in ROM, strength, and muscular endurance in BCS in the short term have been documented. These impairments likely have an effect on overall UE function as self-report functional scores indicate. The limitation of these data show deficits compared to the contralateral limb or to a healthy population in the short term only. These deficits may not be long term, but rather due to the necessary healing time required following treatment. Methodological considerations, inconsistencies in results, and the lack of comparison of BCS to a healthy population provide rationale for further

investigation of muscular endurance among this population. For a portion of BCS, motion, strength, and muscular endurance impairments may persist long term, resulting in compromised UE function past the first year following BC treatment.

UE Function 12 months or More after BC Treatment

The prevalence of UE limitations more than one year after treatment has been estimated to be 5-60%.[17,73] The incidence of UE limitations is estimated from 10-64% in a population of BCS 12 months or more from treatment.[74] The complaints reported by BCS include pain, lymphedema, and UE functional decline.

Self-report of function assessment among long term BCS reveals a continued perception that the involved UE is functionally impaired. In a 2 year follow-up of 181 BCS, self-reported function remained impaired as measured by the Shoulder Disability Questionnaire.[12] Self-report of function using the DASH also indicates a continued perception of functional limitations among long term BCS. One study documented moderate disability utilizing DASH scores in participants 2-67 months following treatment, with a mean score of 32.[18] Others have documented that over 25% of BCS 6 years after treatment report DASH scores greater than 20.[17] Comparisons of self-report of function between BCS more than 1 year from diagnosis and treatment and a healthy population have not been reported in the literature. Taken together the studies suggest that BCS perceive that treatment for BC results in continued UE functional disability beyond the first year after treatment.

Deficits in motion, strength and muscular endurance of the UE have been documented more than 5 years following treatment for BC, although the prevalence of deficits declines from the short term.[6,10,12,17,20] Range of motion deficits persisted in more

than 34% of BCS 5 years after diagnosis,[20] with the amount of loss exceeding 25° flexion and abduction motion in 24-38% of BCS 2-4 years after surgery.[12,75] Strength deficits are often self-reported, but in a study of 131 BCS one year following BC surgery, an 8% loss in shoulder abduction strength measured by hand-held dynamometry was documented compared to pre-operative status,[10] and in another study of 75 women with a mean time since surgery of 15 months, strength losses ranged from 7-18% for shoulder elevation measures.[8]

In examining the literature related to muscular endurance among long term BCS, less is known. One study examined an endurance using a test of completing a shoulder press task at 90% of 1 repetition maximum (1RM) until failure. The number of repetitions completed by each limb was compared, and no statistical differences between the involved and non-involved sides were reported.[16] Another study conducted at 18 months following BC surgery examined upper body strength and endurance, documented that 40% of survivors continued to demonstrate deficits comparing involved to non-involved limbs.[15] Whether differences between limbs existed prior to treatment, or are less than levels seen in a population of healthy women, cannot be determined. In total, these losses in motion, strength, and muscular endurance can have an impact on function in a portion of long term BCS.

Although functional deficits which occur immediately following treatment for BC appear to persist longer than the normal time required for tissue healing, it has not been clearly established. The need for a study examining self-reported and objective measures of UE function among long term BCS in comparison to healthy control is needed to understand the extent of problems.

Conclusion

Clinical tools to evaluate UE function include validated self-report scales as well as objective measures to quantify impairment. The most commonly used self-report UE functional scale for BCS is the DASH, with good reliability and validity.[39,43,44] The extensive use of the DASH in both the BC population and other pathological populations provides an opportunity to develop an understanding of the extent of functional impact of BC treatment. This information can then be used by the clinical community to guide rehabilitation efforts as well as provide a means of prospective surveillance for potential dysfunction.

Objective clinical measures of UE function have become more precise and accurate. The use of inclinometry to measure ROM improves accuracy, while HHD more clearly identifies strength values through objective measures not available with MMT. Clinical measures of muscular endurance remain one area in which better assessment tools must be developed. Although the FIT-HaNSA demonstrates good psychometric properties, the test is time consuming to apply clinically. The UBSE as a muscular endurance test lacks psychometric validation at this time. Better clinical tools to measure muscular endurance will provide the rehabilitation community with improved methods to identify functional status and take necessary steps to address any deficits.

Using these clinical assessments of UE function is an important aspect of identifying BCS for whom surgical and adjuvant treatment has resulted in impairments of UE function. Approximately one-third of BCS have persistent losses in ROM and strength more than one year after treatment.[17] These deficits often impair overall UE abilities.[74] By measuring ROM, strength, and muscular endurance, and combining these

findings with self-report of function, the clinician can developed a focused rehabilitation program aimed at a return of function.

CHAPTER THREE

This chapter describes typical upper extremity functional performance among a population of healthy women ages 30-69. The experimental design, including participant selection, dependent measures, data collection procedures and analysis, results, and discussion of findings, are presented here. The data from this study will help establish how these measures change over the decades, and be used in future comparison to women treated for breast cancer.

Introduction

Adequate motion, strength, and muscular endurance of the upper extremity (UE) are required to complete functional tasks. These parameters of UE function are detailed in the International Classification of Functioning, Disability, and Health (ICF) within the body function domain and are important to understand health within a context of function.[7] Successful performance of activities of daily living has been shown to correlate with range motion of the shoulder[76,77] and is dependent upon adequate strength. Sustaining functional activity over a period of time requires muscular endurance. The level of UE functional ability is typically measured with self-report and through objective measures of motion, strength, and muscular endurance. Following injury or pathology, an understanding of typical levels of self-reported function and objective measures of range of motion (ROM), strength, and muscular endurance is needed to be able to clinically address deficits in any of these areas with the goal of full return to function.

Typical values of UE functional self-report, ROM, strength, and muscular endurance throughout the adult lifespan have not been consistently documented in the literature, and when such reports are available, conflicting information emerges. Self-

report of function using the Disabilities of the Arm, Shoulder and Hand (DASH) shows a decline in function with increasing age in a sample of 716 individuals,[46] but these declines are not specific to gender. Declines in motion and strength with increasing age have been reported by several researchers,[62,63,78-82] but a clear picture of the age at which decline begins and whether it is correlated with changes in function, is lacking. Changes in muscular endurance with aging have been minimally studied; one study reported that muscular endurance was greater in an older population cohort than a younger one,[83] but the methodology used, isokinetic measures, is not readily available clinically. A clear picture of the evolving changes in UE function over time needs to be defined.

Whether and to what extent long term deficits in objective measures of shoulder motion, strength, and muscular endurance among BCS are different than those seen in normal aging is not clear. By providing typical values of function throughout the adult lifespan, comparisons between a pathological population and a healthy cohort can be made. The primary aim of this study is to collect data to describe UE motion, strength and muscular endurance in a healthy female population aged 30-69. The primary hypothesis is that as women age, there will be declines in all areas: ROM, strength, and muscular endurance. A secondary aim is to examine the effect of dominance on objective measures of UE function. Specifically, it is expected that the dominant extremity will have less available motion, and greater strength and muscular endurance than the non-dominant extremity.

Methods

Subjects

A sample of convenience of 79 healthy women (age 49± 11years) agreed to participate in this study. To be included in this study, participants had to be between the ages of 30 and 69, and report no history of breast cancer. Participants were excluded if they had recent (6 month) history of shoulder, cervical or thoracic spine pathology diagnosed by a physician, or a history of shoulder, cervical or thoracic surgery. All participants read and signed an approved consent form prior to starting the study. The consent form was approved by the Institutional Review Boards of the University of Kentucky, Lexington, Kentucky, the University of Dayton and Miami Valley Hospital, Dayton, Ohio. Participants were stratified into decades, 30-39, 40-49, 50-59, 60-69, with 20 participants per decade except the 60-69 group, which had 19. The 4 groups did not significantly differ in body mass index (BMI) (p=.18) or activity level measured by the International Physical Activity Questionnaire (IPAQ) (p=.85).

Procedures

Each participant came one time to the clinical laboratory for data collection. Measurements were taken by three investigators trained in landmark identification for ROM measures, use of a hand-held dynamometer for strength assessment, and in administering the Functional Impairment Test – Hand and Neck, Shoulder, Arm (FIT-HaNSA). The FIT-HaNSA demonstrates good-excellent reliability,[24] and ranges from .89-.99.[28,29]

Participants completed all self-report forms prior to other components of the testing. Demographic variables of age and arm dominance were recorded, and height in

meters and weight in kilograms to the nearest tenth were measured and recorded to calculate BMI.

Dependent Variables

Self-Report Scales

Activity level was measured using the 7-item International Physical Activity Questionnaire (IPAQ), which has good test-retest reliability (r= .70-.90).[84] Quality of life was measured using the Functional Assessment of Cancer Therapy – Breast (FACT-B), which has good construct validity (r=.90) and test-retest reliability (ICC=.88).[33] This scale is comprised of 27 core questions making up the FACT-G (General cancer quality of life scale), plus 9 additional items specific to breast cancer. Scores range from 0 to 144; higher values indicate a higher quality of life. Self-reported UE function was measured using the Upper Extremity Functional Index (UEFI), a 20 item questionnaire with score ranging from 0 to 100, 100 indicating the highest level of function,[38] and the DASH,[35] a 30 item disability scale scored 0 to 100, with lower scores denoting less disability. Both measures have been found to be reliable and valid tools in the evaluation of UE function.[38-40]

Objective Clinical Measures:

Range of Motion: Bilateral active ROM of shoulder flexion, hand behind back (HBB), and external rotation (ER) were measured by taking a photograph of the participant completing the motion. ImageJ software (National Institutes of Health, Washington DC) was employed to calculate measurements. This method of measuring ROM was chosen because multiple investigators were utilized for data collection, and initial pilot testing with digital inclinometry produced unacceptable inter-rater reliability

levels. Inter-rater reliability of landmark identification for ROM was established with further pilot testing and interclass correlation coefficients (ICC) ranged from .90- .99. The ICC for intra-rater reliability of digital measurement of ROM with ImageJ was consistently >.95, with a standard error of measurement of less than 2°.

Landmark identification was completed prior to photographing of the motion. For shoulder flexion, two dots were placed along the midshaft of the humerus aligned with the greater tuberosity and lateral epicondyle of the humerus, and two additional dots were placed along the midline of the thorax.[85] Active shoulder flexion was measured by instructing the participant to elevate her arm as high as possible in forward flexion. To form the shoulder flexion angle, a line was drawn bisecting the two points demarking the midshaft of the humerus, and another was drawn bisecting the two points of the midthorax line; the angle in degrees of the intersection of the two lines was measured.[85] (Figure 3.1)

For HBB, a marker was placed at C7, an easily and reliably palpated structure.[86] The HBB measurement was taken by having the participant reach her hand as high up the back as possible while standing; a 10cm reference was in the same plane as the participant. This reference line is necessary to provide a spatial scale of the image so that measurement results are in calibrated units, and addresses the issue of perspective.[87] Using ImageJ software, the reference distance was measured to set the scale of measurement, and then the distance in centimeters from the C7 spinous process to the spinous process in line with the tip of the thumb was recorded; a lower value indicates greater motion.[27]

For ER, a dot was placed at the olecranon process and another at the ulnar styloid process.[85] Active shoulder ER was measured with the participant lying supine with the shoulder abducted and elbow flexed to 90° with the elbow resting on two towels to approximate the plane of the scapula. The participant was instructed to externally rotate her arm as far as possible. The ER angle was formed by a line drawn through the shaft of the ulna and a line perpendicular to the plinth. (See Figure 3.3) Two trials for each motion and each extremity were recorded, and the mean of these values was calculated.

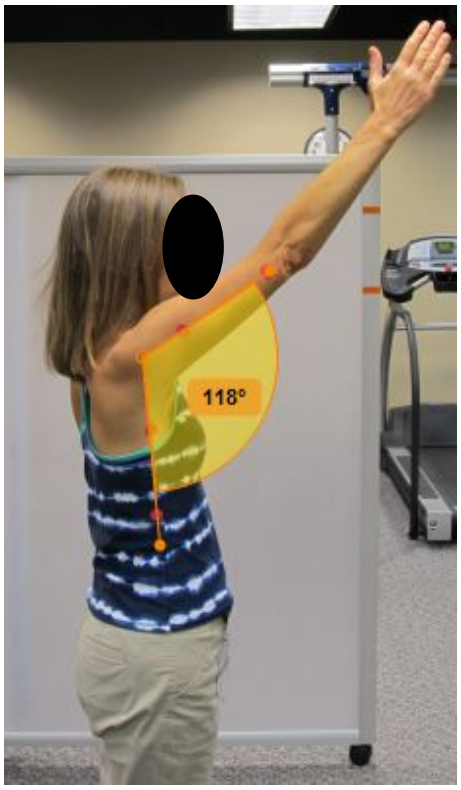


Figure 3.1: Flexion ROM
Arc of motion generated for illustrative purposes only by Kinovea.org

Figure 3.2: Hand Behind Back

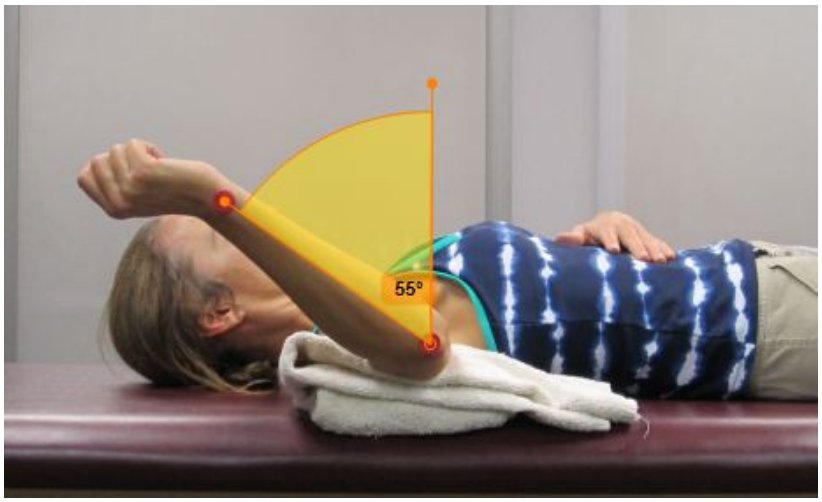


Figure 3.3: External Rotation ROM
Arc of motion generated for illustrative purposes only by Kinovea.org

Strength: The strength of the shoulder flexors, internal and external rotators was measured by hand-held dynamometry (Lafayette Manual Muscle Test System, Lafayette Instruments, Lafayette, IN). An inelastic 2" wide nylon strap was placed around the participant's wrist for each motion to provide a consistent, immovable resistance for the hand-held dynamometer. Each participant was instructed to generate force to a maximal level over 5 seconds in each direction of testing.[7,63] Two submaximal practice trials were completed prior to testing, followed by 3 trials with 10 seconds rest in between. The average of the 3 trials was used for later statistical analysis.[54] Shoulder flexion was measured with the participant seated, arm elevated to 90°.[51] (Figure 3.4) To measure IR and ER, the participant's upper arm was supported on two towels while lying supine with the arm at 90° of abduction and 90°elbow flexion.[51] In pilot testing , the ICCs for inter-rater reliability for strength measures ranged from .78-.80, and the standard error of measurement was consistently below 1.2%. (Figures 3.5-3.6) Strength was normalized to

body weight and is presented as a percentage of body weight (kg of force/body weight in kg).

