Title
Upper Extremity Function Following Treatment for Breast Cancer

Author
Smoot, Betty

Publication Date
2009

Peer reviewed|Thesis/dissertation

Upper Extremity Function Following Treatment for Breast Cancer

by

Betty Smoot

MANUSCRIPT

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHYSICAL THERAPY SCIENCE

in the

GRADUATE DIVISIONS

of the

UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

and

SAN FRANCISCO STATE UNIVERSITY

[redacted]

AKNOWLEDGMENTS

The author would like to thank Marylin Dodd, RN, PhD, and Nancy Byl, PT, PhD for the opportunity to carry out this study, and Kimberly Topp, PT, PhD, and Linda Wanek, PT, PhD, for providing research guidance. Thank you to Josephine Wong, MD, and Bruce Cooper, PhD, for assistance with data management and data analysis.

This study was funded by a grant from the National Institute of Nursing Research (NIH 1R21 NR0101282U). This study was also supported by NIH/NCRR UCSF-CTSI Grant Number UL1 RR024131. Its contents are solely the responsibility of the author and do not necessarily represent the official views of the National Institutes of Health.

Upper Extremity Function Following Treatment for Breast Cancer

by

Betty Smoot

ABSTRACT

BACKGROUND: Breast-cancer-related lymphedema affects ~25% of the 2 million breast cancer survivors in the US and may impact function and quality of life. **PURPOSE:** 1) To compare upper extremity (UE) function between women with and without lymphedema after breast cancer treatment; 2) To determine the impact of impairments on arm function and quality of life (QOL). **SUBJECTS:** 144 women post breast cancer treatment, 73 diagnosed with lymphedema. **METHODS/MATERIALS:** Demographic, symptom, Disability of Arm-Shoulder-Hand (DASH), and QOL questionnaires were completed. Objective measures included Purdue pegboard, finger tapper, Semmes-Weinstein monofilaments, vibration perception threshold, strength, range of motion (ROM), and volume. **ANALYSIS:** T-tests, Mann-Whitney ranked sum analysis, and chi square for significance of differences between groups were performed. Analysis-of-variance was carried out for within and between group comparisons. Linear regression was used to assess the contribution of variables to the variance in DASH and QOL scores. **RESULTS:** Women with lymphedema had more lymph nodes removed ($p < .001$), more frequent reports of UE symptoms ($p< .001$), higher BMI ($p =.041$), and higher DASH scores (greater disability) ($p < .001$). There were no differences in QOL scores between groups. For all participants there was less strength (elbow flexion, wrist flexion, grip), less shoulder ROM (abduction, flexion, ER), decreased sensation at the medial upper arm, and greater volume in the affected arm ($p < .05$). The differences between sides were greater in the women with lymphedema, particularly in shoulder abduction ROM. ($p < .05$). Women with lymphedema had *bilaterally* less elbow flexion strength and shoulder ROM (flexion, abduction, ER) ($p < .05$). Variables found to significantly contribute to the variance of the DASH scores were past diagnosis of lymphedema, affected UE grip strength, affected UE shoulder abduction ROM, and number of comorbidities (R 0.681, R^2 of 0.463, $p < .001$). Age and number of comorbidities explained 33% of the variance in the QOL total score. Affected UE summed strength score contributed to

the variance in 3 QOL subscale scores: physical (16%), psychological (8%), and social (11%).

CONCLUSIONS: Women with lymphedema have greater UE impairment than women without, which negatively impacts arm function.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Treatment for breast cancer has improved dramatically over the last two decades. While these treatments have significantly increased the five year survival rates, they are not without lasting adverse effects. Currently there are over two million breast cancer survivors in the U.S. [1-3] and a considerable number of these women have or will develop complications, such as lymphedema or post treatment pain, as a result of their treatment. It is our hypotheses that following breast cancer treatment women will demonstrate upper extremity impairment and that those who develop lymphedema will demonstrate greater upper extremity impairment than women who do not develop lymphedema. Further, we hypothesize that these impairments will negatively impact activity and quality of life.

Breast cancer treatments include surgery, radiation, and systemic therapies and each is associated with short and long term sequelae. Chemotherapy, for example, is known to induce neuropathy, impaired concentration and memory, and generalized fatigue. [4-6]. Chemotherapy plus radiation therapy after axillary node dissection have been associated with chronic pain, particularly in the ipsilateral arm [7]. Axillary dissection or radiation therapy following surgical excision of the tumor can also be associated with increased incidence of long term arm morbidity, including impaired shoulder mobility and lymphedema [8, 9]. For example, shoulder range of motion is limited in up to 45% of patients who have sentinel node biopsy, and 86% of patients who have undergone axillary clearance [10].

Breast-cancer-related lymphedema develops in 5% to 42% of women following breast cancer treatment, dependent, in part, on the aggressiveness of treatment [11, 12].

Lymphedema is the accumulation of protein rich interstitial fluid as a result of impaired lymphatic function [13]. Lymphedema related to breast cancer treatment may result from surgical removal of lymph nodes and lymphatic drainage pathways. Further damage to the lymphatic system may result from soft tissue fibrosis following inflammation, infection, or radiation. Of significant importance to patients, breast-cancer-related lymphedema can adversely affect upper extremity function and quality of life [14-18].

Though several recent studies have investigated upper extremity function in women following breast cancer treatment, none have compared objective measures of physical function between women with lymphedema and those without. The primary aim of the present study is to compare differences in upper extremity impairment between women who have developed lymphedema after breast cancer treatment and those who have not developed lymphedema. Our secondary aim is to determine the impact of these impairments on activity and quality of life.

Many of the complications arising from breast cancer treatment go unrecognized and few of these women are referred for rehabilitation [19]. If there are known and predictable impairments in women after breast cancer treatment, then early physical therapy assessment and intervention can be implemented which may decrease pain, reduce loss of flexibility and strength, and minimize restriction in activities, and improve participation in activity and quality of life.

METHODS

Participants

Women, with and without lymphedema, who had completed active breast cancer treatment at least 6 months previously, were recruited. The women were required to be at least18 years of age, and able to read, speak, and understand English. Women were excluded for bilateral breast cancer, current upper extremity infection, lymphangitis, pre-existing lymphedema, pre-existing neuromuscular or musculoskeletal conditions that would affect local upper extremity testing, or current recurrence of breast cancer. Study participants were recruited through the National Lymphedema Network website, San Francisco Bay area hospitals, San Francisco Bay area breast cancer or lymphedema support groups, and breast cancer conferences.

One hundred and forty eight women completed testing. Of those, three were found to have had bilateral mastectomies and one had a total shoulder replacement, and were therefore excluded from data analysis. The study was approved by The UCSF Committee on Human Research and the Clinical and Translational Science (CTSI) Clinical Research Center Advisory Committee. Written informed consent was obtained from all participants prior to testing.

