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Comparison of shoulder flexibility, strength, and function between breast cancer survivors and healthy participants

Shana Harrington · Darin Padua · Claudio Battaglini · Lori A. Michener · Carol Giuliani · Joseph Myers · Diane Groff

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Abstract
Introduction Deficits after breast cancer treatment have been examined by comparing the surgically affected upper extremity to the unaffected extremity. It is not possible to know precisely if anti-cancer treatment such as radiation and chemotherapy had any effect on the unaffected arm. The purpose of this study was to compare ROM, strength, and shoulder function between breast cancer survivors and healthy, matched controls.
Methods Shoulder pain and function was assessed using the Disabilities of the Arm Shoulder Hand (DASH) and the Pennsylvania Shoulder Score (PSS). Active and passive range of motion (ROM) for shoulder flexion, extension, external rotation (ER) at 0° and 90° of abduction, internal rotation (IR) at 90° of abduction were measured on the affected side using a digital inclinometer. Strength was measured using a hand held dynamometer for scapular abduction and upward rotation, scapular depression and adduction, flexion, internal rotation, ER, scaption, and horizontal adduction.
Results Significant differences were found between the two groups for the DASH ($p<0.001$) and PSS ($p<0.001$), active flexion ($p<0.001$), 90° ER ($p=0.020$), extension ($p=0.004$) and passive flexion ($p<0.001$) and 90° ER ($p=0.012$). All 7 of the shoulder girdle strength measures were significantly different between groups for abduction and upward rotation ($p=0.006$), depression and adduction ($p=0.001$), flexion ($p<0.001$), ER ($p=0.004$), IR ($p=0.001$), scaption ($p<0.001$), and adduction ($p<0.001$).
Discussion/Conclusions These results provide preliminary evidence to suggest clinicians focus on these particular ROM, strength, and shoulder function measures when treating a breast cancer survivors.
Implications for Cancer Survivors Shoulder ROM, strength, and function are important to assess in BCS.

Keywords Breast cancer · Shoulder · Shoulder function · Oncology

S. Harrington (✉)
Department of Clinical and Applied Movement Sciences,
The University of North Florida,
1 UNF Drive,
Jacksonville, FL 32224, USA
e-mail: s.harrington@unf.edu

D. Padua · J. Myers
Department of Exercise and Sport Science,
The University of North Carolina at Chapel Hill,
Chapel Hill, NC, USA

C. Battaglini · D. Groff
UNC Lineberger Comprehensive Cancer Center,
Department of Exercise and Sport Science,
The University of North Carolina at Chapel Hill,
Chapel Hill, NC, USA

L. A. Michener
Department of Physical Therapy,
Virginia Commonwealth University—MCV Campus,
Richmond, VA, USA

C. Giuliani
Department of Allied Health Sciences,
The University of North Carolina at Chapel Hill,
Chapel Hill, NC, USA

Introduction

In the United States it is estimated that 2.5 million women have been diagnosed with and treated for breast cancer [1]. Approximately 89% of women diagnosed with breast cancer survive for 5 years or longer [1]. While survival rates continue to improve, the focus on survivorship issues and quality of life related to breast cancer treatment has recently gained significantly more attention [2]. Breast cancer survivors (BCS) should be afforded the best possible care to manage the effects of breast cancer treatment and restore optimal shoulder function.

Given the impact breast cancer treatment has on individuals, it is evident that the care continuum should include evidence based supportive therapeutic services to help limit fatigue, deconditioning, and upper extremity dysfunction during and following treatment [3, 4]. Several studies have found restricted shoulder movements [4–18], decreased upper extremity strength [12, 14, 17, 19–23], and impaired shoulder function in BCS [2, 8, 10]. Although restricted upper extremity ROM and strength deficits after treatment in BCS have been previously reported in the literature, these evaluations were conducted by comparing the surgically affected upper extremity to the unaffected extremity. Through the current empirical evidence, it is not possible to know precisely if anti-cancer treatment such as radiation and chemotherapy had any effect on the unaffected arm, thus making it difficult to quantify any functional decline in upper extremity of BCS. Furthermore, examining these variables on both the affected and unaffected extremity is often a taxing experience for women who are recently recovering from their primary surgery. Because of these factors, comparisons between BCS with healthy controls are needed. Currently there have been no studies conducted that have compared ROM, strength, or shoulder function in BCS to healthy age, matched, and gender controls.

The purpose of this study was to examine differences that may exist between BCS and healthy age, gender and body mass index matched controls for shoulder range of motion (ROM), strength, and self-report shoulder function. We hypothesized that the BCS group would have 1) a greater loss of function, as measured by two self-report measures of the Disabilities of the Arm, Shoulder and Hand (DASH) and the Pennsylvania Shoulder Score (PSS), 2) decreased active and passive shoulder ROM, and 3) decreased shoulder strength when compared to the age, gender and body mass index matched control group. Results from this study will enhance the understanding of the impact that breast cancer treatment has on the shoulder in BCS.