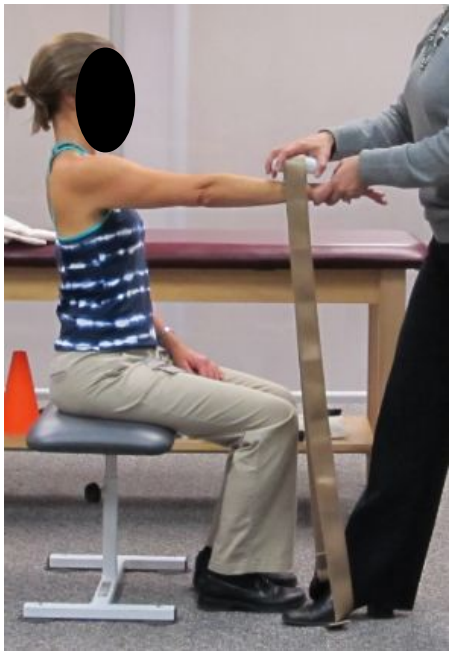


Figure 3.4: Flexion Strength

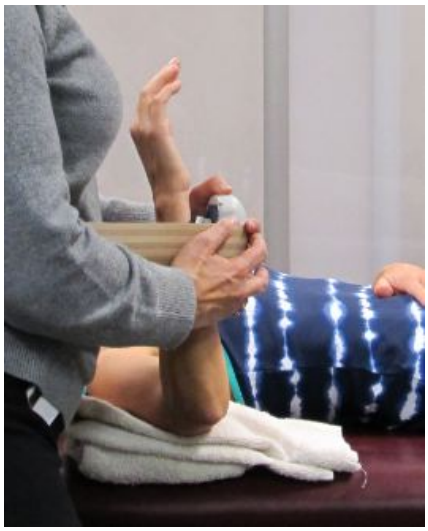


Figure 3.5: Internal Rotation Strength

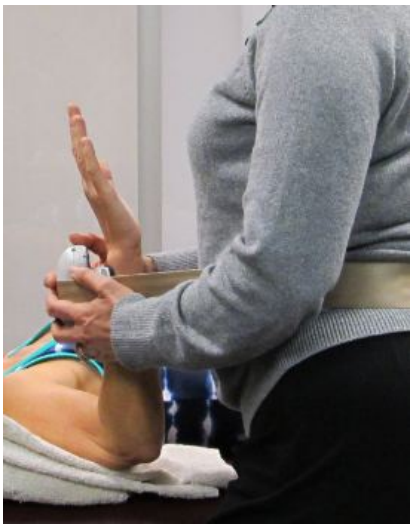


Figure 3.6: External Rotation Strength

Muscular Endurance: Upper extremity muscular endurance was measured by using the FIT-HaNSA sub-tests 2 and 3 following a previously established protocol for performance and termination of testing.[29] (Figures 3.7 and 3.8). The FIT-HaNSA demonstrates good-excellent test-retest reliability (ICC=.79-.97), and moderate concurrent validity (*r*=.71-.76) with self-reported UE functional scales.[28,29]

Figure 3.7: FIT-HaNSA sub-test 2

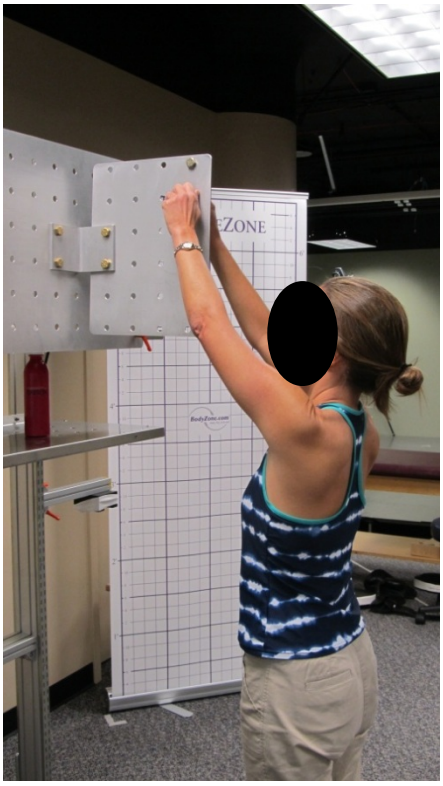


Figure 3.8: FIT-HaNSA sub-test 3

Statistical Analysis

Data were analyzed using IBM SPSS Statistics 19 (New York, NY). Descriptive statistics were calculated for all dependent variables. An independent samples t-test was used to analyze BMI. Mann Whitney U was used to examine activity level (IPAQ), and self-reported QOL (FACT-B) and function (DASH and UEFI), as these values were not

normally distributed. A repeated measures analysis of variance (ANOVA) with one within factor (limb) and one between factor (group) was used to analyze all measures of motion, strength, and muscular endurance with the exception of the FIT-HaNSA sub-test 3 as this is a bilateral test. There were 2 levels of limb (dominant, non-dominant) and 4 levels of decades (30-39, 40-49, 50-59, 60-69). Significance was set at $p \leq .05$. If a significant difference was found, a Tukey's post hoc analysis was performed to identify differences with significance set at $p \leq .05$. The FIT-HaNSA sub-test 3 was analyzed with ANOVA, and Tukey's post hoc testing was performed if the ANOVA was significant at $p \leq .05$.

Results

Descriptive analyses with means and standard deviations of all variables are found in Tables 1-4. The three self-report scales (FACT-B, DASH, UEFI) were not different between the 4 age groups (p value ranges .16-.59). (Table 3.1) There was no significant interaction between group by dominance for any measure of motion, strength, or endurance. Age was found to have a significant main effect on flexion ROM (p=.01). Tukey's post hoc analysis identified that 60 year olds (148° ± 8) have less flexion motion than 30 year olds (159° ± 10) across sides (p=.01). For all other objective measures of ROM, strength, and muscular endurance, no significant differences were found between ages (p value ranges .07-.95).

When examining the influence of limb dominance on ROM, there was significantly less motion for the HBB motion on the dominant side (16.4cm±4.3) compared to the non-dominant side (13.2cm±4.2) (p<.001); no other differences were observed for flexion or external rotation (Table 3.2). The dominant limb (9.6%±3.1) was

stronger than the non-dominant limb (9.0%±3.1) only in flexion (p=.001); no other differences were found for measures of strength (Table 3.3). The dominant limb (271sec±54) was observed to have greater endurance than the non-dominant limb (266sec±63) while performing the FIT-HaNSA sub-test 2 (p=.03) (Table 3.4).

Table 3.1: Means (standard deviation) for Self-report Measures

Decade	FACT-B Total	DASH	UEFI
30 (n=20)	124.8 (15)	2.71 (7.2)	98.88 (2.1)
40 (n=20)	123.4 (16)	3.03 (5.2)	99.12 (1.6)
50 (n=20)	123.0 (24)	2.55 (3.7)	97.84 (4.0)
60 (n=19)	127.2 (45)	4.23 (4.7)	97.36 (3.4)
Total (n=79)	124.6 (27)	3.12 (5.3)	98.32 (2.9)

Abbreviations: FACT-B: Functional Assessment of Cancer Therapy – Breast; DASH: Disabilities of the Arm, Shoulder and Hand; UEFI: Upper Extremity Functional Index

Table 3.2: Means (standard deviation) Active Range of Motion

	Flexion		Hand Behind Back		External Rotation	
Decade	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
30 (n=20)	159 (10°)	157 (10°)	14.5 (3.3cm)	13 (3.5 cm)	93 (10°)	93 (11°)
40 (n=20)	154 (9°)	156 (10°)	18.2 (5.0cm)	13.1 (5.3 cm)	95 (11°)	95 (7°)
50 (n=20)	155 (9°)	154 (8°)	15.5 (2.8cm)	13.1 (3.2 cm)	93 (8°)	92 (6°)
60 (n=19)	148 (8°)	150 (8°)	17.2 (4.9cm)	13.7 (4.6 cm)	97 (9°)	95 (8°)
Total (n=79)	154 (8°)	155 (9°)	16.4 (4.3cm)	13.2 (4.2 cm)	95 (10°)	94 (8°)

Table 3.3: Means (standard deviation) Strength (% of body weight)

	Flexion		Internal Rotation		External Rotation	
Decade	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
40 (n=20)	10.4 (3)	9.8 (3)	16.0 (.5)	15.2 (.4)	14.9 (3)	14.6 (4)
50 (n=20)	9.3 (3)	8.3 (3)	13.9 (.4)	13.8 (.4)	14.3 (5)	14.7 (5)
60 (n=19)	8.2 (3)	8.1 (3)	13.1 (.4)	13.5 (.5)	13.9 (5)	13.7 (5)
Total (n=79)	9.6 (3.1)	9.0 (3.1)	14.5 (4.4)	14.2 (4.3)	14.4 (4.4)	14.5 (4.7)

Table 3.4: Means (standard deviation) Endurance (seconds)

	FIT-HaNSA sub-test 2		FIT-HaNSA
Decade	Dominant	Non-dominant	sub-test 3
30 (n=20)	275 (48)	276 (47)	286 (32)
40 (n=20)	285 (48)	280 (49)	288 (31)
50 (n=20)	262 (62)	257 (81)	278 (55)
60 (n=19)	262 (60)	250 (70)	277 (48)
Total (n=79)	271(54)	266(63)	282(42)

Discussion

The primary aim of this study was to describe and determine if differences occur with aging in self-reported measures of QOL and UE function, and ROM, strength, and muscular endurance among healthy women ages 30-69. The hypothesis that these measures would decrease with increasing age was not met for 10 of 11 variables. These findings suggest that in general, the level of ROM, strength, and muscular endurance do not change in women between the ages of 30 through 69, and future comparisons between women with UE pathology to a group of healthy controls, age does not need to be considered. The secondary hypothesis, that the dominant limb would show less motion, and greater strength and endurance than the non-dominant limb, was met for 3 of 7 measures. Dominance does play a role in some measurements of ROM, strength, and endurance, and therefore, limb to limb comparisons should not be relied upon to provide accurate comparisons.

Self-Report Scales

Quality of life as reported using the FACT-B was consistently high in this population. No studies have reported mean scores on the FACT-B in a healthy population however, in a study of over 1000 healthy individuals, the mean score on the FACT-G was 80.[88] Calculating the FACT-G scores from this study sample, the range is 87-91, comparable to previously reported research.[88] The overall high scores seen in this sample population suggest that QOL does not diminish with age. It should be noted however, that the FACT-B is specific to women treated for BC, and many questions on the scale would not apply to an individual without BC. Although the scale can be scored

with skipped questions, it is possible that the results cannot truly measure QOL among a population who has not had an experience with BC.

Self-reported arm function using the DASH and UEFI showed no significant functional decline across the four decades. Mean DASH scores in this study, ranging from 2.55 – 4.23, are somewhat lower to those reported in other research.[45,46] These findings indicate that the sample in this study is without UE functional disability. UEFI scores exceeded 97 for all age groups. No published data are available for UEFI in a healthy population, but 2 studies in a pathological population report a mean and standard deviation far lower (43.2±17.7[38] and 65.2±17.9[89]) which would indicate that the participants in this study are likely representative of a healthy sample. Overall, the sample of women in this study presented with little to no perceived level of upper extremity disability and a high level of self-reported function.

The Impact of Age on ROM, Strength, and Muscular Endurance

Only shoulder flexion ROM decreased with increasing age, while age showed no effect on all other dependent measures. These findings are consistent with other research on the impact of age on ROM changes, with no changes noted in a study of 90 women under the age of 60,[81] and a decline in flexion motion noted between 2 groups of women aged 50-69 and over 70.[90] The findings in this study suggest that the decline in shoulder flexion ROM may occur in latter decades. Furthermore, the mean values for active ROM for shoulder flexion (148°-159°) in this study are consistent with other studies using goniometry.[78,79] Our use of digital photography and software to measure precise angles resulted in high reliability and low measurement error, but is essentially the same process as traditional goniometric measurement.

A minimum of 120° of shoulder flexion is required to complete UE functional tasks such as hair care, bathing, feeding, and most reaching tasks, [76,91] and 148° is the threshold required to reach high shelves.[92] All mean flexion values in this study were 148° or greater. These values indicate that in this sample women appear to retain the flexion motion necessary to complete even higher level UE functional tasks. Trends toward declining flexion motion over time have been suggested by other researchers,[78,81,90] and these changes may impact function. Younger participants in this study showed greater flexion values, providing them with approximately 15-20% reserve capacity in motion should any shoulder pathology result in a decline in flexion motion, while older participants have less reserve capacity available before ROM loss impacts function. Awareness of this trend is important to consider when presenting with an UE pathology.

Although data are not available on typical HBB distance among a healthy population, the mean value of the HBB measure in this study indicates greater mobility than is seen in pathological populations;[26,49] no study has previously examined change in HBB with aging. Comparison of the HBB to other studies investigating IR ROM is difficult as the measures are not identical. Internal rotation measured using HBB is commonly used clinically and mimics functional tasks such as donning/doffing a bra or tucking in a shirt. We selected this method to improve reliability of our measure as stabilizing the scapula for pure glenohumeral internal rotation was found to be difficult between multiple examiners. It should be understood that measuring the distance from C7 to the tip of the thumb represents more than shoulder internal rotation; it also incorporates shoulder extension and scapular mobility,[49] yet remains a useful functional description of

shoulder motion, and is considered a more accurate measure than identifying vertebral level of hand placement.[27] As the minimum distance of the HBB measure required to complete functional tasks has not been established, it is difficult to identify at which point a lack of motion might interfere with UE function. The clinician, then, should combine the measurement with functional abilities questions to determine whether a lack of motion is impacting function.

The mean values of ER ROM (92°-97°) of this study sample are consistent with other research,[78,79] but literature is inconsistent in terms of increases or decreases with rotation motion over time.[79,90] Minimum values of ER motion to complete functional tasks such as placing items on shelves, hair care, and opening doors require no more than approximately 60°.[91] All participants demonstrated ER in excess of 90°, indicating no functional loss of ROM is present in this sample. Furthermore, mean values in this study suggest that healthy women ages 30-69 possess a significant buffer of 30% of ER ROM should future pathology limit this motion. In this study, no change in ER was seen with aging, suggesting that everyday UE use is sufficient to retain functional ranges.

Age did not impact any strength measurements of participants in this study. The mean flexion and rotational strength values in this study were lower by approximately 20-50% than those reported by other researchers using hand-held dynamometry,[62,63] however, conflicting results may be attributed to a difference in methodologies. The dynamometer placement for shoulder flexion in one study was just proximal to the humeral epicondyles [62] rather than more distally at the ulnar styloid process as in our study. This change of position shortens the lever arm and subsequently increases force production. The rotation measures were taken at 45° of abduction [63] rather 90° as in our

study. Again, a change in the amount of abduction can change force production. No research has detailed minimum strength measures to complete functional tasks. When examining our strength levels in light of UE function, since participants in this study reported minimal disability or functional decline, it can be construed that the strength measures obtained are adequate to complete most functional tasks.

Muscular endurance does not appear to change across the decades from ages 30 to 69. The mean endurance times for sub-tests 2 and 3 of the FIT-HaNSA in this study are in agreement with previous literature in a healthy population.[28,29] Furthermore, it is interesting to note that in the current study the mean age is 20 years greater than in these published studies. This suggests muscular endurance appears to remain stable with increasing age. As participants in this study reported no significant functional limitations, the mean values reported here indicate this healthy sample has adequate endurance to complete functional tasks.

The Impact of Dominance on Motion, Strength, and Muscular Endurance

The results of this study show that dominance impacts certain motions, but not all. The HBB motion was found to be significantly less for the dominant arm, and although some researchers did not find that dominance had an effect on HBB ROM,[79,81] others have substantiated this difference.[78,90,93] Diminished IR ROM on the dominant limb has been documented in literature related to throwing athletes, and this decline has been attributed to an increase in humeral retroversion, as well as muscular changes resulting from the demands on the limb.[94] In gathering data on the participants in this study, we only examined current activity level but did not investigate what specific activities in which these individuals participated presently or in the past. It is possible that the

decreased HBB measure on the dominant limb may be related to similar physiological changes seen in throwing athletes based on activity participation. Whether less HBB motion on the dominant extremity impacts functional tasks is unclear, however since the self-report of function scores do not indicate any functional deficit, it could be concluded that the difference is not clinically important.

Dominance appears to affect strength only for the shoulder flexion measurement in this study. Other researchers have found that dominance had an effect on both flexion and rotation strength measures,[62,82] while the rotation strength measurements in this study were similar for both dominant and non-dominant limbs. The flexion strength difference between limbs in this study is not likely clinically significant as the difference is small (less than 1% of body weight), and self-report scores do not indicate functional deficits.

Muscular endurance does appear to be affected by dominance. For sub-test 2 of the FIT-HaNSA, participants had significantly greater endurance on the dominant limb when compared to the non-dominant limb. To our knowledge, this is the first study examining the impact of dominance on muscular endurance using the FIT-HaNSA in a healthy population. This dominance effect conflicts with a study of 20 healthy participants (male and female) who completed a unique test of muscular endurance on 2 separate occasions.[95] On the first test session, the non-dominant limb showed greater endurance, but on the second session, the durations were equal.[95] This retest increase in endurance was attributed to effects of motor learning.[95] Further investigation of muscular endurance of the UE will need to occur to determine the impact of dominance, but the findings of this study suggest that dominance must be considered when measuring muscular endurance of the upper extremities.

Limitations and Future Research

This current study had several limitations. By choosing to measure IR ROM by using the HBB measure, we were not measuring pure IR motion, limiting our ability to compare our findings with other research, and our ability to determine whether differences were due to any particular motion. Limited information is available on typical values of HBB in a healthy population, and we lacked data on specific physical activities in which participants engaged, limiting our ability to determine whether sport or activity impacted the HBB measure. The HBB measure, however, remains a functional measure of ability to reach behind the back and is a clinically relevant concern of most patients with upper extremity disorders.