Procedures

All participants attended a single evaluation session. Both upper extremities were assessed. Testing was completed by one investigator (BS). All testing was performed in the UCSF CTSI Clinical Research Center.

Fine motor function was assessed using the standardized Purdue Pegboard (North Coast Medical, Morgan Hill, CA) and the Finger Tapper Test (Psychological Assessment

Resources, Inc, Lutz, FL). Strength was assessed using hand held dynamometers. Participants were instructed to maximally resist the force of the examiner, or to squeeze with maximal effort for the grip tests. Strength scores were obtained for shoulder abduction, elbow flexion, and wrist flexion using the MicroFET2 dynamometer (Hoggan MicroFET2 Muscle Tester, Model 7477, Pro Med Products, Atlanta, GA). Three grip tests were performed: full grip using a hand dynamometer (North Coast Medical, Morgan Hill, CA), key grip (lateral opposition) using a pinch gauge (North Coast Medical, Morgan Hill, CA), and pinch grip (terminal opposition or 3-point chuck) using the MicroFET2. Three trials of each strength test were performed, and a mean was calculated for each test. Additionally, a combined strength score was calculated as the sum of all strength scores for each upper extremity.

A goniometer was used to measure ranges of motion (ROM) of the upper extremities. Shoulder flexion, shoulder abduction, shoulder external rotation, elbow flexion and extension, wrist flexion and extension, and flexion of the proximal interphalangeal joint of digit two were measured following standardized procedures reported by Norkin [20]. In addition to individual joint measurements, an overall summed ROM score was calculated for each upper extremity.

Semmes-Weinstein monofilaments (North Coast Medical, Morgan Hill, CA) were used to assess tactile sensitivity of the upper extremities. Test locations were the inner and outer aspects of the arm and forearm, the dorsal aspect of first web space of the hand, the radial aspect of the 2^{nd} digit distal phalanx, and the ulnar aspect of the 5^{th} digit distal phalanx. Each region was tested beginning with the smallest diameter monofilament (2.83; 0.07 grams force) and progressed to successively larger diameter monofilaments,

until 5 of 5 correct responses were obtained. Vibration Perception Threshold (VPT) was determined using the Bio-Thesiometer (Bio-Medical Instrument Company, Newbury, Ohio). The pad of each distal phalanx, the radial styloid, and medial epicondyle were assessed. The Bio-Thesiometer probe was placed on the test area and the amplitude increased from zero until the participant reported feeling vibration.

Circumferential assessment and bioimpedance were employed to objectively assess upper extremity limb volume. A flexible tape measure was used to measure circumference of each upper extremity at the ulnar styloid, designated as "0" centimeters, and at 10 centimeter intervals proximal to "0" to a maximum of 40 centimeters. Hand circumference was measured at the metacarpophalangeal joints and 2 cm proximally. Volume was calculated from circumference measures using the formula for volume of a truncated cone, $V= 1/12\Pi \Sigma h (C_1^2 + C_1C_2 + C_2^2)$, where h is the length of each measured segment and C is the circumference at each end of that segment [21]. The Impedimed measurement system (SPF7, Garden City, Australia) was used to measure upper extremity impedance to an alternating electrical current which provided information about fluid distribution in specific regions of the body. Electrodes were placed on the dorsum of the hands, wrists, feet and ankles. The participants were instructed to lie supine for 10 minutes with no pillows, arms at sides and lower extremities flat and slightly abducted [22].

A demographic questionnaire was used to collect information on age, health, income, ethnicity, menopausal status, performance and activity status, occupation, and health status. Information regarding comorbidities was obtained. Twelve comorbidities were included in the comorbidity count: heart disease, high blood pressure, lung disease,

diabetes, stomach disease or ulcer, urinary tract disorders/kidney disease, liver or gallbladder disease, anemia or other blood disease, depression, osteoarthritis, rheumatoid arthritis, and back pain/problems. All participants completed The Disabilities of Arm, Shoulder, and Hand (DASH), and the Quality of Life – Cancer Survivors questionnaire (QOL-CS). The DASH is a 30-item, self-report questionnaire which measures physical function and symptoms on a 1-5 response scale, in people with musculoskeletal disorders of the upper extremity [23]. Scores are typically converted to 0 to100 with higher scores reflective of greater disability. The QOL-CS is a 41-question self rating instrument, designed to assess quality of life in cancer survivors [24]. Each question is scored from 0 to 10, higher scores reflecting better outcome. Four subscales are calculated and represent physical, psychological, social, and spiritual domains. Scores from these subscales also range from 0-10, as does the overall QOL-CS score.

A questionnaire was completed by the participants to collect information regarding symptoms in the affected breast, symptoms in the upper extremity on the side of the surgery, and general symptom experience. The women also completed the Norman Questionnaire, an instrument designed to describe the signs and symptoms of breast-cancer-related lymphedema, originally developed as a phone interview questionnaire by Norman, et al [25]. Questions on the Norman Questionnaire relate to differences in size of the upper extremities, degree of the size difference, associated symptoms and distress, and treatment received.

Data Analysis

Sample size estimate of 120 participants was determined prospectively, based on an alpha level of 0.05, and power of 0.80. This sample size estimate was based on an

estimated correlation coefficient of 0.25 for regression of the predictor variables on the outcome variable.

Statistical analyses were performed using SPSS statistical software (version 16, SPSS Inc, Chicago, IL). Means and standard deviations for interval data were obtained and unpaired t-tests for significance of differences were performed for normally distributed data. Mann-Whitney ranked sum analysis was used for non-normally distributed interval data. Chi square was used to assess significance of differences in proportions for nominal and categorical variables. To compare interlimb differences between women with lymphedema and those without, analysis of variance (ANOVA) was carried out for within and between group differences.

Regression analysis was used to evaluate the contribution of variables of theoretical interest to the outcome measure. Multiple linear regression was selected for normally distributed interval data. The DASH was used as the outcome measure for function. Based on the Item Response Theory method, raw DASH scores were converted to logit scores (the natural log of the probability of obtaining a particular set of responses versus the probability of not obtaining that set of responses). This analysis allowed conversion of the raw DASH scores to an authentic interval scale. The QOL-CS was used as the outcome measure for quality of life.

RESULTS

Participant characteristics

Results of 144 women were included. Of those, 73 reported a previous diagnosis of lymphedema. At the time of testing, the mean number of years since breast cancer

diagnosis was 4.94 (4.06) for the Non-lymphedema group, and 7.37 (6.15) for the Lymphedema group *(p= 0.006)*. Characteristics for study participants are summarized in Table 1. There were no significant differences in age, side treated for breast cancer, dominant side, or affected side involving the participant's dominant arm. There was a statistically significant difference in body mass index (BMI) between groups. The Lymphedema group demonstrated higher BMI. During the 3 months prior to the study visit, more women in the Lymphedema group reported symptoms of pain, heaviness, ache, or strange sensations (68%) than in the Non-lymphedema group (39%). There were no differences between groups in numbers of medical comorbidities. Overall, the most commonly reported comorbidities were back pain (n = 46), depression (n = 34), and high blood pressure (n = 33). Ninety percent of the women had 3 or fewer comorbidities.

The type of surgery was dichotomized to breast conserving surgery (lumpectomy, segmentectomy, quadrantectomy) and mastectomy (simple, modified radical, or radical). No differences in the number of women were found between groups for radiation, chemotherapy, or type of breast surgery. However, more women with lymphedema underwent axillary node dissection, with significantly more lymph nodes removed.

The difference in DASH and QOL–CS scores between the 2 groups are presented in Table 2. Women with lymphedema scored higher on the DASH than the women without lymphedema, indicative of relatively greater disability. There were no significant differences between groups for the total QOL-CS score or the quality of life subscale scores. However, women with lymphedema felt that there illness interfered more with activity at home (7.35, SD 2.84) compared to the women without lymphedema (8.3, SD 2.35), (p = 0.033). Higher scores on the QOL-CS indicate better perceived quality of life.

Differences between sides

Paired t-tests were performed to assess the differences between the affected and unaffected sides for each group. Results are summarized in Table 3. In the Non-lymphedema group, the affected side demonstrated less shoulder abduction strength, and less range of motion of shoulder flexion, abduction, and external rotation, and the overall ROM score ($p < 0.05$) compared to the unaffected side. There was also a statistically significant increase in sensitivity to Semmes-Weinstein monofilament testing on the affected little finger. No other differences between sides were observed in the Non-lymphedema group. For the Lymphedema group, the affected side had less strength in elbow flexion, wrist flexion, and 2 of the 3 grip tests, which resulted in an overall decrease in upper extremity strength compared to the unaffected side. There was less sensitivity to Semmes-Weinstein monofilament testing at the medial aspect of the arm, medial forearm and index finger in the Lymphedema group. In addition, there were less ROM of the affected shoulder (flexion, abduction, and ER), wrist (flexion), and index proximal interphalangeal (flexion); and a lower overall ROM score ($p < 0.05$). The largest differences were seen in shoulder abduction. The affected side in the Lymphedema group demonstrated 17.53 degrees less shoulder abduction than the unaffected side (11.7, 23.35; 95% CI). Analysis of variance revealed additional within and between group differences. Bilaterally, women with lymphedema had less elbow flexion strength, and less ROM in shoulder flexion, abduction, external and internal rotation, elbow extension, and index proximal interphalangeal flexion compared to the women without lymphedema. These differences were most pronounced in shoulder abduction ROM (Figure 1). Moreover, the differences between affected and unaffected

sides were greater in the women with lymphedema than in the women without lymphedema in elbow flexion strength, in 1 of 3 grip measures, in 4 of the 7 regions tested for light touch, and in ROM (shoulder flexion, abduction, wrist flexion, and index proximal interphalangeal flexion). The loss of range of motion in shoulder abduction on the affected side in the Lymphedema group was twice the loss of that seen in the Non-lymphedema group (Figure 1). Table 4 summarizes significance levels for the within subjects and between groups differences.

Regression Analysis

Regression analysis was used to evaluate the contribution of the predictor variables to variance in the DASH scores (upper extremity activity) and the QOL-CS scores (quality of life). Predictors included in the regression analysis were self report variables: age, prior diagnosis of lymphedema, affected side = dominant side, current work situation, whether the participant lived alone, number of days of exercise per week, presence of upper extremity symptoms in the 3 months prior to study visit, and number of comorbidities. Objective measures included BMI, strength scores, ROM scores, volume difference, Semmes-Weinstein scores, and Purdue Pegboard time.

Predictors found to significantly contribute to the variance of the DASH scores, included in the final regression model, were past diagnosis of lymphedema, grip strength on the affected upper extremity, shoulder abduction ROM on the affected side, and number of comorbidities. This combination of predictors resulted in an R of 0.681, R^2 of 0.463, which explained 46.3% of the variance in the DASH scores (Table 5).

Table 6 summarizes the quality of life regression analysis. The combination of the predictor variables age and number of comorbidities explained 33% of the variance in the

QOL-CS total score. Though the summed strength score for the affected upper extremity did not contribute to the variance in the total QOL score, it did significantly contribute to the variance in 3 of the 4 subscales: physical 15.5%; psychological 8.0%; and social 10.6%.

DISCUSSION

The results of this study support our hypothesis that following breast cancer treatment, upper extremity functioning is impaired on the side of breast cancer treatment. Furthermore, our study demonstrates that women with lymphedema demonstrate greater impairments and greater limitation in activities than women without lymphedema.

Range of Motion

Interlimb differences in upper extremity ROM were most notable for shoulder abduction, and may indicate a need for physical therapy intervention to improve function and quality of life in women treated for breast cancer. Our findings are consistent with those of Thomas-MacLean, et al, who found restricted shoulder abduction ROM (< 170 degrees on the side of treatment) in 205 out of 347 women 6-12 months following breast cancer treatment, and an interlimb difference of greater than 10 degrees in 41% of the women [18]. Deficits in ROM following breast cancer treatment may be the result of postoperative scar tissue formation, radiation-induced fibrosis, protective posturing, disuse, and/or pain. Limitations in shoulder abduction may interfere with daily activities including reaching behind the head to wash or comb one's hair, or movements requiring maximal shoulder elevation. Indeed, our study indicates that reductions in shoulder ROM are associated with greater upper extremity disability (higher DASH scores), as became apparent with regression analysis.

Interlimb differences in shoulder abduction were greater in women with lymphedema compared to those without (18 degrees versus 9 degrees). Our data are in agreement with the findings of Kwan, et al, who compared 3 groups of women following breast cancer treatment: those with no upper extremity symptoms (n = 51); those with symptoms but no signs of lymphedema (n = 47); and those with lymphedema (n = 14). Interlimb differences in abduction ROM were 5.9 degrees, 19.9 degrees, and 31.1 degrees, respectively [26]. More aggressive breast cancer treatments, such as mastectomy versus breast conserving surgery, and axillary node dissection versus sentinel node biopsy, are associated with greater deficits in shoulder abduction ROM [27-29]. Women who undergo more aggressive treatment for their breast cancer and women who develop lymphedema may require more vigilant musculoskeletal screening following treatment.

Strength

Strength differences between the two groups of women were found primarily in elbow flexion. Compared to the women without lymphedema, reduction of elbow strength was seen bilaterally in the women with lymphedema and the deficit was greater on the affected side. Elbow flexion strength was correlated with the DASH item related to carrying objects over 10 pounds. Past advice for women with lymphedema included avoidance of lifting or carrying moderately heavy items with the affected upper extremity [30, 31] . Activity avoidance advice may be a disservice, as upper extremity strength may worsen over time with decreased use, consistent with our findings of reduced elbow flexion and grip strength in women with lymphedema. Though the interlimb difference in grip strength (1.37 kg) between groups did not reach statistical significance, grip strength did contribute to the variance in DASH scores.