The use of hand-held dynamometry quantifies muscular strength and can be performed easily in the clinic, where manual muscle testing remains subjective. However, the method to stabilize the hand-held dynamometer is important for accurate measurement.[58,59] We attempted to minimize this issue by using a resistant nylon strap and the clinician as the stabilizing force however, it is possible that inaccurate measures were taken resulting in the lack of differences between limbs observed.

Future research should focus on reliable, valid, and clinically feasible methods to measure UE strength with a hand-held dynamometer. Muscular endurance measures across ages needs to be established, and differences based on dominance need to be further explored. Furthermore, the link between objective clinical measures and self-report of function needs to be identified.

Conclusion

The findings in this study show that only flexion motion declines with aging, however, does appear to remain within functional ranges. The decline in the 60+ age range, however, leaves less reserve capacity for loss of motion due to pathology. Strength and muscular endurance appear to remain stable throughout the ages assessed in this study. Dominance plays a role in motion, strength, and muscular endurance. These limb-to-limb differences need to be considered in clinical evaluations. It is often a convenient comparison to measure to the contralateral side using the assumption that limbs are symmetrical, but it appears that in an otherwise healthy population there are some measures that are asymmetrical. Comparisons to typical values or normative data may provide a more accurate assessment of these objective measures of shoulder function than limb to limb comparisons typically done in the clinic.

CHAPTER FOUR

The focus of this chapter is the comparison of upper extremity function between survivors of breast cancer (BCS) and a population of healthy women, using in part data derived from the first study (Chapter 3). Additionally, the differences between the involved and non-involved limbs of BCS, considering whether the involved limb is the dominant limb, will be investigated. Typical levels of self-reported quality of life (QOL) and arm function, and values of shoulder range of motion (ROM), strength, and muscular endurance of BCS will be presented. Differences between BCS and controls, and involved/non-involved limbs are discussed, and the need for more responsive measures of muscular endurance are presented.

Introduction

Functional performance of the upper extremity (UE) includes adequate levels of ROM, strength, and muscular endurance, defined both through the International Classification of Functioning, Disability, and Health (ICF) and the ICF Core Set for breast cancer (BC).[7,13] Persistent complaints of UE functional deficits in long term BCS have been documented,[6,70,73,96-98] but the extent of these deficits and whether they can be attributed to BC treatment or normal aging has not been adequately examined. Specifically, 21% of long term BCS report a decline in UE function measured on the Disabilities of the Arm, Shoulder and Hand (DASH) scale up to 6 years following diagnosis.[17] A 10% decline in ROM has been reported more than 5 years following treatment for BC.[18] Strength declines of 10-15% are reported 1-5 years after treatment.[8,18] These studies have examined UE function in relation to self-report and the contralateral limb, but have not made a direct comparison to a group of healthy women.

These deficits may actually be a result of changes seen with normal aging. It is important for direct comparison of measures of UE function between BCS and healthy women to determine whether existing deficits are due to BC treatment or normal aging.

Muscular endurance, the ability to sustain an activity over time and a necessary component of UE function,[7] has been minimally examined in the BC population. In a study using 90% of 1 repetition maximum (1RM) weight in a repetition to failure activity, no significant differences between involved and non-involved limbs were found,[16] however, using 90% of 1RM may bias strength rather than endurance muscle fibers. A unique test of upper body strength and endurance (UBSE)[14] was used in 2 studies. At 6 months, a 20% deficit in the involved limb of BCS was documented, which declined to 10% but persisted at 18 months.[14,15] These inconsistent findings and limited data on muscular endurance in long term BCS warrants the need for further investigation into UE muscular endurance as a component of UE function.

Subjective self-reported function and objective ROM, strength, and muscular endurance measures of BCS in comparison to a healthy cohort need to be examined in order to identify whether the potential deficits are due to BC interventions or to the normal aging process. The purpose of this study is to determine the extent of UE functional deficits in BCS compared to a population of healthy controls. We hypothesize that BCS will have lower levels of self-reported QOL and UE function, and ROM, strength, and muscular endurance compared to women without a history of BC. A secondary aim is to examine differences between the involved and non-involved limb of BCS who are at least 12 months post treatment, also considering dominance. We

hypothesize that the involved limb will have less motion, strength and endurance compared to the non-involved limb in BCS.

Methods

Subjects: A sample of convenience of 50 BCS agreed to participate in this study. To be included in this study, participants had to be between the ages of 30 and 69, and have received at least one of the following BC treatments: mastectomy, axillary lymph node dissection (ALND), axillary radiation. All treatments had to be completed 12 months or more from the date of testing. Participants were excluded if they had recent (6 month) history of shoulder, cervical or thoracic spine pathology diagnosed by a physician, or a history of shoulder, cervical or thoracic surgery. All participants read and signed an approved consent form prior to starting the study. The consent form was approved by the Institutional Review Boards of the University of Kentucky, Lexington, Kentucky, the University of Dayton and Miami Valley Hospital, Dayton, Ohio. One participant with breast cancer was excluded after screening revealed she had undergone rotator cuff surgery on her involved side prior to the cancer diagnosis. Two other BCS were excluded after clarification that the radiation received was local to the tumor site and not the axilla. Additionally, 5 BCS had been diagnosed with bilateral BC, and were excluded as limb to limb comparisons could not be made. Forty-two BCS are included in the final analyses. Data from the initial study describing typical values of UE function among women without breast cancer (Chapter 3) were used for comparison. Women who had not had breast cancer ages 30-39 were excluded from final analysis for comparison as no breast cancer survivors in the same age range were recruited with a resulting 59 women without breast cancer.

Procedures: Each participant came one time to the clinical laboratory for data collection. Measurements were taken by three investigators trained in landmark identification for ROM measures, use of a hand-held dynamometer for strength assessment, and in administering the Functional Impairment Test – Hand and Neck, Shoulder, Arm (FIT-HaNSA). The FIT-HaNSA demonstrates good-excellent reliability,[24] and ranges from .89-.99.[28,29]

Participants completed all self-report forms prior to other components of the testing. Demographic variables of age and arm dominance were recorded, and height in meters and weight in kilograms to the nearest tenth were measured and recorded to determine BMI.

Dependent Variables

Self-Report Scales

Activity level was measured the 7-item International Physical Activity Questionnaire (IPAQ), which has good test-retest reliability (Spearman correlation coefficients .70-.90).[84] Quality of life was measured using the Functional Assessment of Cancer Therapy – Breast (FACT-B), which has good construct validity (r=.90) and test-retest reliability (ICC=.88).[33] This scale is comprised of 27 questions making up the FACT-G (General cancer quality of life scale) plus 9 additional items specific to breast cancer for a score of ranging from 0 to144; higher values indicate a higher quality of life. Self-report of UE function was measured by the Upper Extremity Functional Index (UEFI), a 20 item questionnaire with score ranging from 0 to 100, 100 indicating the highest level of function,[38] and the DASH, a 30 item disability scale scored 0 to 100, with lower scores

denoting less disability. Both measures have been found to be reliable and valid tools in the evaluation of UE function.[38-40]

Objective Clinical Measures:

Range of Motion: Bilateral active ROM of shoulder flexion, hand behind back (HBB), and external rotation (ER) were measured by taking a photograph of the participant completing the motion. ImageJ software (National Institutes of Health, Washington DC) was employed to calculate measurements. This method of measuring ROM was chosen because multiple investigators were utilized for data collection, and initial pilot testing with digital inclinometry produced unacceptable inter-rater reliability levels. Inter-rater reliability of landmark identification for ROM was established with further pilot testing and interclass correlation coefficients (ICC) ranged from .90- .99. The ICC for intra-rater reliability of digital measurement of ROM with ImageJ was consistently >.95, with a standard error of measurement of less than 2°.

Landmark identification was completed prior to photographing of the motion. For shoulder flexion, two dots were placed along the midshaft of the humerus aligned with the greater tuberosity and lateral epicondyle of the humerus, and two additional dots were placed along the midline of the thorax.[85] Active shoulder flexion was measured by instructing the participant to elevate her arm as high as possible in forward flexion. To form the shoulder flexion angle, a line was drawn bisecting the two points demarking the midshaft of the humerus, and another was drawn bisecting the two points of the midthorax line; the angle in degrees of the intersection of the two lines was measured.[85]

For HBB, a marker was placed at C7, an easily and reliably palpated structure.[86] The HBB measurement was taken by having the participant reach her hand as high up the

back as possible while standing; a 10cm reference was in the same plane as the participant. This reference line is necessary to provide a spatial scale of the image so that measurement results are in calibrated units, and addresses the issue of perspective.[87] Using ImageJ software, the reference distance was measured to set the scale of measurement, and then the distance in centimeters from the C7 spinous process to the spinous process in line with the tip of the thumb was recorded; a lower value indicates greater motion.[27]

For ER, a dot was placed at the olecranon process and another at the ulnar styloid process.[85] Active shoulder ER was measured with the participant lying supine with the shoulder abducted and elbow flexed to 90° with the elbow resting on two towels to approximate the plane of the scapula. The participant was instructed to externally rotate her arm as far as possible. The ER angle was formed by a line drawn through the shaft of the ulna and a line perpendicular to the plinth. Two trials for each motion and each extremity were recorded, and the mean of these values was calculated.

Strength: The strength of the shoulder flexors, internal and external rotators was measured by hand-held dynamometry (Lafayette Manual Muscle Test System, Lafayette Instruments, Lafayette, IN). An inelastic 2" wide nylon strap was placed around the participant's wrist for each motion to provide a consistent, immovable resistance for the hand-held dynamometer. Each participant was instructed to generate force to a maximal level over 5 seconds in each direction of testing.[7,63] Two submaximal practice trials were completed prior to testing, followed by 3 trials with 10 seconds rest in between. The average of the 3 trials was used for later statistical analysis.[54] Shoulder flexion was measured with the participant seated, arm elevated to 90°.[51] To measure IR and ER, the

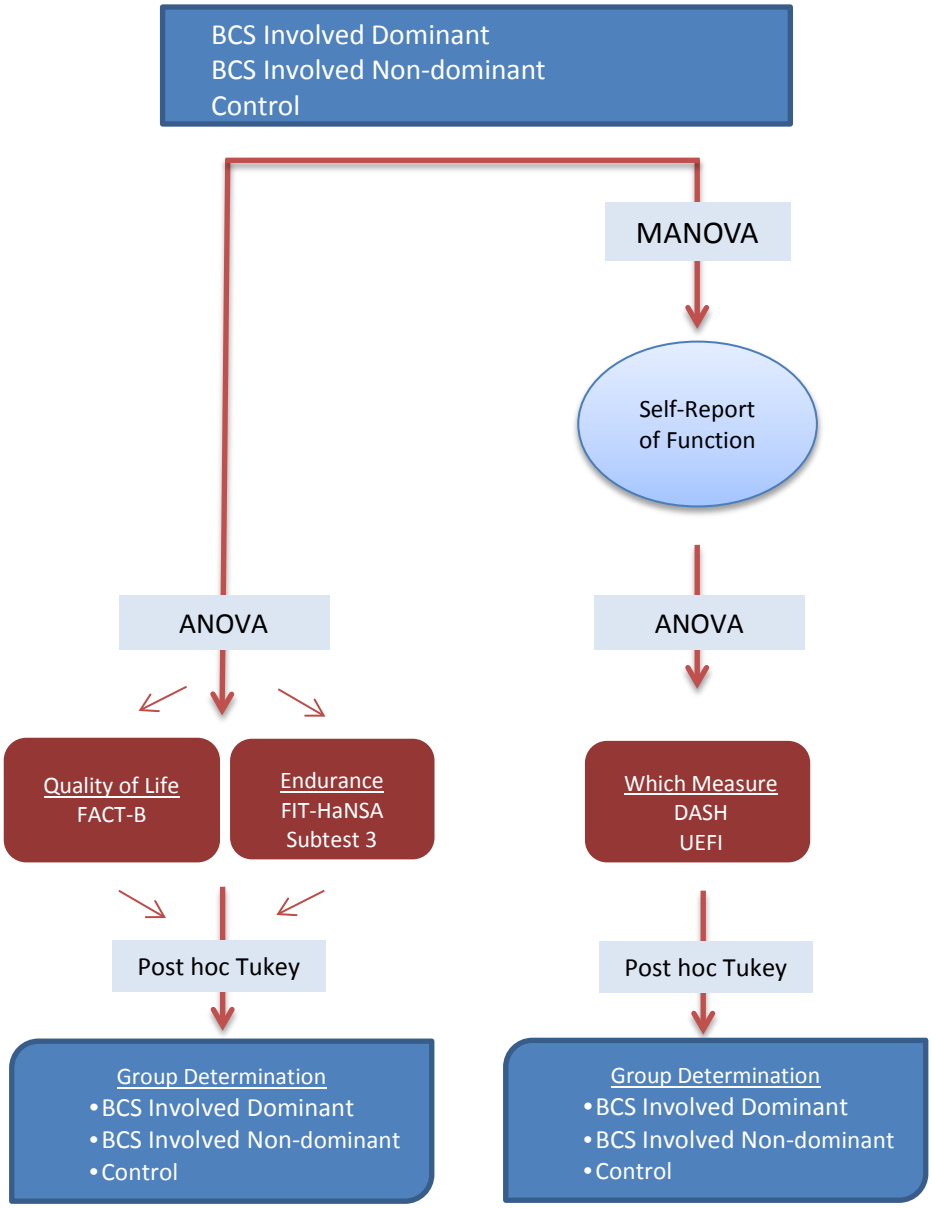
participant's upper arm was supported on two towels while lying supine with the arm at 90° of abduction and 90°elbow flexion.[51] In pilot testing, the ICCs for inter-rater reliability for strength measures ranged from .78-.80, and the standard error of measurement was consistently below 1.2%. Strength was normalized to body weight and is presented as a percentage of body weight (kg of force/body weight in kg).

Muscular Endurance: Upper extremity muscular endurance was measured by using the FIT-HaNSA sub-tests 2 and 3 following a previously established protocol for performance and termination of testing.[29] The FIT-HaNSA demonstrates good-excellent test-retest reliability (ICC=.79-.97), and moderate concurrent validity (r=.71-.76) with self-reported UE functional scales.[28,29]

Statistical Analysis

Data were analyzed using IBM SPSS Statistics 19 (New York, NY). Descriptive statistics were calculated for all variables of self-reported QOL and function, ROM, strength, and muscular endurance for each group. To confirm that the characteristics of each group were similar, independent samples t-tests were used to analyze age, BMI and activity level.

Whether the dominant or the non-dominant limb was the involved limb in BCS had to be considered prior to data analysis. This is based on findings from previous research in Chapter 3 which show that dominance has an effect on at least one measure in ROM, strength, unilateral muscular endurance tasks. Therefore, the BCS group was subdivided into two groups: involved dominant or involved non-dominant. The level of complexity of comparisons resulted in multiple analyses being conducted. (Figures 4.1-4.2) Significance for all analyses was set *a priori* at $p \leq .05$.