Pain and sensation

The women with lymphedema more frequently reported upper extremity symptoms such as pain, ache, numbness, or heaviness in the arm. Sensory disturbances in the affected upper extremity following breast cancer treatment may result from nerve damage during surgery or following radiation, neuropathy due to chemotherapy, or may be related to lymphedema. The women with lymphedema demonstrated reduced sensation in the medial arm, which may be the result of trauma to the intercostobrachial or other nerves during axillary node dissection, resulting in subsequent sensory loss. Development of chronic pain following mastectomy has been associated with damage to the intercostobrachial nerve[32]. In the current study, there was a statistically significant but weak correlation between pain and sensory loss; women with less medial arm sensation more frequently reported pain in the upper extremity. The discomfort can be differentiated from chemotherapy-induced peripheral neuropathy, in which symptoms tend to be bilateral and begin in the fingers and toes before proceeding proximally [33]. Self-report symptoms of heaviness, numbness, and swelling have been previously associated with lymphedema and suggested as possible early indicators [34]. Clinical practice guidelines for lymphedema management include assessment of heaviness, tightness, or swelling in the affected upper extremity, in addition to circumference measurement [35].

Body mass index

Body mass index was found to be significantly higher in the women with lymphedema than those without. Twenty-one of the 31 women who had a BMI over 30, and thus would be considered to be “obese”, were in the Lymphedema group. These

findings are in agreement with extant literature, in which obesity and weight gain following breast cancer treatment have been associated with the development of lymphedema [36]. There is also evidence that high BMI and lack of vigorous physical activity may be associated with increased breast cancer risk [37]. Furthermore, it is well known that high BMI is associated with increased risk of chronic diseases such as cardiovascular disease and diabetes. These findings suggest that weight management may prove to be an important component of rehabilitation following breast cancer treatment to aid in prevention and management of lymphedema, as well as to prevent cancer recurrence and the development of other chronic illnesses.

DASH Scores

Women with a previous diagnosis of lymphedema scored higher on the DASH, indicating greater limitation in upper extremity function, compared to the women without history of lymphedema. Although the DASH scores for the women in this study indicated a relatively high level of upper extremity function, there was a statistically significant difference (10 points) between the Lymphedema and Non-lymphedema groups. A 10-point difference has been suggested as the minimal important change in DASH scores following treatment of upper extremity musculoskeletal impairments [23].

Our findings are consistent with those of Dawes, et al, who examined scores for the DASH questionnaire for a group of women following breast cancer surgery. Of the 204 respondents, 72 (35%) reported more than one symptom associated with lymphedema. These women had significantly higher scores on the DASH compared to non-symptomatic women, indicative of greater limitation in upper extremity function. Clinical assessment of a sample of 50 of the women with lymphedema symptoms yielded

statistically significant compromise in manual dexterity, grip strength, and scores on the Medical Outcome Study Short Form 36 Physical Component Scale [38]. We found similar impairments in strength in the women in our study.

Grip strength and shoulder abduction ROM on the affected side, number of comorbidities, and previous diagnosis of lymphedema significantly to the variance in the DASH scores. Interestingly, in spite of the contribution of past diagnosis of lymphedema, neither arm volume (calculated from circumference) nor impedance ratios (from bioimpedance spectroscopy) contributed to the variance in the DASH scores, which is consistent with the findings of Dawes, et al [38]. Most of the women in the Lymphedema group had mild lymphedema. Only four women had volume differences greater than 750 milliliters. This is consistent with the distribution of lymphedema categories in the three year incidence of lymphedema found by Norman, et al [11], and may be reflective of lymphedema severity in the general breast cancer-related lymphedema population. Furthermore, all but seven of the women in our study who were previously diagnosed with lymphedema had received lymphedema treatment. Previous treatment included education, compression, remedial exercise, manual lymph drainage, bandaging, and instruction in self care and management. It is possible these women chose to limit use of the affected upper extremity as part of lymphedema management, regardless of current limb volume, which may have contributed to higher DASH scores in this group. Actual volume of lymphedema does not explain concurrent functional arm limitation and may not be reflective of the true impact of chronic lymphedema.

Our study highlights the impact of upper extremity impairment, medical comorbidities, and lymphedema on upper extremity function in women following breast

cancer treatment, and underscores the need for increased exercise and physical activity in this group. Studies of exercise interventions are beginning to emerge in the literature. Ahmed, et al, in a randomized controlled trial of women with and without breast-cancer-related lymphedema, compared twice weekly weight training (n= 23) to a non-exercise control group (n = 22). The gradually progressive strengthening program resulted in significantly improved leg press and bench press strength in the exercise group, and there was no evidence of new or worsening lymphedema [30]. More recently, 32 women with breast-cancer-related lymphedema participated in a single blind randomized control study designed to evaluate the effects of aerobic and weight training exercises on lymphedema. Exercise did not exacerbate lymphedema, and two of the women in the exercise group had no evidence of lymphedema at the conclusion of the study [15]. These recent studies suggest that increased activity and exercise is beneficial and safe for women with breast-cancer-related lymphedema.

Quality of Life Scores

Surprisingly, no significant differences were demonstrated between the Lymphedema and Non-lymphedema groups for the QOL-CS total or subscale scores. Average scores for both groups were comparable to those obtained by Dow, et al [24]. That we found no significant differences between groups is in contrast to other quality of life studies in which breast-cancer-related lymphedema was associated with poorer perceived quality of life. This inconsistency may be due in part to the different QOL assessment tools utilized [39-41]. Variability of scores was high, from 3.15 to 9. 48 for the total QOL-CS score. Importantly, the number of comorbidities contributed significantly to the variance in the overall QOL score, as well as to each of the subscale

scores, with QOL scores declining with increasing numbers of comorbidities. While no difference in number of comorbidities was found between groups, the impact of these comorbidities, particularly those most common to the entire group, should be considered when evaluating the quality of life for all participants, and when assessing function in breast cancer survivors.

In addition to age and number of comorbidities, the overall strength in the affected upper extremity contributed to the variance in three of the QOL subscales (physical, psychological, and social). There were, as noted, statistically significant differences in upper extremity strength between affected and unaffected arms. Though on initial analysis these differences did not appear to be clinically significant, based on the results of regression analysis it appears strength may indeed contribute to quality of life. Therefore, upper extremity strength warrants evaluation at the least, and if found to be impaired, early treatment to promote improved function and quality of life.

Limitations

While we provide evidence that lymphedema is associated with greater reduction in upper extremity function, due to the cross sectional design we cannot conclude that the presence of lymphedema is the cause of reduced upper extremity activity.