BCS = Breast Cancer Survivor
ANOVA = Analysis of variance
MANOVA = Multivariate analysis of variance
ROM = Range of motion
FACT-B = Functional Assessment of Cancer Therapy – Breast
FIT-HaNSA = Functional Impairment Test – Hand and Neck, Shoulder, Arm
DASH = Disabilities of the Arm, Shoulder, Hand
UEFI = Upper Extremity Functional Index
HBB = Hand Behind Back ROM
IR = Internal Rotation Strength
ER = External Rotation

Figure 4.1a: Statistical Analyses for Between Group Comparisons; All 3 Groups

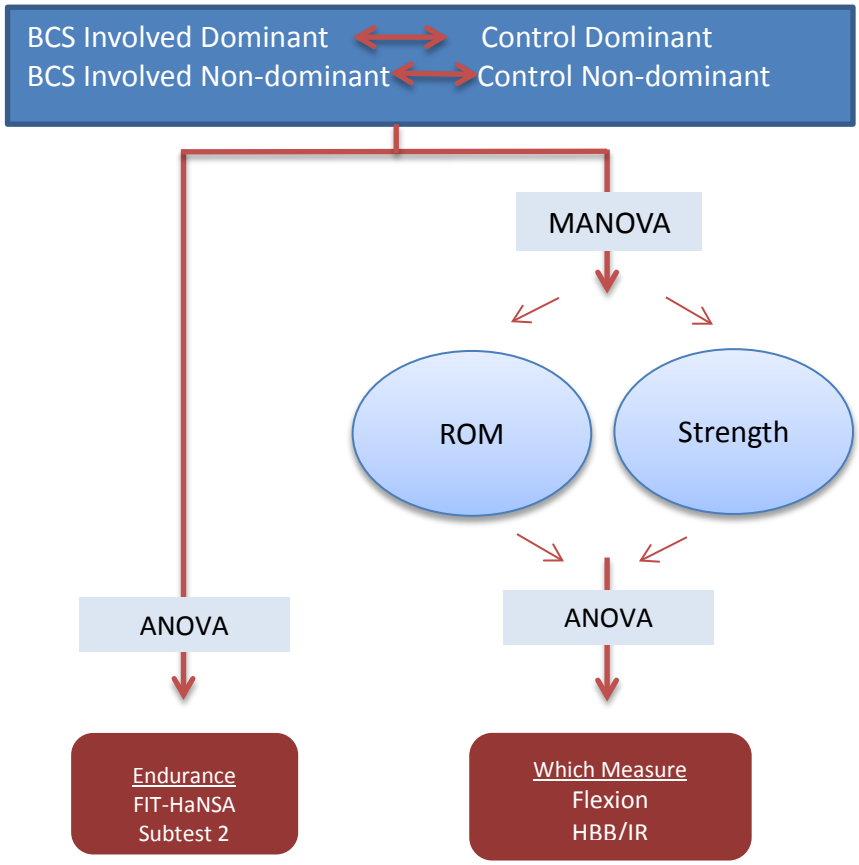


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Figure 4.1b: Statistical Analyses for Between Group Comparisons; Limb to limb Comparisons

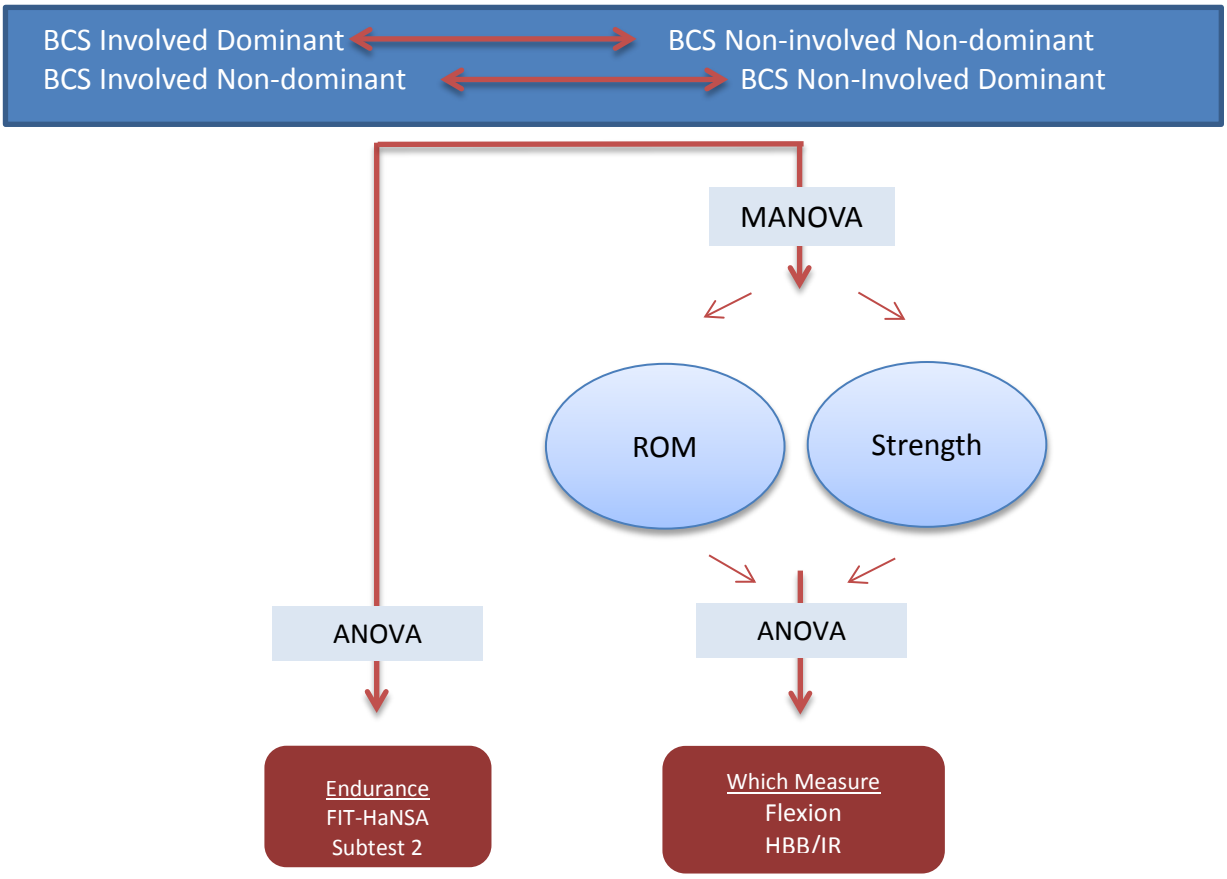


Figure 4.2: Comparison of Involved to Non-involved Limbs of BCS

Comparison between the BCS and Control Group

We first analyzed the FACT-B scores and sub-test 3 of the FIT-HaNSA, (a bilateral task) using two separate ANOVAs, with three groups: BCS involved dominant, BCS involved non-dominant, and control group. If significance was found, *post hoc* testing with Tukey's was used to determine for which group significance was found.

Direct comparisons of the involved limb of BCS to the respective limb of the control group were necessary for the FIT-HaNSA sub-test 2, a unilateral endurance task. Two separate ANOVAs were performed comparing BCS involved dominant limb to the dominant limb of the control group, and BCS involved non-dominant limb to the non-dominant limb of the control group. With only 2 groups being compared, no *post hoc* testing was necessary.

To compare differences in self-report of function between the BCS and control group, a MANOVA was used because the comparison involved two related measures (UEFI and DASH), and three groups (BCS involved dominant, BCS involved non-dominant, and control). If significance was found, a subsequent ANOVA was performed to determine which measure was involved. Significant differences on the ANOVA were analyzed *post hoc* with Tukey's to determine for which group significant differences existed.

The dependent variables ROM and strength each had 3 measures (flexion, HBB/IR, ER) on 2 limbs (dominant and non-dominant); therefore results could be related. Consequently, the MANOVA model was used assessing these potential relationships. Four separate MANOVAs were used to compare the involved limb of BCS to the respective limb of the control group: ROM dominant, ROM non-dominant,

strength dominant, and strength non-dominant. Direct comparisons were made between the involved dominant limb of BCS to the dominant limb of control group, and the involved non-dominant limb of the BCS to the non-dominant limb of the control group. In the presence of a significant difference in these variables, ANOVAs were carried out to determine for which specific variable differences existed. As only 2 groups were involved, either BCS involved dominant and the dominant limb of controls, or BCS involved non-dominant and the non-dominant limb of controls, no *post hoc* testing was needed.

Figure 4.1 details the analyses performed comparing BCS to the control group.

BCS Involved to Non-involved Comparison

Because dominance may impact some dependent measures, the BCS group subdivisions were maintained: involved dominant and involved non-dominant. To compare involved and non-involved limb in BCS, the change score of the involved limb minus the non-involved limb was calculated for all measures of ROM, strength, and muscular endurance (FIT-HaNSA sub-test 2, only). The affected limb, dominant or non-dominant, was considered as a fixed factor in comparisons. Significance was set *a priori* at $p \leq .05$ for all analyses. Figure 4.2 details these analyses.

The ANOVA model was used to compare the change score on sub-test 2 of the FIT-HaNSA. Two separate MANOVAs were used to compare ROM and strength variables. In the presence of a significant difference in these variables, ANOVAs were carried out to determine for which specific variable differences existed. No *post hoc* testing was necessary for 2 group comparisons.

Results

Participant demographics of age (p=.50), body mass index (p=.53) and activity levels were similar. (Table 4.1) Among BCS, the mean duration since surgical treatment was 69 months (range 12-241); 31 underwent a mastectomy, 20 underwent ALND, and 13 had axillary radiation. Of these, 11 BCS had both a mastectomy and ALND, and 6 underwent all three procedures.

Comparison Between the BCS and Control Group

Quality of life measured by the FACT-B was statistically significantly lower among BCS compared to the control group (p=.040). (Table 4.2) Post hoc testing showed that this was the case for women whose BC was on the non-dominant limb (p=.050), with mean values for BCS (108±17.4) lower compared to the control group (124.7±30.7).

The MANOVA was significant for self-report functional measures (p<.001), with the subsequent ANOVA showing both UEFI and the DASH were significant at p<.001. *Post hoc* testing revealed BCS report lower levels of UE function and higher levels of UE disability than the control group, regardless of whether the involved limb was on the dominant or non-dominant side. (Table 4.2)

For ROM measures comparing the involved limb of BCS to the respective limb of controls, MANOVAs were significant for both dominant and non-dominant ROM. For dominant limb ROM, both flexion (p=.01) and ER (p=.03) ROM were less in the BCS group than the control group. When the non-dominant limb was the involved limb, all 3 ROM measures, flexion (p=.001), HBB (p=.01), and ER (p=.01) ROM were less in the BCS group compared to the control group. (Table 4.3)

Strength measures were significantly lower in BCS only when the non-dominant limb was the involved limb. Non-dominant IR (p=.004) and ER (p=.004) strength were less among BCS when compared to the control group. (Table 4.4)

Muscular endurance measured by the FIT-HaNSA was not different between BCS and the control group. The mean of control group and BCS for sub-test 2 on the dominant limb was 270±57sec and 248±84sec, respectively (p=.18), and for the non-dominant limb, the mean for the control group was 263±68sec, and BCS 244±70sec (p=.30). The mean of the control group for sub-test 3 was 281±45sec, and for BCS it was 271±61sec (p=.61).

BCS Involved to Non-involved Comparison

MANOVA results of the involved to non-involved limb were statistically significant different for ROM only (p<.001); all other dependent variables were not significantly different for strength measures (p=.35), and sub-test 2 on the FIT-HaNSA (p=.07). Subsequent ANOVA testing on ROM revealed that HBB and ER were significantly different between the involved and non-involved sides. In examining the specific direction of differences, these findings indicate that the dominant limb had on average 3 cm less HBB motion than the non-dominant limb, regardless of BC involvement (p<.01). Similar results were observed for ER ROM (p=.03*)*. In those women who had BC on their dominant side, ER was 4° greater than on the non-involved non-dominant side. Among BCS with BC on the involved non-dominant side, dominant ER was 5° greater on the dominant non-involved side. Dominant ER ROM was greater regardless of which side BC occurred.

Table 4.1: Baseline Characteristics (mean (SD))

	Age, years	BMI	IPAQ (mets)
Control (n=59)	54 (8)	26.8 (5.4)	3190 (2926)
BCS (n=42)	56 (8)	27.9 (6.3)	3260 (4056)

Abbreviations: BMI = Body Mass Index; IPAQ = International Physical Activity Questionnaire

Table 4.2: Self-Report Scores (mean (SD))

	FACT-B	**UEFI**	**DASH**
Control (n=59)	124.7 (30.7)	98.1 (3.2)	3.3 (4.6)
BCS Involved Dominant (n=23)	114 (16.2)	91.2 (9.7)	11.5 (11.3)
BCS Involved Non Dominant (n=19)	108 (17.4)	89.9 (11.7)	10.3 (13.4)

Abbreviations: FACT-B = Functional Assessment of Cancer Therapy, Breast; UEFI = Upper Extremity Functional Index; DASH = Disabilities of the Arm, Shoulder, Hand

Table 4.3: Range of Motion (mean (SD))

	Flexion		Hand Behind Back		External Rotation	
	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
Control	152°(9)	153°(9)	17cm (4.5)	13.5cm (4)	95°(9)	94°(7)
BCS	146°(13)	142°(18)	18cm (5.6)	16.9cm (6.4)	89°(11)	87°(14)

Control n = 59, BCS Involved Dominant n = 23, BCS Involved Non-dominant n = 19.
For BCS, all motions are on the involved limb only.

Table 4.4: Strength (% Body Weight) (mean (SD))

	Flexion		Internal Rotation		External Rotation	
	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
Control	9.3 (3)	8.7 (3)	14.3 (4.5)	14.2 (4.2)	14.3 (4.2)	14.3 (4.4)
BCS	8.3 (2.6)	7.6 (2.7)	12.9 (4.5)	11 (3.5)	14.6 (5.8)	10.8 (4.7)

Control n = 59, BCS Involved Dominant n = 23, BCS Involved Non-dominant n = 19.
For BCS, all strength measures are on the involved limb only.

Discussion

This study compared self-reported QOL and UE function levels, and objective measures of function limited to shoulder ROM, strength, and muscular endurance in BCS and healthy controls. This study was unique in that it directly compared BCS to a group of healthy women, considering limb dominance. These comparisons have been minimally investigated among long term BCS. We hypothesized that BCS would have lower levels of self-reported QOL and UE function, and objective measures of motion, strength, and muscular endurance than a sample of women without BC, which was true for most but not all variables. Women treated for BC report lower QOL levels, lower UE function and higher disability, and demonstrate less overall UE ROM, and less IR and ER strength, than a sample of women without breast cancer. We expected that long term BCS would have lower objective measures of ROM, strength, and muscular endurance on the involved limb compared to the non-involved limb but this was not found to be true in this sample. Range of motion results indicated differences were due to arm dominance, rather than the impact of BC treatments.

Comparison Between the BCS and Control Groups

Among women whose BC occurred on the non-dominant limb, statistically lower values of QOL were reported compared to the control group, suggesting that this subgroup of BCS may have more difficulty returning to a level of QOL similar to healthy counterparts. Only one study examined the impact of the whether the cancer occurred on the dominant or non-dominant side on QOL, and in a study of 59 BCS with lymphedema, QOL was not associated with side of cancer.[99] The sample population in this current study did not have lymphedema, perhaps accounting for a difference in findings. Yet,

when examining the levels of QOL and objective measures of function among BCS, those with cancer on the non-dominant limb not only have lower QOL levels, but also consistently demonstrate statistically significantly lower ROM and strength than a sample of healthy women. These findings may indicate that in this sub-population of BCS, return of function and QOL may not reach the same levels as when cancer occurs on the dominant limb, perhaps because the non-dominant limb is not used as frequently. The effects of dominance on QOL need further investigation.

Self-report of UE function on both the DASH and UEFI were statistically significantly lower among BCS compared to levels reported by a healthy sample, however the values are not clinically significant. Although the mean values of the DASH for BCS in this study were similar to a study of 53 BCS who underwent a mastectomy at least 12 months prior to measurement (range: 10.12 ±9.39 - 12.97 ±11.6),[100] they are lower compared to reports of BCS 6 months after treatment whose mean DASH score was 19.4 ±17,[9] suggesting that there is a perceived return of function occurring over time. In evaluating our results in comparison to those of a general population, BCS report similar levels of function. The mean DASH score of a general population sample of 1706 adults was 10.1±14.7,[45] and among 327 healthy women age 18-65 was 14.3±14.9.[46] The mean score on the DASH among BCS 6 years after treatment in this study are approximating these cited values, and indicate that recovery of function to normal ranges can occur with adequate time.

Nearly all ROM measures in BCS were impaired by 5-10% compared to a healthy sample even at 6 years post-treatment. Only the HBB measure on the dominant involved side was not significantly diminished, and even in a healthy population, there appears to

be limited IR motion on the dominant side compared to the non-dominant side.[94] The mean shoulder flexion motion among BCS in this study is 11-15° less than that reported among BCS within the first 6 months after treatment,[9] suggesting that shoulder flexion ROM loss may continue past one year. Although none of the motions declined to what is generally accepted as clinically significant level, a minimum range of 148° of shoulder flexion is necessary for reaching a high shelf.[92] A secondary analysis of BCS with motion less than 148° revealed that 25 of 42 (60%) participants of this sample did not have this level of motion available on the involved limb, and 9 of the 25 (36%) reported moderate to severe difficulty in reaching an overhead shelf on their DASH self-report form. A Chi square analysis however, revealed no significant relationship between loss of motion and self-report (p=.08). The HBB and external rotation motions, although statistically significantly less among BCS, would not be considered to be clinically deficient. All functional UE tasks can be completed with minimal to no difficulty at the measured HBB and ER ROM levels. Overall, although ROM is significantly less among BCS in this study, the values are not clinically relevant, with only a portion of the sample demonstrating a limitation in one specific functional task. BCS at 6 years following treatment generally demonstrate ROM at a level similar to their healthly counterparts.

Loss of strength was found to primarily affect BCS who had cancer on their non-dominant side. Strength impairments in IR and ER show a 23-25% deficit compared to a population of women without a history of BC. Additionally, the values of IR and ER strength of BCS in this study are more than 30% less than published reference values for a healthy population of similar aged females.[62,63] Although methodologies for measurement differed slightly (flexion resistance at the epicondyle instead of distally at

the ulnar styloid process,[62] and rotation positioning at 45° abduction instead of 90° abduction[62,63]), the deficits appear greater than expected through differing methodologies. Whether these deficits can be definitively linked to a decline in UE function is less clear, as minimum strength values for completing tasks are difficult to define. As DASH scores were within normal ranges, that most strength measures among BCS in this study appear to not be impaired. Overall, BCS demonstrate levels similar to those of women without breast cancer.

BCS Involved to Non-involved Comparison

Our hypothesis that ROM, strength and muscular endurance in the involved limb would be less than the non-involved limb was not supported. Although both rotation motion measures, HBB and ER ROM, were statistically significantly different, the results showed that dominance was the effect rather than whether the limb underwent BC treatment. Dominant limbs had less HBB motion and greater ER ROM than non-dominant limbs regardless of cancer status, a finding in agreement with other research examining the effect of dominance on shoulder rotation motion.[93] Muscular endurance appeared to recover to levels of the non-involved limb in this sample of BCS 6 years following treatment, and these findings are in agreement with a study of 40 BCS approximately 2 years after treatment who demonstrated similar levels of endurance on the involved and non-involved limbs.[16]

It appears that over time, BCS regain motion, strength, and muscular endurance to similar levels of the non-involved limb. In previous work among a healthy cohort of women, dominance impacted the HBB measure, flexion strength, and muscular endurance measured on sub-test 2 of the FIT-HaNSA (see Chapter 3). The cohort of

BCS did not have greater flexion strength and muscular endurance on their dominant limb. This could suggest that when BC occurs on the dominant side, the recovery may not be complete. Because there are no significant limb-limb differences in BCS as would be expected, when cancer occurs on the non-dominant side, our results suggest a decline occurs in these measures on the non-involved dominant limb. These findings can be explained in part by a recent study examining three-dimensional shoulder kinematics and EMG muscle activity among a group of 155 BCS with unilateral cancer approximately 3 years after treatment (47 participants underwent mastectomy, and 48 axillary lymph node dissection and/or axillary radiation).[101] The BCS were compared to 21 age-matched healthy women. The authors concluded that all kinematic parameters were abnormal and EMG output was less among BCS compared to healthy counterparts.[101] That both the involved and non-involved limbs in this study differed from a healthy cohort but not from each other substantiate that the BC treatment effects can extend into the non-involved limb. These findings support the need to make clinical comparisons of motion and strength beyond the non-involved side but should be evaluated against a healthy population to better assess the level of dysfunction.

The Importance of Muscular Endurance Assessment

Research on muscular endurance among BCS is in the early stages. Two published studies that have examined this aspect of UE function have used a test which does not yet have established reliability and validity, yet has shown a decline in endurance compared to the non-involved limb.[14,15] The current study is the first study to examine the use of the FIT-HaNSA in a population of BCS. Although the findings in this study show that UE endurance is not impaired compared to a similar healthy population,

the mean scores on sub-test 2 and 3 of the FIT-HaNSA among all the participants in this study compare similarly to a study of 17 younger (mean age 32) individuals with shoulder pathology.[29] This would suggest there are some deficits in endurance but that they appear to be an aging effect not a result of the breast cancer. It is also possible that no differences between groups were found because this test demonstrated a low level of responsiveness with large variances among groups. Furthermore, a large ceiling effect was observed in performing the FIT-HaNSA. Sixty-six to eighty-one percent of the control group completed the full test duration of 300 seconds and 53-76% of BCS completed the full test. Examining muscular endurance with a more responsive test might provide a clearer picture of the level of muscular endurance among BCS.

Limitations

Several limitations in this study may have impacted the results. No information about whether the BCS in this study had previous rehabilitation was collected. It is possible that this group had interventions directed toward UE functional return. The range of time after BC treatment was long (12-271 months). This lengthy time period may allow normal tissue healing to occur. A longitudinal study analyzing at what point in time after treatment BCS symptoms improve may give insight into the probable timeline for return of function. The variance associated with the FIT-HaNSA was large (>60 seconds), indicating that this measure was not as responsive in identifying those with decreased endurance as is preferred. Furthermore, the significant ceiling effect of greater than 50% of all participants finishing the complete test does not allow for discrimination between levels of muscular endurance.

Identifying why women who have BC on their non-dominant limb have greater long term deficits need to be accomplished. Determining why BCS seem to have a carryover loss in function on their non-involved limb is also important to investigate and focus rehabilitation efforts. Better clinical measures of muscular endurance, those which are less variable in responsiveness and without a significant ceiling effect, need to be investigated. Together, answering these questions can guide early rehabilitation to prevent long term problems.

Conclusion

The findings in this study suggest that the self-reported level of QOL and UE function among BCS is lower than women without BC even at 6 years following treatment. The primary objective limitations were lower ROM measures among BCS than a control group. This loss of motion may have potential implications on functional tasks. The differences between BCS and a control population on self-report scales, combined with objective measures of UE function, indicate a lower level of UE function among long term BCS. An interesting yet unexpected finding was the effect dominance plays in BCS UE function. Those found to have BC affecting their non-dominant side appear to have more persistent ROM and strength deficits compared to BCS affecting their dominant side.

CHAPTER FIVE

A modification of a clinical test used to measure upper body strength and endurance is presented in this chapter. The experimental design, including participant selection, dependent measures, data collection procedures and analysis, results, and discussion of findings, are presented here. The modified Upper Body Strength and Endurance test will be used to examine muscular endurance in healthy women and women who have been treated for breast cancer. The new test will be compared to the Functional Impairment Test – Hand and Neck, Shoulder, and Arm, to determine whether it is a more responsive and therefore better clinical tool to measure UE muscular endurance.

Introduction

Muscular endurance is an essential component of upper extremity (UE) abilities, and is one component of UE function within the body structure and function domains of the International Classification of Functioning, Disability and Health (ICF).[7] Few options exist for the clinician to measure UE muscular endurance, and as a result, it is not often tested. Options include using an isokinetic testing device, the Functional Impairment Test – Hand and Neck, Shoulder, and Arm (FIT-HaNSA),[29] or the Upper Body Strength and Endurance Test (UBSE).[14]

Clinically feasible measures of muscular endurance must be easy to perform, take a reasonably short amount of time to complete, and require minimal specialized equipment. Furthermore, these tests should demonstrate sound psychometric properties including reliability, validity, and responsiveness. Responsiveness is defined as the ability to measure important difference between groups.[102] Isokinetic testing, which has good psychometric features, can be time intensive and requires expensive equipment. The

FIT-HaNSA has demonstrated good reliability (ICC=.79-.97)[28,29] and convergent validity(r=.76),[28] in research focusing on rotator cuff and shoulder impingement pathology.[28,29] Testing requires an adjustable shelving unit and up to 15 minutes of time to test one limb. The FIT-HaNSA has not been used to our knowledge in published research for BCS, however, previous research (Chapter 4) suggests that there is a large ceiling effect for BCS. This ceiling effect indicates the test may not be demanding enough. Large variances were present as well, indicating a lower level of responsiveness. The UBSE was introduced to capture the strength and muscular endurance in BCS.[14,15] This test is easy to perform, requires minimal equipment, but can be time consuming; the total test time varies based on and individual's fatigue level, but with several stages, can take over 15 minutes. Data on the psychometric properties of the UBSE are not available from the literature.

A responsive, easy to execute, and reliable test of UE muscular endurance is needed to assess this component of UE function. The purpose of this study is to compare muscular endurance among BCS who completed treatment a minimum of 12 months earlier, to matched controls. The hypothesis is that BCS will demonstrate lower levels of muscular endurance than a group of women without BC. A secondary purpose is to investigate a modification of the Upper Body Strength and Endurance test (mUBSE) for clinical use in the measurement of muscular endurance. It is expected that the mUBSE will be less variable compared to the FIT-HaNSA, and demonstrate a greater challenge to muscular endurance.

Methods

Subjects

A sample of convenience of 18 BCS and 18 matched participants without BC agreed to participate in this study. To be included in this study, participants had to be between the ages of 40 and 69; BCS had to have received at least one of the following BC treatments at least 12 months prior to data collection: mastectomy, axillary lymph node dissection (ALND), axillary radiation. Participants were excluded if they had recent (6 month) history of shoulder, cervical or thoracic spine pathology diagnosed by a physician, or a history of shoulder, cervical or thoracic surgery. Participants were matched on age and body mass index (BMI). All participants read and signed a consent form approved by the Institutional Review Board of the University of Dayton, Dayton, Ohio, prior to starting the study. One BCS and one control participant were removed from analysis as no participants who matched on age and BMI were recruited.

Procedure

Each participant came one time to the clinical laboratory for data collection. After consent was signed, demographic variables of age and arm dominance were recorded, and height in meters and weight in kilograms to the nearest tenth were measured and recorded to determine BMI. Heart rate was taken for a baseline measure; this was repeated before and after each endurance test. Each participant then completed a 5 minute warm-up on the treadmill, with 1 pound wrist weights. Participants were instructed to walk at a comfortable pace and swing their arms to include UE muscular warm-up.

Following warm-up, the participant was instructed in testing procedures, including maximal voluntary isometric contraction (MVIC) testing using a hand-held dynamometer. Strength testing was performed at 6 different time points during the testing. At each time point, 3 trials of MVIC were recorded and averaged. The first 2 testing trials were utilized for familiarization and baseline assessment. The trial which had the greatest mean and had less than a 10% coefficient of variance was then used for comparison of later strength testing for muscle recovery. The second trial was used as baseline 65% of the time.

Estimated 1 repetition maximum (1RM), a submaximal repetition test, was used to determine a 1RM value. Each participant was given a heavy load, and the number of repetitions correctly performed was counted. The estimation is based on the following formula where *x* is the number of repetitions completed:[23]

$$\text{Estimated 1RM} = \text{weight lifted}/(1.0278-.0278x)$$

Endurance testing was randomized such that either the FIT-HaNSA or the mUBSE was completed first. After completing each endurance test, the participant was asked to rate her level exertion using the Borg CR-10.[103] A 25 minute minimum rest break was given between the endurance testing procedures to allow for muscle recovery.[104] During this time, participants completed 5 self-report questionnaires. After 25 minutes, a brief warm-up of the UE was completed prior to the final endurance test. To be able to begin endurance testing, the strength measurement had to reflect a value of at least 90% of baseline to ensure that muscle recovery had occurred.[104] If the participant could not achieve this 90% level, additional rest and/or warm-up was provided, until the

90% level could be reached. Heart rate was taken, and if it had not returned to baseline, further rest was also provided.

In a pilot study of 5 healthy females, data on 10 limbs was collected to assess test-retest reliability. MVIC strength testing and the mUBSE demonstrated acceptable reliability, ICC=.76 and .75 respectively.

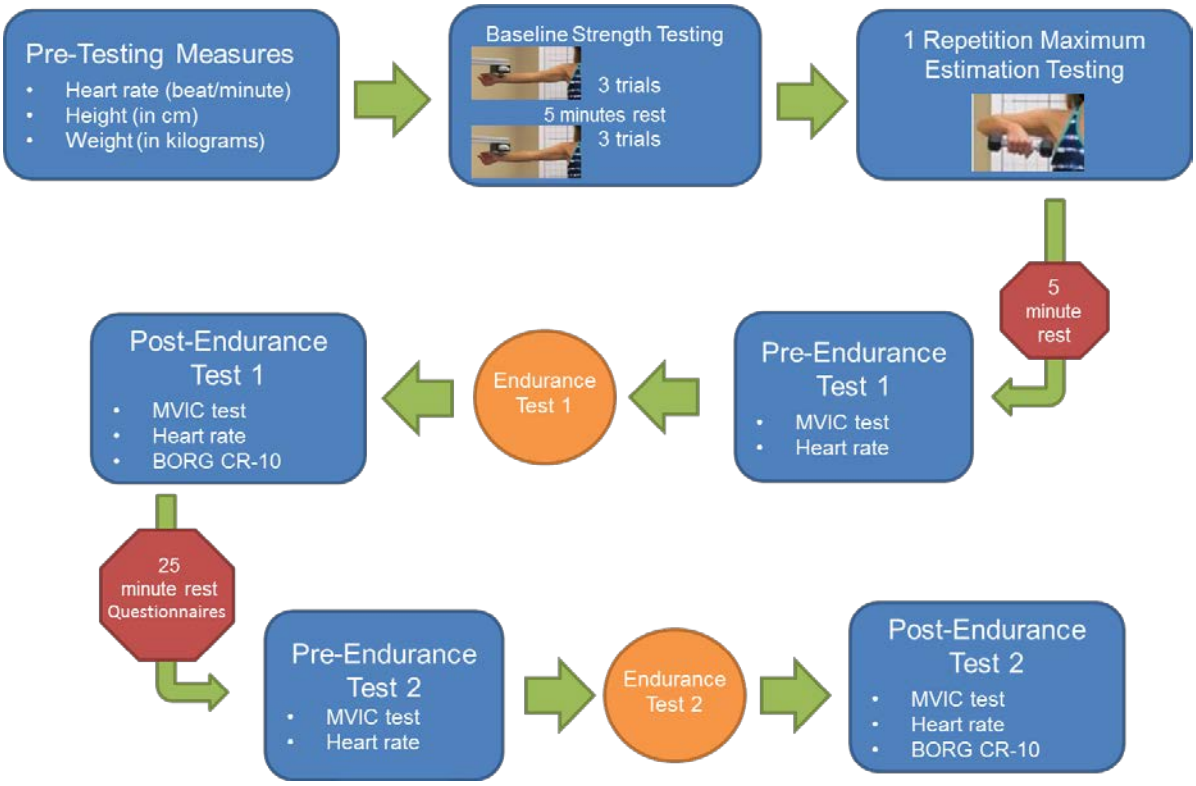


Figure 5.1: Data Collection Procedure

Dependent Variables

Self-report Scales

Activity level was measured using the 7-item International Physical Activity Questionnaire (IPAQ), which has good test-retest reliability (*r*= .70-.90).[84] Quality of life was measured using the Functional Assessment of Cancer Therapy – Breast (FACT-B), which has good construct validity (*r*=.90) and test-retest reliability (ICC=.88).[33] This scale is comprised of 27 questions making up the FACT-G (General cancer quality of life scale) plus 9 additional items specific to breast cancer for a score of ranging from 0 to144; higher values indicate a higher quality of life. Self-reported UE disability was assessed with the Disabilities of the Arm, Shoulder, and Hand (DASH), a reliable and valid[39,40] 30 question disability scored 0-100, with lower scores indicating less disability. The Piper Fatigue Scale, a reliable and valid scale frequently used in the cancer population to assess levels of fatigue resulting from treatment, has 22 scaled questions related to levels of fatigue.[105-107] The scale is scored 0-10, with lower scores indicating lower fatigue.[106] The Physical Activity Assessment Inventory (PAAI) is a new scale intended to assess levels of self-efficacy in relation to physical activity among BCS, scored 0-100 with higher scores indicating higher self-efficacy levels.[108] Preliminary research has shown this scale to be reliable (Cronbach's alpha=.95).[108]

Objective Clinical Measures:

Perceived Exertion: Perceived exertion was measured using the BORG CR-10, a 1-10 scale with higher scores indicating more perceived exertion, with good reliability and validity.[103] Perceived exertion can indicate how strenuous an activity is.[103] The levels of

the BORG CR-10 will be compared after each endurance test to provide information about the tests.

Strength: The strength of the shoulder abduction was measured using hand-held dynamometry. The hand held dynamometer (Lafayette Manual Muscle Test System, Lafayette Instruments, Lafayette, IN) was set in a fixed bracket to ensure consistent resistance for all participants, with the participant seated, and arm positioned at 90° abduction in approximately 30° of the frontal plane.[7] (Figure 5.2) Each participant was instructed to generate force to a maximal level over 5 seconds.[7,63] Two submaximal practice trials were completed prior to testing; 10 seconds rest was given between trials. The peak force produced for each trial was recorded, and an average of 3 trials was used for analysis.[54] Baseline testing included two sessions of 3 trials; the highest average value with ≤10% coefficient of variance was used as the baseline strength measure.