The DASH had a floor effect in our study, which may have influenced the responsiveness of the instrument to differences in women who occupy the lower range of scores on the scale. While we did find a significant difference in scores between groups, perhaps a more responsive instrument would highlight more subtle differences in the higher functioning participants. Further investigation of upper extremity physical functioning questionnaires for use in this population may be warranted.

CONCLUSION

Our study indicates that following breast cancer treatment women with and without lymphedema present with upper extremity impairments. Women with lymphedema more frequently report pain, demonstrate bilateral deficits in shoulder ROM and upper extremity strength compared to women without lymphedema, and present with greater restrictions in activity. Reduced upper extremity strength is associated with poorer quality of life in the physical, psychological, and social subscales of the QOL-CS questionnaire. Each of these limitations is amenable to physical therapy intervention, and based on the results of this study, physical therapy should play an active role in the management of sequelae following breast cancer treatment. Physical therapy assessment and treatment of breast cancer survivors should address limb volume (and volume changes), bilateral upper extremity ROM and strength, sensation and pain, BMI and presence of other medical comorbidities, activity limitations and quality of life. It is important to keep in mind that complications from breast cancer treatment, such as lymphedema and fibrosis, may not be apparent for months to years after the cancer treatment has ended. In light of the growing numbers of breast cancer survivors, and the likelihood for development of sequelae from cancer treatment, it is imperative that physical therapists are aware of the unique problems faced by this population and advocate for prevention and evidence-based intervention.

References

1. Jemal, A., et al., *Cancer statistics, 2006.* CA Cancer J Clin, 2006. **56**(2): p. 106-30.
2. Smigal, C., et al., *Trends in breast cancer by race and ethnicity: update 2006.* CA Cancer J Clin, 2006. **56**(3): p. 168-83.
3. *American Cancer Society Cancer Facts and Figures*. 2007 [cited 2007 October 11]; Available from: http://www.cancer.org/downloads/STT/CAFF2007PWSecured.pdf.
4. de Jong, N., et al., *Prevalence and course of fatigue in breast cancer patients receiving adjuvant chemotherapy.* Ann Oncol, 2004. **15**(6): p. 896-905.
5. Jansen, C.E., et al., *A metaanalysis of studies of the effects of cancer chemotherapy on various domains of cognitive function.* Cancer, 2005. **104**(10): p. 2222-33.
6. Wampler, M.A., Miaskowski, C., Hamel, K., Byl, N., Rugo, H., Topp, K., *The Modifed Total Neuropathy Score: A Clinically Feasible and Valid Measure of Taxane-Induced Peripheral Neuropathy in Women With Breast Cancer.* The Journal of Supportive Oncology, 2006. **4**(8): p. 9-16.
7. Steegers, M.A., et al., *Effect of axillary lymph node dissection on prevalence and intensity of chronic and phantom pain after breast cancer surgery.* J Pain, 2008. **9**(9): p. 813-22.
8. Calitchi, E., et al., *Long-term results of neoadjuvant radiation therapy for breast cancer.* Int J Cancer, 2001. **96**(4): p. 253-9.
9. Fehlauer, F., et al., *Long-term radiation sequelae after breast-conserving therapy in women with early-stage breast cancer: an observational study using the LENT-SOMA scoring system.* Int J Radiat Oncol Biol Phys, 2003. **55**(3): p. 651-8.
10. Leidenius, M., et al., *Motion restriction and axillary web syndrome after sentinel node biopsy and axillary clearance in breat cancer.* American Journal of Surgery, 2003(185): p. 127-130.
11. Norman, S.A., et al., *Lymphedema in breast cancer survivors: incidence, degree, time course, treatment, and symptoms.* J Clin Oncol, 2009. **27**(3): p. 390-7.
12. McLaughlin, S.A., et al., *Prevalence of lymphedema in women with breast cancer 5 years after sentinel lymph node biopsy or axillary dissection: objective measurements.* J Clin Oncol, 2008. **26**(32): p. 5213-9.
13. Mortimer, P.S., *The pathophysiology of lymphedema.* Cancer, 1998. **83**(12 Suppl American): p. 2798-802.
14. Hayes, S.C., et al., *Lymphedema after breast cancer: incidence, risk factors, and effect on upper body function.* J Clin Oncol, 2008. **26**(21): p. 3536-42.
15. Hayes, S.C., H. Reul-Hirche, and J. Turner, *Exercise and secondary lymphedema: safety, potential benefits, and research issues.* Med Sci Sports Exerc, 2009. **41**(3): p. 483-9.
16. Heiney, S.P., et al., *Quality of life and lymphedema following breast cancer.* Lymphology, 2007. **40**(4): p. 177-84.
17. Thomas-MacLean, R., B. Miedema, and S.R. Tatemichi, *Breast cancer-related lymphedema: women's experiences with an underestimated condition.* Can Fam Physician, 2005. **51**: p. 246-7.

18. Thomas-Maclean, R.L., et al., *Arm morbidity and disability after breast cancer: new directions for care.* Oncol Nurs Forum, 2008. **35**(1): p. 65-71.
19. Cheville, A.L., et al., *Prevalence and treatment patterns of physical impairments in patients with metastatic breast cancer.* J Clin Oncol, 2008. **26**(16): p. 2621-9.
20. Norkin, C.C., White, D. J., *Measurement of Joint Motion, A Guide to Goniometry*. 3rd ed. 2003, Philadelphia: FA Davis.
21. Sander, A.P., et al., *Upper-extremity volume measurements in women with lymphedema: a comparison of measurements obtained via water displacement with geometrically determined volume.* Phys Ther, 2002. **82**(12): p. 1201-12.
22. Waeber, M., Castiglione-Gertsch, M., Dietrich, D., Thurlimann, B., Goldhirsch, A., Brunner, K. W., Borner, M. M., *Adjuvant therapy after excision and radiation of isolated postmastectomy locoregional breast cancer recurrence: definitive results of a phase III randomized trial (SAKK 23/82) comparing tamoxifen with observation.* Ann Oncol, 2003. **14**(8): p. 1215-21.
23. Gummesson, C., I. Atroshi, and C. Ekdahl, *The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery.* BMC Musculoskelet Disord, 2003. **4**: p. 11.
24. Dow, K.H., et al., *An evaluation of the quality of life among long-term survivors of breast cancer.* Breast Cancer Res Treat, 1996. **39**(3): p. 261-73.
25. Norman, S.A., et al., *Development and validation of a telephone questionnaire to characterize lymphedema in women treated for breast cancer.* Phys Ther, 2001. **81**(6): p. 1192-205.
26. Kwan, W., et al., *Chronic arm morbidity after curative breast cancer treatment: prevalence and impact on quality of life.* J Clin Oncol, 2002. **20**(20): p. 4242-8.
27. Rietman, J.S., et al., *Long term treatment related upper limb morbidity and quality of life after sentinel lymph node biopsy for stage I or II breast cancer.* Eur J Surg Oncol, 2006. **32**(2): p. 148-52.
28. Lauridsen, M.C., et al., *Shoulder disability and late symptoms following surgery for early breast cancer.* Acta Oncol, 2008. **47**(4): p. 569-75.
29. Nesvold, I.L., et al., *Arm and shoulder morbidity in breast cancer patients after breast-conserving therapy versus mastectomy.* Acta Oncol, 2008. **47**(5): p. 835-42.
30. Ahmed, R.L., et al., *Randomized controlled trial of weight training and lymphedema in breast cancer survivors.* J Clin Oncol, 2006. **24**(18): p. 2765-72.
31. Harris, S.R. and S.L. Niesen-Vertommen, *Challenging the myth of exercise-induced lymphedema following breast cancer: a series of case reports.* J Surg Oncol, 2000. **74**(2): p. 95-8; discussion 98-9.
32. Torresan, R.Z., Cabello, C., Conde, D. M., Brenelli, H. B., *Impact of the preservation of the intercostobrachial nerve in axillary lymphadenectomy due to breast cancer.* Breast J, 2003. **9**(5): p. 389-92.
33. Visovsky, C., et al., *Evaluation and management of peripheral neuropathy in diabetic patients with cancer.* Clin J Oncol Nurs, 2008. **12**(2): p. 243-7.
34. Armer, J.M., et al., *Predicting breast cancer-related lymphedema using self-reported symptoms.* Nurs Res, 2003. **52**(6): p. 370-9.