Figure 5.2: Strength Testing Position

Endurance

FIT-HaNSA: Participants completed sub-tests 2 and 3 of the FIT-HaNSA following a previously established protocol for performance and termination of testing.[29] The FIT-HaNSA demonstrates good-excellent reliability,[24] ranging from .89-.99,[28,29] and good convergent validity.[28]

mUBSE: This endurance test modifies the UBSE[14] by removing the stages of incremental increase in resistance. In this modified version, the participant uses 50% of her 1RM estimated weight for the combination upright row/shoulder press motion. This weight is repeatedly lifting through the motion until failure. Criteria for stopping the test include: 1) Participant can no longer continue lifting weight; 2) Participant cannot reach her maximum high point 2 times consecutively; 3) Participant cannot maintain cadence of lift (2 beats up/2 beats down); and 4) Participant demonstrates extremely poor form of lift. The number of repetitions completed is recorded. Each arm is tested separately as pilot testing showed that it was difficult for participants to continue on one arm when the other fatigued which would limit evaluation of limb differences in the BCS group. See Figures 5.3-5.5.

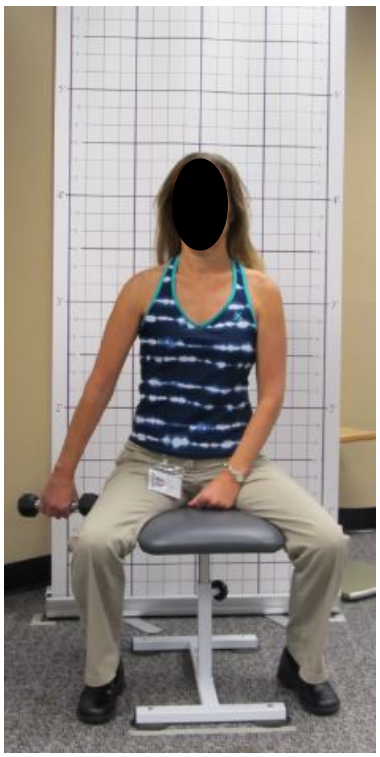


Figure 5.3:
Beginning mUBSE

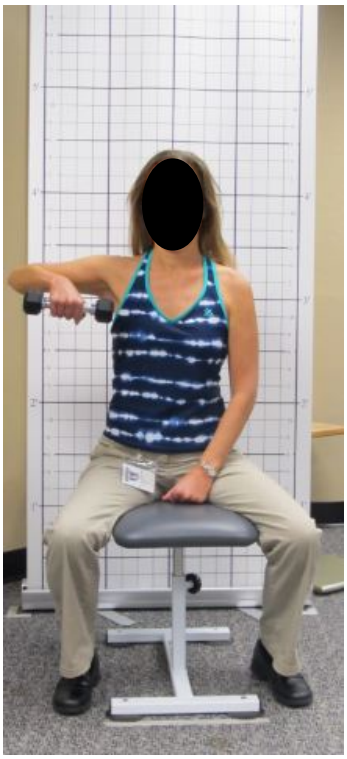


Figure 5.4:
Mid-point mUBSE

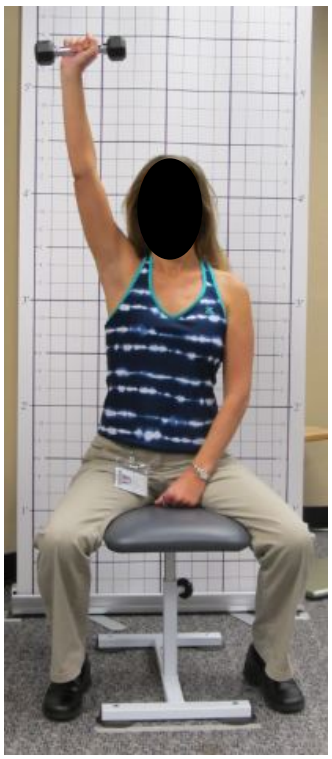


Figure 5.5:
Top position mUBSE

Statistical Analysis

An *a priori* analysis of power was completed on pilot data. The mean (SD) of a control group completing the mUBSE was 19 (4), and for BC was 14(1). Conservative values were used to calculate power and effect size, increasing the BC mean (SD) to 15(4). With these values, the power analysis conducted at *alpha* = .05, revealed a true power of 82%; 14 participants per group (28 total) would provide an effect size of 1.0.

Data were analyzed using IBM SPSS Statistics 19 (New York, NY). Descriptive statistics were calculated for all variables of self-report scales, and muscular endurance for each group. To confirm that the characteristics of each

group were similar, independent samples t-tests were used to analyze age, BMI and activity level.

Whether the dominant or the non-dominant limb was the involved limb in BCS was recorded for data analysis. This is based on findings from previous research in Chapter 3 which show that dominance has an effect on at least one measure in ROM, strength, unilateral muscular endurance tasks. Therefore, the BCS group was subdivided into two groups: involved dominant or involved non-dominant. Comparisons were then made for like limbs: involved dominant BCS to dominant control, and involved non-dominant to non-dominant control. Significance for all analyses was set *a priori* at $p \leq .05$

To examine differences between BCS and the control group, analysis of variance (ANOVA) models were constructed for the DASH, FACT-B, Piper Fatigue Scale, PAAI, and the bilateral muscular endurance test sub-test 3 of the FIT-HaNSA. If significance was found ($p \leq .05$), then Tukey post hoc testing was used to determine which group was involved. To examine differences between the BCS and controls for the mUBSE and sub-test 2 of the FIT-HaNSA, we ran separate ANOVAs. The involved dominant limb of BCS was compared to the dominant limb of controls, and the involved non-dominant limb of the BCS to the non-dominant limb of the control group. Because only two groups were compared, the involved limb to the respective limb of the control group, no *post hoc* testing was necessary

The level of responsiveness of mUBSE was compared to the FIT-HaNSA by examining the level of variance of each test. We ran separate ANOVAs

comparing the involved limb to the non-involved limb of BCS, and evaluated the F-statistic of each endurance test. Secondary analyses with independent samples t-tests included comparison of percent change in MVIC and heart rate levels, and the level of perceived exertion using BORG CR-10.

Results

Participant characteristics are detailed in Table 5.1. Participant demographics of age and body mass index (BMI) were similar (p>.05). BCS had a significantly greater activity level than the control group (p=.049). (Table 5.1) Among BCS, the mean duration since surgical treatment was 85 months (range 17-217); 14 underwent a mastectomy, 12 ALND, and 4 had axillary radiation. Of these, 5 BCS had both a mastectomy and ALND, and 3 underwent all three procedures.

Comparison of BCS to the Control Group

No significant differences were found between BCS and the control group on any of the self-report scales (p=.07-.40). (Table 5.2) No significant differences were found between the BCS and the control group on either the FIT-HaNSA or the mUBSE (p=.44-.72). (Table 5.3)

Comparison of the FIT-HaNSA to the mUBSE

To compare the levels of variability of the FIT-HaNSA and mUBSE, the F-statistic of an ANOVA was evaluated using repeated measures general linear models comparing the involved limb to the non-involved limb of BCS. Both F-statistics were 2.5.

The percent change in MVIC and HR after each endurance test was used to evaluate how demanding each test was. The MVIC and HR after each test was subtracted from the pre-test value to calculate the change score. Only the percent change in MVIC for mUBSE on the dominant side resulted in a statistically significant difference between groups on the independent samples t-tests. The control group (22±14%) had a statistically greater drop in endurance than the involved dominant BCS (<1±20%) (p=.01). The percent change in MVIC on the non-dominant mUBSE was not statistically significant between groups. (Table 5.4) The percent change in heart rate pre- to post on the mUBSE for BCS (29±16%) and controls (30±14%) was not statistically different. The percent change in heart rate pre- to post on the FIT-HaNSA for BCS (27±18%) and controls (31±15%) also was not statistically significant. The BORG CR-10 perceived exertion levels were also not statistically different for BCS and controls on either the mUBSE (9±1 and 8±1, respectively) or the FIT-HaNSA (7±1 and 8±2, respectively).

Table 5.1: Baseline Characteristics for Group Comparisons

	Age, years	BMI	IPAQ (mets)
Control (n=17)	58 (7)	28.5 (5.5)	2107 (1554)
BCS (n=17)	58 (7)	28.7 (5.3)	4392(4339)

Abbreviations: BMI = Body Mass Index; IPAQ (International Physical Activity Questionnaire

Table 5.2: Self-Report Scales

	FACT-B	**DASH**	**Piper**	**PAAI**
Control (n=17)	103.9 (11.4)	6.0 (5.5)	2.1 (1.4)	74.2 (19.1)
BCS Inv Dom (n=6)	119.6 (10.3)	9.8 (16.1)	2.6 (1.6)	65.9 (25.6)
BCS Inv ND (n=11)	107.9 (18.2)	15.7 (16.0)	3.5 (2.2)	62.8 (25.5)

Abbreviations: FACT-B=Functional Assessment of Cancer Therapy-Breast; DASH=Disabilities of Arm, Shoulder, and Hand; PAAI=Physical Activity Assessment Inventory; BC=breast cancer; Inv Dom=Involved Dominant; Inv Non-dom=Involved Non-dominant

Table 5.3: Muscular Endurance

	mUBSE		**FIT-HaNSA sub-test 2**		FIT-HaNSA subtest 3
	Dominant	Non-dominant	Dominant	Non-dominant	
Control (n=17)	18 (5)	15 (4)	254 (75)	233 (86)	273 (54)
BCS (n=17)	19 (12)	16 (4)	266 (65)	257 (64)	258 (72)

BCS Involved Dominant n=6; BCS Involved Non-dominant n=11
For BCS, all endurance values are on the involved limb, except Fit 3, which is a bilateral task.
mUBSE measured in repetitions; FIT-HaNSA in seconds

Table 5.4 Percent Change MVIC pre-post mUBSE and FIT-HaNSA

	mUBSE		**FIT-HaNSA**	
	Dominant	Non-dominant	Dominant	Non-dominant
Control (n=17)	22 (14%)	19 (15%)	23 (15%)	17 (19%)
BCS (n=17)	<1 (20%)	16 (9%)	14 (15%)	12 (22%)

Abbreviations: mUBSE = modified Upper Body Strength and Endurance test; FIT-HaNSA = Functional Impairment Test – Hand and Neck, Shoulder, Arm

Discussion

The primary aim in this study, to investigate levels of UE muscular endurance between a sample of BCS and a control group, revealed no differences between the groups on either measure of muscular endurance. Analyses of self-report measures examining quality of life, UE function, fatigue, and self-efficacy regarding physical activity also showed no differences between groups. The findings of this study indicate that BCS 7 years after treatment appear to achieve a full return of UE function and endurance.

Comparison of BCS to the Control Group

In examining self-report scales, although no differences were found between BCS and the control group, perceptions of quality of life and UE function trended toward differences. BCS in this study reported a higher FACT-B score (p=.07), indicating a higher perceived quality of life than the control group. The FACT-B is written specifically for BCS with questions unique to a person who has had cancer. It is possible that women who had not had cancer could not accurately answer the questions. Although the scale can be scored with blank answers, it may be that too many answers were left blank, making any assessment of quality of life among this group inaccurate. Whether the control group had difficulty answering these questions or the number of questions left blank resulted in an inaccurate assessment of QOL, the FACT-B may not be interpretable.

While the DASH scores for BCS were higher than the control group (p=.07), these scores are within a range of what could be considered normal scores. Two large studies examining typical DASH scores among a population

without UE pathology reported scores between 10.1(14.7)[45] - 14.3(14.9).[46] Despite a trend toward a difference indicating a more disability among BCS, the findings in this study reveal that recovery of function occurs by 7 years after treatment.

Endurance is one component of UE function, and the findings of this study show that women who have had treatment for BC on average 7 years prior demonstrate levels of endurance comparable to women without BC. No studies have investigated muscular endurance at this point in the recovery of BCS for comparison. One study examined muscular endurance using the Upper Body Strength and Endurance test in 186 BCS 18 months after treatment and reported that 40% continued to demonstrate a loss endurance compared to the non-involved limb.[15] Further evidence that BCS recover muscular endurance is that the values on the FIT-HaNSA among the BCS in this study were actually higher than those of the control group. The large variance associated with this test may have made any differences between groups difficult to appreciate. Values on the FIT-HaNSA among a similar group of 42 BCS were slightly lower than seen in this study (see Chapter 4). These findings may be explained in part by the activity level among this sample of BCS. The BCS reported high levels of activity on the IPAQ; a mean score of 4392 mets is categorized as a high activity level.[84] Whether comparing the results of this study to previous work or to the control group, BCS appear to have normal levels of muscular endurance.

Breast cancer survivors who are, on average, 7 years removed from BC treatment, have regained a level of UE function and endurance similar to that of

women without a history of BC. Furthermore, an active lifestyle as reported by this sample may mitigate any long range effects on UE endurance.

Comparison of the FIT-HaNSA to the mUBSE

The units of measure and magnitude of results of the FIT-HaNSA and mUBSE greatly differ, making direct comparisons of their respective variances invalid. The FIT-HaNSA scores ranged from 92-300 seconds, with standard deviations as large as 86, whereas the mUBSE scores ranged from 11-44, with standard deviations no greater than 12. The F-statistic in an ANOVA tests whether the variances of two populations are significantly different.[24] The F-statistic was examined for each endurance test using an ANOVA comparing the involved limb to the non-involved limb in BCS. For both the FIT-HaNSA and the mUBSE, the F-statistic was 2.5, suggesting that both tests have similar variance. Although not statistically significant, it is interesting to note that the mean endurance on the involved limb was less than the non-involved on the mUBSE, as would be expected, but greater than the non-involved on the FIT-HaNSA. This may suggest that the mUBSE is more accurately assessing the endurance as the direction of difference is as expected in the involved limb. The ceiling effects on the FIT-HaNSA remain high, with as many as 71% (12/17) of BCS and 76% (13/17) of the control group reaching the full test duration of 300 seconds. The mUBSE without a ceiling effect offers an alternative measure of muscular endurance.

To examine whether one endurance test was a greater physiological challenge than the other, the percent change in MVIC and heart rate, and the

levels of the BORG CR-10 perceived exertion were examined. The significant finding that the percent change in MVIC for the mUBSE was greater among the control group than the BCS may be explained by the presence of highly active BCS as indicated by high IPAQ scores; this BCS subgroup had more than twice as high of an activity level measured on the IPAQ (5235±4122) compared to the controls (2107±1554). That this percent change of MVIC was the only significant finding out of 4 variables examining MVIC change, suggests that both tests similarly challenge muscular endurance. The percent change in heart rate was not different between groups for either endurance test, indicating neither test challenges the cardiovascular system more than another. Mean BORG CR-10 levels were not different, suggesting that each test was equally difficulty. Both tests were perceived as a hard activity. These findings indicate that the mUBSE is not as challenging as the FIT-HaNSA.

That the mUBSE compared similarly in our study to the FIT-HaNSA, which has been more extensively studied in the general shoulder population and demonstrates good reliability and validity with self-report scales, suggests that this test of muscular endurance may be used in lieu of the FIT-HaNSA. The test takes less than 5 minutes to perform, and because it is a repetition to failure test, has no ceiling effects. These features may make it an attractive alternative to the FIT-HaNSA in clinical practice.

Limitations

This study had a limited number of participants, although an *a priori* power analysis of the mUBSE indicated the sample size was adequate. The long

survival period among the BCS of 7 years (range 17-217 months) may have allowed full healing to occur. The BCS in this sample were highly active, exceeding the activity level of the control group. It is possible this group was a not a true representation of BCS in term of this activity level.

Future research into UE endurance among BCS should focus on more immediate post treatment time periods to determine how long deficits persist. Continued comparisons to a healthy population need to be made to fully appreciate any differences. Better tests of UE muscular endurance need to be investigated.

Conclusion

Breast cancer survivors who are 7 years post treatment appear to have similar levels of muscular endurance to that of women without a history of BC. Furthermore, these women report a level of quality of life and UE function similar to healthy women. Less variable clinical measures of muscular endurance have yet to be developed, but the mUBSE presents a possible alternative to the FIT-HaNSA in testing upper extremity muscular endurance as it takes less time to administer and suffers no ceiling effects.

CHAPTER SIX

Despite research documenting the deficits in upper extremity (UE) function in survivors of breast cancer (BCS) post-operatively and beyond the first year of treatment, few studies have compared BCS to a sample of healthy controls using a battery of functional tests. The impairments of BCS have not been examined in light of any decline which occurs with normal aging. Whether self-reported quality of life (QOL) and UE function, range of motion (ROM), strength, and muscular endurance deficits in BCS are due to aging or breast cancer (BC) treatment has not been fully investigated. The need to understand the level of impairment in long term BCS in comparison to women without BC shoudl be established. The primary purpose of this research was to compare UE function among long term BCS and similar aged women without cancer. We expected that BCS who received treatment more than 12 months previously would demonstrate less motion, strength, and muscular endurance and higher levels of self-reported UE disability as well as lower levels of QOL than similar aged women without BC.