35. Harris, S.R., et al., *Clinical practice guidelines for the care and treatment of breast cancer: 11. Lymphedema.* Cmaj, 2001. **164**(2): p. 191-9.
36. Vignes, S., M. Arrault, and A. Dupuy, *Factors associated with increased breast cancer-related lymphedema volume.* Acta Oncol, 2007. **46**(8): p. 1138-42.
37. Silvera, S.A., et al., *Energy balance and breast cancer risk: a prospective cohort study.* Breast Cancer Res Treat, 2006. **97**(1): p. 97-106.
38. Dawes, D.J., et al., *Impact of lymphoedema on arm function and health-related quality of life in women following breast cancer surgery.* J Rehabil Med, 2008. **40**(8): p. 651-8.
39. Chachaj, A., et al., *Physical and psychological impairments of women with upper limb lymphedema following breast cancer treatment.* Psychooncology, 2009.
40. Ridner, S.H., *Quality of life and a symptom cluster associated with breast cancer treatment-related lymphedema.* Support Care Cancer, 2005. **13**(11): p. 904-11.
41. Mak, S.S., et al., *Lymphedema and quality of life in Chinese women after treatment for breast cancer.* Eur J Oncol Nurs, 2009. **13**(2): p. 110-5.

Table 1. Characteristics for participants, grouped by self-report of previous lymphedema diagnosis
Mean (SD) or numbers of women

Characteristics	All participants n = 144	No Lymphedema n = 71	Lymphedema n = 73	Difference in means (sd)	95% CI	Signif *(p)*
Age (years)	56.33 (9.44)	55.17 (8.76)	57.47 (9.98)	2.30 (1.57)	-5.39 to 0.80	0.15†
Body mass index	26.4 (5.54)	25.45 (4.63)	27.33 (6.22)	1.88 (0.91)	-3.68 to -0.08	0.04†
Arm volume difference (ml)	109.9 (243.21)	-7.9 (72.61)	224.5 (292.16)	-232.34 (35.26)	-302.5 to -162.2	< 0.001†
Affected side Right/Left	67/77	29/42	38/35			0.18‡
Dominant UE R/L/ambidext.	130/11/3	64/5/2	66/6/1			0.81‡
Affected side = Dominant side	71	33	38			0.50‡
Years of education	16.69 (2.71)	17.04 (2.48)	16.33 (2.98)	0.71 (0.45)	-0.18 to 1.60)	0.12†
Days/week of exercise	3.41 (1.72)	3.51 (1.64)	3.31 (1.80)	0.21 (0.29)	-0.37 to 0.77	0.48†
No. of women working for pay	85	41	44			0.76‡
Years since BC diagnosis	6.17 (5.35)	4.94 (4.06)	7.37 (6.15)	2.43 (0.87)	-4.15 to -0.72	0.01†
No. of women who had: BCS Mastectomy	 82 62	 39 32	 43 30			0.63‡
Sentinel lymph node biopsy	93	54	39			0.01‡
Axillary lymph node dissection	108	46	62			<0.005‡
No. of nodes removed	10.99 (7.48)	8.59 (6.43)	13.39 (7.73)	4.80 (1.20)	-7.18 to -2.43	< 0.001†
No. who received radiation therapy	107	49	58			0.15‡
No. who received chemotherapy	101	48	53			0.51‡
No. who received prior treatment for lymphedema	81	15	66			<0.001‡

BC: breast cancer
BCS: breast conserving surgery
CI: confidence interval

† independent t-tests for differences in means
‡ Chi square

Table 2 DASH and QOL-CS scores

	Non-Lymphedema Group		Lymphedema Group		Difference in the means DASH: Mann Whitney U QOL: 95% CI of the difference
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
DASH (0-100 scale) Higher score: greater disability	8.67 (12.63)	3.67 (0-57.8)	18.48 (17.30)	14.17 (1-76.7)	$p < .001$
QOL-CS total score (0-10) Higher score: better QOL	6.75 (1.26)	6.12 (3.18-9.28)	6.50 (1.48)	6.63 (3.15-9.48)	0.28 (-.20. .71)
QOL-Physical (0-10)	8.18 (1.20)	8.43 (4.88-10)	7.83 (1.35)	8 (3.4-10)	0.10 (-.07, .77)
QOL-Psychological (0-10)	6.39 (1.54)	6.56 (2.50- 9.06)	6.13 (1.74)	6.39 (2.33-9.72)	.34 (-.28. .80)
QOL Social (0-10)	7.23 (1.87)	7.75 (1.88-9.75)	6.91 (2.13)	7.25 (.62-10)	.35 (-.35, .99)
QOL Spiritual (0-10)	5.56 (1.87)	5.43 (.14-9.43)	5.59 (1.93)	5.71 (1.57-10)	.93 (-.66. ,60)

Table 3 Comparison of means

	Non Lymphedema group N = 71 Unaffected arm versus affected arm			Lymphedema group N = 73 Unaffected arm versus affected arm		
UE measure	Unaffected Mean (SD)	Affected Mean (SD)	Mean diff (95% CI)	Unaffected Mean (SD)	Affected Mean (SD)	Mean diff (95% CI)
Purdue Pegboard time(sec)	80.2 (8.1)	80.6 (12.3)	-0.4 (-3.0, 2.2)	82.4 (10.4)	82.8 (12.1)	-0.3 (-3.1, 2.4)
Finger Tapper (no. of taps)	44.5 (7.6)	45.4 (7.0)	-0.9 (-2.3, 0.6)	43.0 (7.5)	43.5 (6.9)	-0.5 (-2.1, 1.1)
Shoulder abduction strength kg	12.5 (2.4)	12.1 (2.6)	0.4 (0.03 ,0.8) *	11.8 (2.5)	11.5 (4.6)	0.3 (-0.6, 1.2)
Elbow flexion strength	20.9 (4.0)	20.9 (4.2)	-0.01 (-0.4, 0.4)	19.6 (3.7)	18.5 (3.8)	1.1 (0.6, 1.5) *
Wrist flexion strength	9.4 (2.2)	9.6 (2.2)	-0.2 (-0.5, 0.1)	8.9 (2.2)	9.4 (2.2)	-0.4 (-0.8, -0.1)*
Grip strength	27.5 (7.0)	26.6 (7.1)	0.9 (-0.02, 1.8)	26.6 (6.4)	25.2 (6.2)	1.4 (0.3, 2.5) *
Key grip strength	5.6 (1.5)	5.6 (1.6)	0.1 (-0.2, 0.4)	5.5 (1.6)	5.3 (1.4)	0.2 (-0.9, 0.5)
3 point chuck grip	6.5 (1.7)	6.7 (1.8)	-0.2 (-0.5, 0.1)	6.7 (1.8)	6.3 (1.7)	0.4 (0.1, 0.7) *
All strength	82.8 (15.4)	81.6 (15.9)	1.3 (-0.3, 2.9)	79.5 (13.8)	75.8 (14.9)	3.8 (1.6, 5.9) *
VPT digits (microns)	.1 (.1)	.13 (.148)	-0.01 (-0.03, 0.003)	.12 (0.078)	.13 (.103)	-0.01 (-0.03, 0.002)
VPT radial styloid	.5 (.4)	.5 (.5)	-0.03 (-0.1, 0.04)	.5 (.4)	.5 (.3)	-0.1 (-0.1, 0.01)
VPT medial epic.	.9 (.9)	.8 (.9)	0.1 (-0.1, 0.2)	.9 (.864)	1.1 (1.08)	-0.2 (-0.5, 0.1)
SWM web	20.5 (2.7)	20.9 (2.6)	-0.4 (-1.1, 0.3)	20.04 (2.42)	20.18 (2.30)	-0.2 (-0.7, 0.4)
SWM index finger	20.5 (2.4)	21.0 (2.28)	-0.5 (-1.0, 0.03)	20.6 (2.67)	20.1 (2.9)	0.5 (0.04, 1.03) *
SWM little finger	21.5 (2.5)	22.1 (2.2)	-0.6 (-1.1, -0.03) *	21.6 (2.6)	21.7 (2.7)	-0.1 (-0.6, 0.5)
SWM lateral forearm	20.8 (2.5)	21.3 (2.1)	-0.5 (-1.0, 0.1)	20.3 (2.2)	19.9 (2.9)	0.5 (-0.2, 1.2)
SWM medial forearm	19.8 (2.0)	19.8 (1.9)	-0.04 (-0.5, 0.4)	19.3 (2.2)	18.6 (2.2)	0.7 (0.2, 1.2) *
SWM lateral arm	20.1 (2.3)	20.1 (2.5)	-0.04 (-0.6, 0.5)	19.7 (2.2)	19.4 (2.2)	0.3 (-0.1, 0.8)
SWM medial arm	19.1 (2.5)	18.9 (2.6)	0.3 (-0.3, 0.8)	19.1 (2.6)	17.4 (3.2)	1.7 (0.9, 2.5) *
Shoulder flexion ROM	169 (8)	166 (9)	3.0 (1.7, 4.5) *	167 (9)	161 (12)	6.0 (3.9, 8.2) *
Shoulder abduction ROM	162 (19)	153 (25)	9.3 (4.8, 13.7) *	158 (20)	140 (29)	17.5 (11.7, 23.4) *
Shoulder ER ROM	93 (9)	89 (11)	3.7 (1.4, 6.0) *	89 (10)	86 (13)	2.8 (0.3, 5.3) *
Shoulder IR ROM	43 (9)	42 (10)	0.9 (-1.1, 2.9)	45 (9)	44 (10)	1.1 (-0.9, 3.2)
Elbow flexion ROM	149 (4)	150 (4)	-0.5 (-1.2, -0.2)	150 (4)	149 (4)	0.8 (-0.1, 1.6)
Elbow extension ROM	2 (4)	2 (4)	0.2 (-0.4, 0.7)	.3 (5)	.9 (4)	-0.7 (-1.4, 0.1)
Wrist flexion ROM	77 (8)	78 (7)	-0.6 (-2.0, 0.8)	77 (7)	75 (7)	2.0 (0.8, 3.1) *
Wrist extension ROM	74 (7)	73 (8)	0.3 (-0.8, 1.3)	72 (7)	71 (8)	1.5 (-0.1, 3.2)
Index PIP ROM	114 (6)	114 (4)	-0.3 (-1.3, 0.7)	112 (9)	110 (7)	1.6 (0.01, 3.2) *
Overall ROM score	882 (40)	866 (54)	15.9 (8.3, 23.4) *	870 (47)	836 (62)	32.7 (22.2, 43.2) *

$p < 0.05$
VPT: vibration perception threshold (in microns)
SWM: Semmes Weinstein Monofilaments (number of correct responses)
ROM: Range of motion (in degrees)

Table 4 Summary of Within and Between Groups Comparison

	Within Subjects Contrasts: Main effect of side Was the difference between sides significant, regardless of group? *p*	Between Subjects Effects: Main effect of lymphedema Was the difference between groups significant, averaged across both arms? *p*	Interaction effect: Side and Lymphedema Were the differences greater in the lymphedema group? *p*
Purdue Pegboard time(sec)	0.68	0.16	0.95
Finger Tapper (no. of taps)	0.23	0.13	0.73
Shoulder abduction strength kg	0.16	0.16	0.82
Elbow flexion strength	0.001	0.004	0.001
Wrist flexion strength	0.01	0.25	0.32
Grip strength	0.02	0.27	0.51
Key grip strength	0.16	0.53	0.51
3 point chuck grip	0.34	0.65	0.002
All strength	<0.001	0.06	0.07
VPT digits(microns)	0.03	0.69	0.98
VPT radial styloid	0.07	0.69	0.66
VPT medial epic.	0.32	0.22	0.06
SWM web	0.20	0.10	0.60
SWM index finger	0.94	0.40	0.01
SWM little finger	0.09	0.57	0.20
SWM lateral forearm	1.0	0.01	0.03
SWM medial forearm	0.07	0.01	0.04
SWM lateral arm	0.42	0.09	0.296
SWM medial arm	0.004	0.04	0.00
Shoulder flexion ROM	< 0.001	0.02	0.02
Shoulder abduction ROM	< 0.001	0.01	0.03
Shoulder ER ROM	< 0.001	0.033	0.59
Shoulder IR ROM	0.15	0.15	0.86
Elbow flexion ROM	0.63	0.91	0.02
Elbow extension ROM	0.29	0.03	0.07
Wrist flexion ROM	0.14	0.13	0.01
Wrist extension ROM	0.07	0.12	0.20
Index PIP ROM	0.16	0.01	0.05
Overall ROM score	<0.001	0.01	0.01