Typical Measures of Upper Extremity Function in Healthy Women 30-69

In making comparisons between BCS and women without BC, it is important to understand whether subjective and objective measures of UE function change with age, or vary limb to limb based on dominance. An understanding of perceived QOL among healthy women is also necessary. We undertook to describe QOL and UE function among women without BC ages 30-69. We hypothesized that as women aged, there would be declines in all

measures, and that the dominant limb would show less ROM, and greater strength and muscular endurance than the non-dominant limb.

In examining UE function among 79 women age 30-69 without BC, available UE ROM varied little as women aged, with statistical significance found only for dominant flexion ROM between women in their 30's and women in their 60's. This difference was not clinically relevant however, as the mean flexion among 60 year old women, at 148°, is great enough to complete even high level UE functional tasks.[92] All other motion, strength, and muscular endurance variables did not differ across the four decades studied.

Dominance appears to play a role in ROM and strength measures. The hand behind back motion, representing some level of internal rotation ROM, was less on the dominant side compared to the non-dominant, and is consistent with other research.[78,90,93] This, however, was the only motion wherein dominance played a role. Shoulder flexion on the dominant side was significantly stronger than the non-dominant side, which may have implications for clinical strength testing in women with breast cancer. These differences did not impact perceived function levels, as self-report functional levels are unimpaired in these women.

The impact of dominance on muscular endurance of the UE has not been extensively studied, but in our study, muscular endurance was greater on the dominant limb. Intuitively, this may be because the dominant limb tends to be used to a greater extent in daily activities, and therefore type I endurance muscle fibers may be enhanced.

A Comparison of Upper Extremity Function Between BCS and Healthy Controls

Research has suggested that long term BCS demonstrate declines in UE function beyond the time required for normal healing,[17,73] however, these are comparisons to a premorbid status which does not account for change over time, or to a contralateral limb, rather than to a population without BC. The purpose of this study was to compare QOL and UE function among women who had been treated for breast cancer at least 12 months prior to data collection to a sample of healthy women. It was believed that BCS would show deficits in self-reported QOL and UE function, and measures of ROM, strength, and muscular endurance. A secondary purpose was to compare ROM, strength, and muscular endurance of the involved limb to the non-involved limb of BCS. We believed the involved UE would demonstrate lower levels on all measures than the non-involved limb.

All self-reported measures of QOL and UE function were statistically significantly lower among BCS compared to a healthy sample. Although BCS report higher levels of disability than women without BC, the value reported is similar to the population at large.[45,46] BCS also demonstrated significantly less motion than women without BC. However, these differences appear to be minimal and may have no clinical relevance as the moderately lower values demonstrated by BCS would still allow daily tasks to be completed. Strength deficits appear when the cancer is on the non-dominant limb. These deficits, however, may not clearly impact functional tasks, as DASH scores remained within a range of normal. Muscular endurance did not appear to be affected by BC treatment, suggesting that over time, women recover to normal levels.

Limb to limb comparisons within the BCS revealed no relevant differences related to BC treatment. Both HBB and ER were significantly less on the dominant limb regardless of whether the limb underwent BC treatment. No other differences were found. These findings may implicate a carry-over effect of treatment to the non-involved limb as the population without BC demonstrated greater strength and endurance in the dominant limb. Therefore, the fact there is no expected difference could indicate an impairment.

Muscular Endurance Among Women

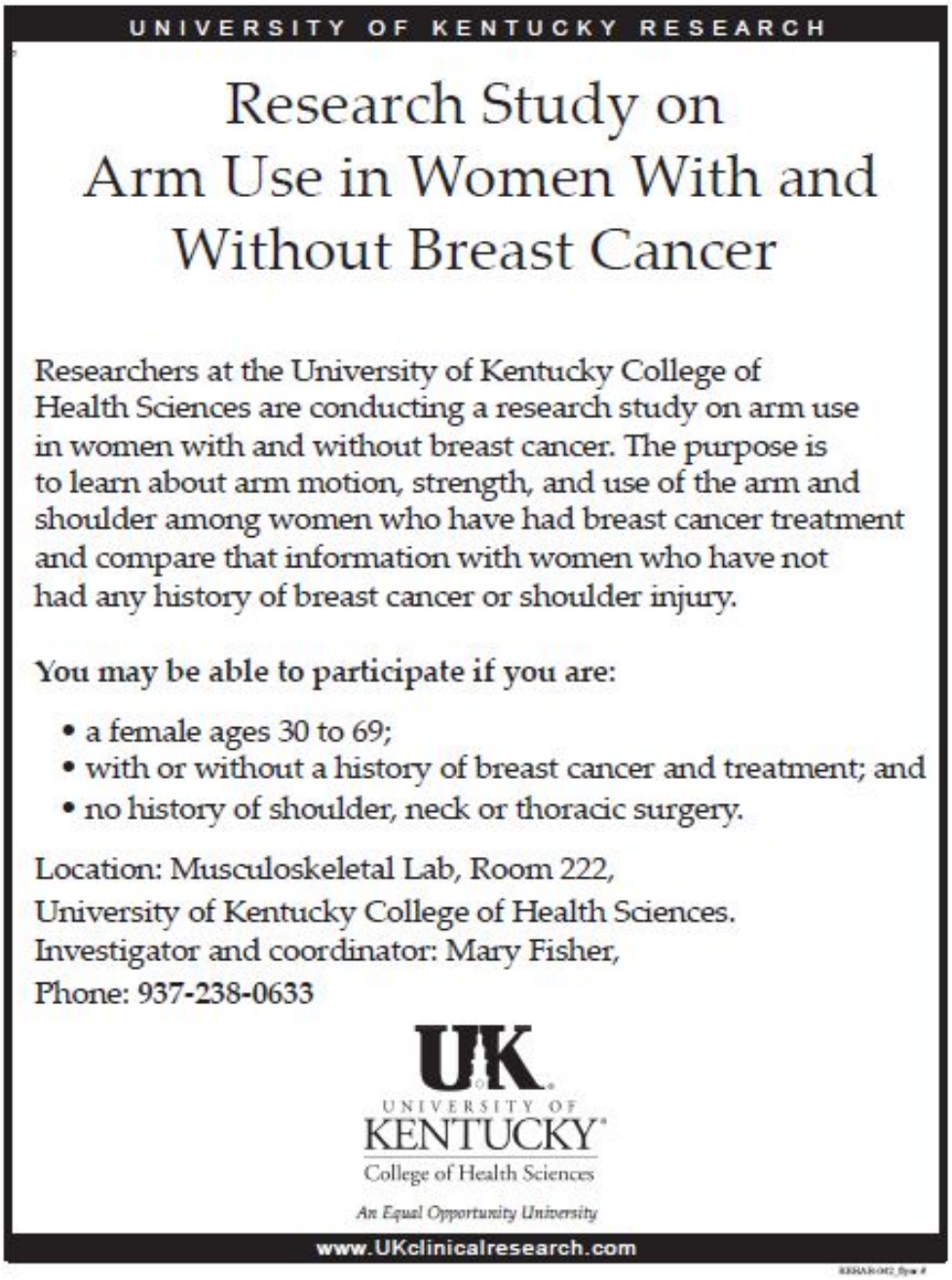
Muscular endurance is not easily measured in the clinic due to a lack of valid and reliable measures. The Functional Impairment Test – Hand, and Neck, Shoulder, Arm (FIT-HaNSA) demonstrated a high variance, suggesting that the level of responsiveness is low, as well as high ceiling effects. The final study examined a new clinical test of UE function. The modified Upper Body Strength and Endurance test (mUBSE) was compared to the FIT-HaNSA in both healthy controls and BCS in a matched study. We hypothesized that BCS would demonstrate lower levels of UE endurance than matched controls. Furthermore, we hoped to see that this new test would be more responsive than the FIT-HaNSA. Results, however, indicated that BCS have nearly the same level of UE endurance as women without BC, suggesting that long term BCS recover muscular endurance over time. The mUBSE, although not suffering from ceiling effects, did not demonstrate more responsiveness than the FIT-HaNSA.

Conclusion

Overall, BCS 6 years removed from treatment recovered UE function to levels similar to a population of women without BC. Self-reported QOL and UE function was lower among BCS than a sample of women who had not had BC but remains within the range of normal. Some deficits in motion and strength are present among long term BCS, but are likely not clinically relevant. Breast cancer survivors can recover UE function over time to levels within normal ranges.

APPENDICES

Appendix A



Appendix B

Consent to Participate in a Research Study

A comparison of upper extremity motion, strength, endurance, function, and quality of life between female breast cancer survivors and healthy controls

WHY ARE YOU BEING INVITED TO TAKE PART IN THIS RESEARCH?

You are being invited to take part in a research study about arm motion, strength, endurance and use in women. You are being invited to take part in this research study because you are a female between ages 30 and 69. If you volunteer to take part in this study, you will be one of about 200 people to do so.

WHO IS DOING THE STUDY?

The person in charge of this study is Mary Fisher PT, a student of University of Kentucky, Department of Rehabilitation Sciences. She is being guided in this research by Tim Uhl, PhD ATC PT. There may be other people on the research team assisting at different times during the study.

WHAT IS THE PURPOSE OF THIS STUDY?

By doing this study, we hope to learn about the motion, strength, endurance, use of the arm and shoulder, and the quality of life among women who have had breast cancer treatment and compare that information to women who have not had any history of breast cancer or shoulder injury.

ARE THERE REASONS WHY YOU SHOULD NOT TAKE PART IN THIS STUDY?

If you are under the age of 30, or older than 69, you may not take part in this study. If you are a male you may not participate in the study. If you had shoulder, neck or back surgery you may not participate in the study. If you have had an injury to your shoulder, neck, or back in the last 6 months you may not participate in this study. If you have had breast cancer that has been limited to lumpectomy and/or sentinel lymph node biopsy you cannot participate in this study.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?

The research procedures will be conducted at the University of Kentucky Musculoskeletal Research Laboratory. This lab is located on the second floor, room 222 of the Charles T. Wethington Building connected to the University of Kentucky Clinic at 900 South Limestone. You will be asked to come to the Musculoskeletal lab 1-2 times during the study. Each of those visits will take about 90 minutes. The total amount of time you will be asked to volunteer for this study is 3 hours over the next 1-2 weeks.

WHAT WILL YOU BE ASKED TO DO?

You will complete five questionnaires about your general health, your arm use, and how you feel. The investigator will take measurements of your arm motion using devices which measure the motion, strength and endurance of your arm.

Questionnaires:

You will complete a general medical questionnaire asking you about your health status, previous surgeries, and any medications you are taking, to see if you can participate in this study. Two questionnaires will ask you about how you use your arm in daily activities. Another questionnaire will ask you about how you feel in general. The last questionnaire will ask you about your overall activity level.

Range of Motion Measurements:

Your arm range of motion will be measured on both sides in three directions, elevation, inward and outward rotation. Shoulder elevation will be measured while upright and you will be asked to lift your arm up in front of you high a possible. Shoulder inward rotation will be measured while you are standing, and you will be asked to place your hand behind your back as high up the spine as possible. Shoulder outward rotation will be measured while lying on your back with your arm out to the side and your elbow resting on two towels. You will rotate your arm toward the floor by your head. A picture will be taken of your arm once you have completed each motion. The angle of motion will be measured from this picture. Once the measurement has been completed, the picture will be destroyed.

Strength Measurements:

Your arm strength will be measured on both sides in the same directions as your motion. A device called a dynamometer will be used to measure your strength and it will be attached to your wrist with an inelastic nylon strap. We will place your arm in a position and you will push against the strap for 5 seconds as hard as you can. This will be repeated twice in all directions on both arms. You will be given a 15 -30 second break between maximal efforts to allow for recovery. You will be given two practice trials and then we will record the two trials of maximal force you exert in each direction. These measures will be taken while seated. For shoulder elevation, you will lift your arm as you did for the range of motion measure. For the inward and outward rotation strength measures, your arm will be at your side and you will rotate toward your stomach or away from your stomach.

Arm Endurance:

You will be asked to lift a 2 pound weight from eye level down about 10 inches and back up as long as you can complete the task, up to 5 minutes with each arm. Lastly, you will be asked to fasten and unfasten bolts in a plate above your head for as long as you can complete the task, up to 5 minutes.

We may request that you be contacted after the study is completed, for further follow-up or future research. If you decline, no further contact with you will be made.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

None of the measurements will be dangerous to you. You may experience minor side-effects of muscle soreness from pushing hard against the force device or stretching your muscles. You may experience minor bruises from pushing hard against the force device. These side-effects should resolve within a day.

Please report any side-effects to the Principal Investigator, Mary Fisher, at 937-238-0633.

There is always a chance that any medical treatment can harm you, and the investigational treatment in this study is no different. In addition to the risks listed above, you may experience a previously unknown risk or side effect.

WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?

There is no guarantee that you will get any benefit from taking part in this study. Your willingness to take part, however, may, in the future, help researchers and clinicians better understand and/or treat other breast cancer survivors. You will be provided a copy of your results along with a standardized exercise program to help you improve in any deficits revealed from testing.

DO YOU HAVE TO TAKE PART IN THE STUDY?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

IF YOU DON'T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?

If you do not want to be in the study, there are no other choices except not to take part in the study.

WHAT WILL IT COST YOU TO PARTICIPATE?

The cost to you for participation in this study requires that you travel to and pay parking costs for the University of Kentucky Musculoskeletal Lab. There are no other costs associated with your participation.

WHO WILL SEE THE INFORMATION THAT YOU GIVE?

We will make every effort to keep private all research records that identify you to the extent allowed by law.

Your information will be combined with information from other people taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. You will not be personally identified in these written materials. We may publish the results of this study; however, we will keep your name and other identifying information private.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. First, we will give

everyone a code number and remove their names from most documents. All information will be kept in a locked lab on a password protected computer. The information that we obtain from you in this study will be included in a larger database in the Research Lab. The information that we obtain from you may be included in future studies for other types of comparisons. However, the information used will have no identifiable link to your personal identification.

This study is being conducted in conjunction with the University of Dayton, and the Institutional Review Board at the University of Dayton may request access to the data collected at the University of Kentucky for review.

You should know, however, that there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court or to tell authorities if you report information about a child being abused or if you pose a danger to yourself or someone else. Officials from the University of Kentucky may look at or copy pertinent portions of records that identify you.

CAN YOUR TAKING PART IN THE STUDY END EARLY?

If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to withdraw you from the study. This may occur if you are not able to follow the directions they give you, or if they find that your being in the study is more risk than benefit to you. There are no expected adverse effects should you withdraw from this study.

ARE YOU PARTICIPATING OR CAN YOU PARTICIPATE IN ANOTHER RESEARCH STUDY AT THE SAME TIME AS PARTICIPATING IN THIS ONE?

You may take part in this study if you are currently involved in another research study. It is important to let the investigator/your doctor know if you are in another research study. You should also discuss with the investigator before you agree to participate in another research study while you are enrolled in this study.

WHAT HAPPENS IF YOU GET HURT OR SICK DURING THE STUDY?
If you believe you are hurt or if you get sick because of something that is due to the study, you should call Mary Fisher at 937-238-0633 immediately. Mary Fisher will determine what type of treatment, if any, that is best for you at that time.

It is important for you to understand that the University of Kentucky does not have funds set aside to pay for the cost of any care or treatment that might be necessary because you get hurt or sick while taking part in this study. Also, the University of Kentucky will not pay for any wages you may lose if you are harmed by this study.

The medical costs related to your care and treatment because of research related harm will be your responsibility but may be paid by your insurer if you are insured by a health insurance company (you should ask your insurer if you have any questions regarding your insurer's willingness to pay under these circumstances).

A co-payment/deductible from you may be required by your insurer or Medicare/Medicaid even if your insurer or Medicare/Medicaid has agreed to pay the costs). The amount of this co-payment/deductible may be substantial.

You do not give up your legal rights by signing this form.

WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?

You will not receive any rewards or payment for taking part in the study. However, if you are interested, we can provide you with a standardized exercise program to address any strength and motion deficits you may have.

WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions, suggestions, concerns, or complaints about the study, you can contact the investigator, Mary Fisher at 937-238-0633. If you have any questions about your rights as a volunteer in this research, contact the staff in the Office of Research Integrity at the University of Kentucky at 859-257-9428 or toll free at 1-866-400-9428. We will give you a signed copy of this consent form to take with you.

WHAT IF NEW INFORMATION IS LEARNED DURING THE STUDY THAT MIGHT AFFECT YOUR DECISION TO PARTICIPATE?

If the researcher learns of new information in regards to this study, and it might change your willingness to stay in this study, the information will be provided to you. You may be asked to sign a new informed consent form if the information is provided to you after you have joined the study.

WHAT ELSE DO YOU NEED TO KNOW?

You will be told if any new information is learned which may affect your shoulder or arm, or influence your willingness to continue taking part in this study.

_____ _____

Signature of person agreeing to take part in the study Date

_____

Printed name of person agreeing to take part in the study

_____ _____

Name of [authorized] person obtaining informed consent Date

_____

Signature of Investigator

Appendix C

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

(August 2002)

SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation

Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ

International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information

More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

Appendix D

FACT-B

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
I have a lack of energy	0	1	2	3	4
I have nausea	0	1	2	3	4
Because of my physical condition, I have trouble meeting the needs of my family	0	1	2	3	4
I have pain	0	1	2	3	4
I am bothered by side effects of treatment	0	1	2	3	4
I feel ill	0	1	2	3	4
I am forced to spend time in bed	0	1	2	3	4
I feel ill	0	1	2	3	4
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
I feel close to my friends	0	1	2	3	4
I get emotional support from my family	0	1	2	3	4
I get support from my friends	0	1	2	3	4
My family has accepted my illness	0	1	2	3	4
I am satisfied with family communication about my illness	0	1	2	3	4
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.*					
I am satisfied with my sex life	0	1	2	3	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
I feel sad	0	1	2	3	4
I am satisfied with how I am coping with my illness	0	1	2	3	4
I am losing hope in the fight against my illness	0	1	2	3	4
I feel nervous	0	1	2	3	4
I worry about dying	0	1	2	3	4
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
I am able to work (include work at home)	0	1	2	3	4
My work (include work at home) is fulfilling	0	1	2	3	4
I am able to enjoy life	0	1	2	3	4
I have accepted my illness	0	1	2	3	4
I am sleeping well	0	1	2	3	4
I am enjoying the things I usually do for fun	0	1	2	3	4
I am content with the quality of my life right now	0	1	2	3	4

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

ADDITIONAL CONCERNS

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

The Upper Extremity Functional Index (UEFI)

We are interested in knowing whether you are having any difficulty at all with the activities listed below **because of your upper limb** problem for which you are currently seeking attention. Please provide an answer for **each** activity.

Today, *do you* or *would you* have any difficulty at all with:

	Activities	Extreme difficulty or unable to perform activity	Quite a bit of difficulty	Moderate difficulty	A little bit of difficulty	No difficulty
1	Any of your usual work, housework, or school activities	0	1	2	3	4
2	Your usual hobbies, recreational or sporting activities	0	1	2	3	4
3	Lifting a bag of groceries to waist level	0	1	2	3	4
4	Lifting a bag of groceries above your head	0	1	2	3	4
5	Grooming your hair	0	1	2	3	4
6	Pushing up on your hands (eg from bathtub or chair)	0	1	2	3	4
7	Preparing food (eg. peeling, cutting)	0	1	2	3	4
8	Driving	0	1	2	3	4
9	Vacuuming, sweeping or raking	0	1	2	3	4
10	Dressing	0	1	2	3	4
11	Doing up buttons	0	1	2	3	4
12	Using tools or appliances	0	1	2	3	4
13	Opening doors	0	1	2	3	4
14	Cleaning	0	1	2	3	4
15	Tying or lacing shoes	0	1	2	3	4
16	Sleeping	0	1	2	3	4
17	Laundering clothes (eg. washing, ironing, folding)	0	1	2	3	4
18	Opening a jar	0	1	2	3	4
19	Throwing a ball	0	1	2	3	4
20	Carrying a small suitcase with your affected limb	0	1	2	3	4
	Column Totals:					

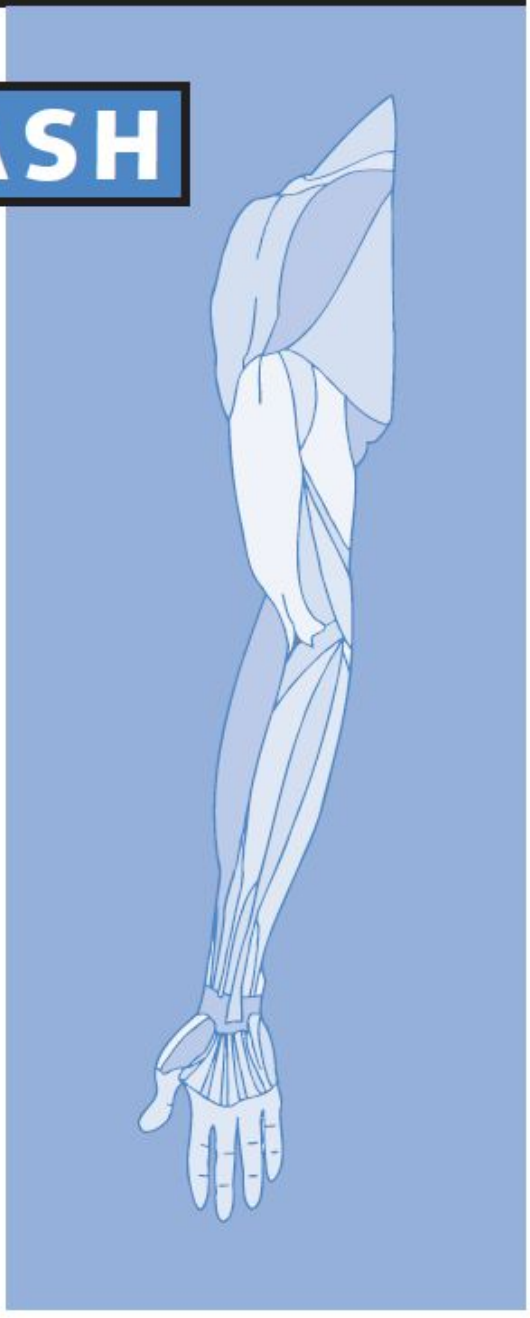
Minimum Level of Detectable Change (90% Confidence): 9 points **SCORE: _____/ 80**

Source: Stratford et al (2001): Development and initial validation of the upper extremity functional index. Physiotherapy Canada 53 (4): 259-67
Minimum detectable change (90% confidence): 6 points.

Appendix F

DISABILITIES OF THE ARM, SHOULDER AND HAND

THE DASH



INSTRUCTIONS

This questionnaire asks about your symptoms as well as your ability to perform certain activities.

Please answer *every question*, based on your condition in the last week, by circling the appropriate number.

If you did not have the opportunity to perform an activity in the past week, please make your *best estimate* on which response would be the most accurate.

It doesn't matter which hand or arm you use to perform the activity; please answer based on your ability regardless of how you perform the task.

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 homemaking if that is your main work role).

Please indicate what your job/work is:_____

p 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:_

o 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.

Appendix G

Date:_____ Qualifying Assessment

ID □□□

PIPER FATIGUE SCALE (PFS)

Directions: Many individuals can experience a sense of unusual or excessive tiredness whenever they become ill, receive treatment, or recover from their illness/treatment. This unusual sense of tiredness is not usually relieved by either a good night's sleep or by rest. Some call this symptom "fatigue" to distinguish it from the usual sense of tiredness.

For each of the following questions, please fill in the space provided for that response that best describes the fatigue you are experiencing now or for today. Please make every effort to answer each question to the best of your ability. If you are not experiencing fatigue now or for today, fill in the circle indicating "0" for your response. Thank you very much!

1. How long have you been feeling fatigue? (Check one response only).

□ 1. not feeling fatigue
□ 2. minutes
□ 3. hours
□ 4. days
□ 5. weeks
□ 6. months
□ 7. other (Please describe) _____

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

No Distress									A Great Deal
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

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

None									A Great Deal
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

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

None									A Great Deal
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

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

None									A Great Deal
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

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

None									A Great Deal
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

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

Mild									Severe
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

8. To what degree would you describe the fatigue which you are experiencing now as being?

Pleasant									Unpleasant
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

9. To what degree would you describe the fatigue which you are experiencing now as being?

Agreeable									Disagreeable
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

10. To what degree would you describe the fatigue which you are experiencing now as being?

Protective									Destructive
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

11. To what degree would you describe the fatigue which you are experiencing now as being?

Positive									Negative
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

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

Normal									Abnormal
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

13. To what degree are you now feeling:

Strong									Weak
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

14. To what degree are you now feeling:

Awake									Sleepy
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

15. To what degree are you now feeling:

Lively									Listless
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

16. To what degree are you now feeling:

Refreshed									Tired
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

17. To what degree are you now feeling:

Energetic									Unenergetic
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

18. To what degree are you now feeling:

Patient									Impatient
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

19. To what degree are you now feeling:

Relaxed									A Great Deal
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

20. To what degree are you now feeling:

Exhilarated									Depressed
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

21. To what degree are you now feeling:

Able to Concentrate									Unable to Concentrate
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

22. To what degree are you now feeling:

Able to Remember									Unable to Remember
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

23. To what degree are you now feeling:

Able to Think Clearly									Unable to Think Clearly
□	□	□	□	□	□	□	□	□	□
1	2	3	4	5	6	7	8	9	10

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

_____
_____
_____

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

_____
_____
_____

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

_____
_____
_____

27. Are you experiencing any other symptoms right now? _____

_____
_____
_____

Appendix H

PHYSICAL ACTIVITY APPRAISAL INVENTORY (PAAI)

Directions: Using the 0-100 scale below, please rate how sure you are that you can perform your usual physical activities regularly under the following conditions. Physical activity refers to all activity at home, work, or leisure.

0 10 20 30 40 50 60 70 80 90 100

Cannot do at all — Moderately certain can do — Certain can do

I am confident that I can perform my usual physical activities (includes all activity at home, work, or leisure): (0-100)

1. When I am feeling tired _____

2. When I am feeling pressure from work or school _____

3. During bad weather _____

4. During or after experiencing personal problems _____

5. When I am feeling depressed _____

6. When I am feeling anxious _____

7. When I feel physical discomfort with an activity____

8. When I have too much work to do at home _____

9. When I/we have visitors _____

10. When there are other interesting things to do _____

11. When I don't have support from my family or friends _____

12. When I have other time commitments _____

13. When I do not feel well _____

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VITA

MARY I. FISHER, PT, MSPT, OCS, CLT

LICENSURE/CERTIFICATIONS

1991	Ohio Physical Therapist License Number: PT-05716
2007	Board Certified Orthopedic Specialist, American Board of Physical Therapy Specialties
2010	Certified Lymphedema Therapist

EDUCATION

2007 - present	Doctoral Candidate, Rehabilitation Sciences Doctoral Program (PhD), College of Health Sciences, University of Kentucky.
1991	Master of Science in Physical Therapy, Sargent College of Health and Rehabilitation Sciences, Boston University.
1989	Bachelor of Arts, Wittenberg University. Graduated *cum laude*. Major: English. Minors: Biology and Political Science. Study abroad experience at The University College of Wales, Aberystwyth, Wales, Fall 1988.

PROFESSIONAL EXPERIENCE

2001 – present	Staff Physical Therapist – Support, Miami Valley Hospital, Dayton, Ohio
1995 – 2001	Clinical Coordinator/Physical Therapist – Offsite Physical Therapy Centers, Miami Valley Hospital, Dayton, Ohio
1994 – 1995	Physical Therapist II/III, Miami Valley Hospital, Dayton, Ohio
1991 – 1994	Physical Therapist, Community Hospital, Springfield, Ohio

ACADEMIC APPOINTMENTS

2010 – present	Assistant Professor, Physical Therapy Doctoral Program, Department of Health Science and Sport Science, School of Education and Allied Professions, University of Dayton, Dayton, Ohio
2008 – 2010	Instructor , Physical Therapy Doctoral Program, Department of Health Science and Sport Science, School of Education and Allied Professions, University of Dayton, Dayton, Ohio
2007 – 2008	Adjunct Faculty, Physical Therapy Doctoral Program, Department of Health Science and Sport Science, School of Education and Allied Professions, University of Dayton, Dayton, Ohio
2006	Guest Lecturer, Physical Therapy Doctoral Program, Department of Health Science and Allied Professions, School of Education and Allied Professions, University of Dayton, Dayton, Ohio
2005 – present	Adjunct Faculty/Guest Lecturer, Physical Therapist Assistant Program, Sinclair Community College**,** Dayton, Ohio
2001 – 2005	Guest Lecturer, Master of Physical Therapy Program, Andrews University, Dayton, Ohio
1995 – 2001	Adjunct Faculty, Master of Physical Therapy Program, Andrews University, Dayton, Ohio

PROFESSIONAL ORGANIZATIONS

Member, American Physical Therapy Association (APTA)
Member, Orthopedic Section of APTA
Member, Women's Health Section of APTA
Member, Oncology Section of APTA

HONORS AND AWARDS

Two-time performance recognition bonus, Miami Valley Hospital, 1997, 1998
Wittenberg University Scholar, 1985 – 1989
Mortar Board Senior Honorary 1989

GRANTS

Rehabilitation Sciences Doctoral Program Grant, University of Kentucky, $2500, 2009

PRESENTATIONS

Educational Session:

Levangie, PK, **Fisher, MI,** Perdomo, M, Kendig, T (February 2012) Oncology Section Task Force on Breast Cancer Outcomes. Combined Sections Meeting, APTA, Chicago, IL.

Technical Session/Platform Presentations:

(Student names underlined)

Fisher, MI, Uhl, TL, Brown, C., Golden, K. A Comparison of Arm Function Between Long Term Breast Cancer Survivors and Healthy Controls. Accepted to the January 2013 Combined Sections Meeting, American Physical Therapy Association.

Capilouto, GJ, **Fisher, MI,** Granger, D, Isaacs, K & Joyner, K. (November 2009) Nursing Perspectives of Readiness to Bottle Feed in Preterm Infants. American Speech and Hearing Association, New Orleans, LA.

Invited Presentations:

Fisher, MI. Oncology Rehabilitation for Therapists: A Focus on Breast Cancer. West Central District Meeting of the Ohio Physical Therapy Association, October 2012.

Fisher, MI. Oncology Rehabilitation for Therapists: A Focus on Breast Cancer. University of Findlay, March 2012.

Poster Presentations:

(Student names underlined)

Brahler, CJ, Donahoe-Fillmore, B, **Fisher, MI**, Anloague, PA. Critical Thinking and Academic Performance are associated with NPTE Scores in Doctor of Physical Therapy Program Graduates. Accepted for presentation at the Combined Sections Meeting, American Physical Therapy Association, San Diego, CA (January 2013).

Brahler, CJ, Hess, NJ, Lorenzo, BM, **Fisher, MI,** Donahoe-Fillmore, B, Glenn, T. Adolescents Engaged In At Least Five Hours Of Physical Activity Weekly Show Numerous Health Benefits**.** American College of Sports Medicine Annual Meeting, San Diego, CA (June, 2012).

Fisher, MI. A Systematic Review of the Effectiveness of Exercise on Arm Function in Breast Cancer Survivors. Markey Cancer Research Day, University of Kentucky, Lexington, KY (March 2011). First Place, Graduate Clinical Sciences Division.

Fisher, MI. A Systematic Review of the Effectiveness of Exercise on Arm Function in Breast Cancer Survivors. Combined Sections Meeting, American Physical Therapy Association, New Orleans, LA (February 2011).

Brahler, CJ, Donahoe-Fillmore, B, **Fisher, MI.** The Effects of Problem-based Learning on Critical Thinking in Graduate Physical Therapy Students. Combined Sections Meeting, American Physical Therapy Association, New Orleans, LA (February 2011).

Fisher, MI, Howell, D. An ICF-based model to empower and improve self-efficacy of breast cancer survivors. Combined Sections Meeting, American Physical Therapy Association, San Diego, CA (February 2010).

Donahoe-Fillmore, B, Brahler, CJ, Beasley, K, **Fisher, MI,** VanCleave, H, & Bowman, R. The Effects of Home-Based vs Class-Based Pilates in Healthy College-Aged Females. Combined Sections Meeting, American Physical Therapy Association, San Diego, CA (February 2010).

PUBLICATIONS

Fisher, MI, Howell, D. The Power of Empowerment: An ICF-Based Model to Improve Self-Efficacy and Upper Extremity Function of Survivors of Breast Cancer, *Rehabilitation Oncology,* Vol 28, Number 3, November 2010.

Donahoe-Fillmore, B, Brahler, CJ, **Fisher, MI**, Beasley, K. The Effect of Yoga Postures on Balance, Flexibility and Strength in Healthy High School Females, *Journal of Women's Health Physical Therapy,* Jan/Apr 2010.

Manuscripts in Press:

Fisher, MI, Levangie, PK. Oncology Section Taskforce on Breast Cancer Outcomes: Scapular Assessment. *Rehabilitation Oncology,* Vol 30, No. 4, January 2013.

Levangie, PK, **Fisher, MI**. Oncology Section Taskforce on Breast Cancer Outcomes: An Introduction. *Rehabilitation Oncology***,** Vol 30, No. 4, January 2013.