Table 5 DASH Regression Summary

DASH Regression Summary

Model	R	R Square	Change Statistics		
			R Square Change	F Change	Sig. F Change *p*
1. Subject diagnosed with lymphedema	.378	.143	.143	23.269	.000
2. Subject diagnosed with lymphedema, grip strength affected side	.592	.351	.208	44.646	.000
3. Subject diagnosed with lymphedema, grip strength affected, shoulder abduction ROM affected	.620	.385	.034	7.618	.007
4. Subject diagnosed with lymphedema, grip strength affected, shoulder abduction ROM affected, number of comorbidities	.681	.463	.078	19.977	.000

Coefficients Table

	Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	.466	.699		0.668	0.51	-.915	1.848
subject diagnosed with lymphedema	.911	.212	.277	4.302	<.001	.492	1.330
shoulder abduction ROM affected	-.012	.004	-.202	-3.072	0.003	-.020	-.004
grip strength affected	-.038	.007	-.341	-5.099	<.001	-.052	-.023
No. of #Comorbidities	.320	.072	.291	4.470	<.001	.178	.461

Table 6 Quality of Life Regression Summaries

a. Model Summary: QOL Total Score

Model	R	R Square	Change Statistics		
			R Square Change	F Change	Sig. F Change
1 Age	.287	.083	.083	12.613	.001
2 Age, No. of Comorbidities	.574	.330	.247	51.193	.000

Coefficients (Dependent Variable: QOL Total Score)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.290	.575		7.46	.000	3.153	5.426
	Age	.054	.010	.374	5.30	.000	.034	.074
	Comorbidities	-.463	.065	-.504	-7.16	.000	-.592	-.335

b. Model Summary QOL Physical Well Being

Model	R	R Square	Change Statistics		
			R Square Change	F Change	Sig. F Change
1 Age	.186	.035	.035	4.981	.027
2 Age, summed strength score affected side	.436	.190	.155	26.441	.000
3 Age, summed strength score affected, Comorbidities	.574	.330	.140	28.550	.000

Coefficients (Dependent Variable: QOL Physical Well Being)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	3.715	.863		4.30	.000	2.008	5.422
	Age	.048	.010	.359	4.83	.000	.029	.068
	Summed strength score affected	.012	.003	.326	4.30	.000	.007	.018
	Comorbidities	-.339	.063	-.389	-5.34	.000	-.464	-.213

Table 6 continued

c. Model Summary QOL Psychological Well Being

Model	R	R Square	Change Statistics		
			R Square Change	F Change	Sig. F Change
1 Age	.278	.077	.077	11.616	.001
2 Age, Summed strength score affected	.396	.157	.080	13.108	.000
3 Age, Summed strength score affected, Comorbidities	.563	.317	.159	31.958	.000

Coefficients (Dependent Variable: QOL Psychological Well Being)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
1 (Constant)	1.253	1.118		1.12	.264	-.958	3.465
Age	.072	.013	.415	5.54	.000	.046	.098
Summed strength score aff.	.010	.004	.202	2.64	.009	.002	.017
Comorbidities	-.464	.082	-.416	-5.65	.000	-.627	-.302

Table 6 continued

d. Model Summary QOL Social Well Being

Model	R	R Square	Change Statistics		
			R Square Change	F Change	Sig. F Change
1 Age	.282	.080	.080	11.756	.001
2 Age, Summed Strength Score aff.	.431	.186	.106	17.641	.000
3 Age, Summed Strength Score aff, Comorbidities	.586	.343	.157	32.058	.000

Coefficients (Dependent Variable: QOL Social Well Being)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
1 (Constant)	.510	1.326		.385	.701	-2.112	3.133
Age	.090	.015	.431	5.80	.000	.059	.120
Summed Strength Score affected	.014	.004	.245	3.22	.002	.005	.022
Comorbidities	-.549	.097	-.413	-5.66	.000	-.741	-.357

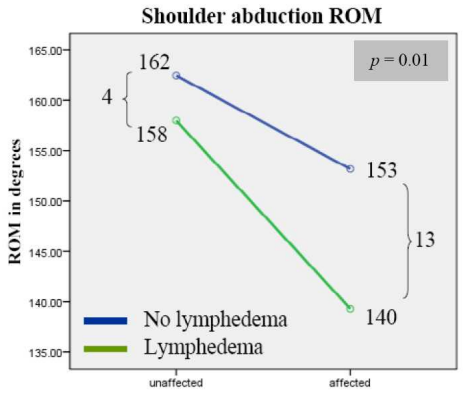
e. Model Summary QOL Spiritual Well Being

Model	R	R Square	Change Statistics		
			R Square Change	F Change	Sig. F Change
1 No. of comorbidities	.172	.030	.030	4.293	.040

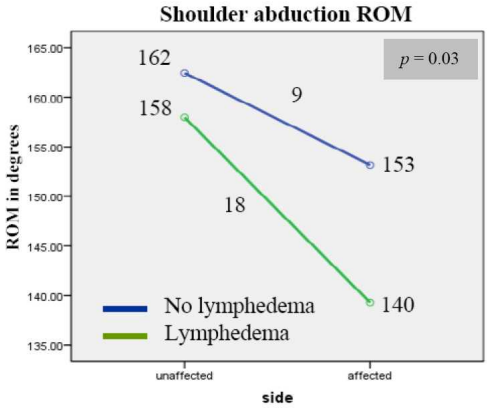
Coefficients (Dependent Variable: QOL Spiritual Well Being)_

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
1 (Constant)	5.912	.226		26.112	.000	5.464	6.360
No. of Comorbidities	-.219	.106	-.172	-2.072	.040	-.427	-.010

Figure 1



Between Subjects Effects:
Bilateral reductions in ROM in the women with lymphedema (p = .01)



Within Subjects Contrasts:
The affected side demonstrates less shoulder abduction than the unaffected side in both groups (p < .001)
The reductions are greater in the lymphedema group (p = .003)

Publishing Agreement

It is the policy of the University to encourage the distribution of all theses, dissertations, and manuscripts. Copies of all UCSF theses, dissertations, and manuscripts will be routed to the library via the Graduate Division. The library will make all theses, dissertations, and manuscripts accessible to the public and will preserve these to the best of their abilities, in perpetuity.

***Please sign the following statement**:*

I hereby grant permission to the Graduate Division of the University of California, San Francisco, to release copies of my thesis, dissertation, or manuscript to the Campus Library to provide access and preservation, in whole or in part, in perpetuity.

Author Signature

6-4-09
Date