Materials and methods

Participants

A case–control design was used to compare BCS and a control (CON) group of healthy, age and gender matched participants. The BCS group consisted of women who had been diagnosed with stage 0-III breast cancer in the Raleigh-Chapel Hill, North Carolina region and had completed all of their primary treatment (surgery, chemotherapy, and/or radiation) no greater than 6 months prior to the testing date. The BCS group was recruited through physicians who had knowledge of the *Get REAL and HEEL Breast Cancer Research Program* eligibility criteria at University of North Carolina-Chapel Hill (UNC-CH). Medical consent was required from each participant's physician prior to beginning this study. The eligibility criteria included: 1) female, age between 25 and 75 years, 2) no recent history of rehabilitation (6 months prior to diagnosis of breast cancer) for an upper extremity, thoracic, or cervical musculoskeletal condition, and 3) no known neuromuscular dysfunctions or taking medications that may influence neuromuscular performance. The CON group was recruited by word of mouth in the same North Carolina region and served as the comparison group. The CON group was matched by gender, age, hand dominance, and body mass index (BMI) to t the BCS group, ages within ±5 years, and a BMI within ±3 kg/m^2. Eligibility criteria for the CON group included the same eligibility criteria as those in the BCS group, as well as no previous diagnosis of breast cancer.

Testing procedures

The method for data collection was the same for both groups. Participants reported for a single testing session at the Neuromuscular Research Laboratory at UNC-CH lasting approximately 75 min. All participants read and signed an informed consent form approved by the UNC-CH Biomedical Institutional Review Board. Participants then completed an intake demographic form and two self-report function/disability questionnaires. Next, shoulder active and passive range of motion (ROM) and strength were measured by the same licensed physical therapist. The physical therapist was not blinded to which group the women belonged to in this study.

Measurements

Shoulder function was measured using the Disabilities of the Arm, Shoulder, and Hand (DASH) and the Penn Shoulder Score (PSS) self-report functional outcome instruments. The DASH consists of 30 questions in the disability and symptoms section, and two optional modules to assess shoulder disability with sport/music and work [24]. For this study, the optional modules were not used. The DASH ranges from 0 to 100, where a higher score is a sign of greater upper extremity disability [25]. The DASH has been shown to be a valid and reliable measure for reporting outcome of patients with a variety of shoulder disorders

[26]. The PSS is a 100-point shoulder-specific self-report questionnaire where lower scores on each subscale indicates decreased function [27]. The PSS consists of 3 subscales: pain, satisfaction, and function [27]. The PSS has been found to be a valid and reliable measure for reporting outcome of patients with a variety of shoulder disorders [27].

Active and passive ROM was measured in degrees using a digital inclinometer (The Saunders Group, Inc., Chaska, MN). Participant's upper extremity active ROM was assessed in the following order: supine flexion, supine ER at 0° of abduction, supine ER at 90° of abduction, supine IR at 90° of abduction, and prone extension. Three trials of active ROM were performed followed by three trials for passive ROM on the affected extremity and the average was used for data analysis. All active and passive ROM measures were performed according to Norkin and White [28]. Intra-tester reliability was established during pilot data for active ROM ($ICC_{3,1}$ 0.84–1.0) and passive ROM ($ICC_{3,1}$ 0.97–1.0).

Strength peak muscle force in pounds was measured by means of a maximal voluntary isometric contraction (MVIC) using a hand held dynamometer (Lafayette Instrument®, Lafayette, IN). Strength was assessed for scapula abduction and upward rotation, scapula depression and adduction, shoulder flexion, shoulder internal rotation, shoulder external rotation, shoulder scaption, and shoulder horizontal adduction in a randomized order to minimize the effects of fatigue. The participants were asked to "push as hard as you can without moving your arm" for a 5 s count. Thirty seconds rest occurred between each trial. A 1 min rest period occurred between each testing position. Scapula abduction and upward rotation and scapula depression and adduction were performed according to Kendall [29] and the test positions of humeral flexion, scaption, and adduction were performed according to Hislop and Montgomery [30]. Each measurement was taken three times and the average was used for data analysis. Intra-tester reliability was been established during pilot data for all shoulder girdle strength measures ($ICC_{3,1}$=0.72–0.99)

Data analysis

Pilot data was collected on ten BCS to determine the a-priori power calculations. Based on the a-priori power calculations, it was estimated that 20–25 participants in each group (BCS and CON) were required for this study to obtain a power of 0.80 in this study.

Means and standard deviations were calculated per group for all variables of function, ROM, and strength as well as the demographic data of age, height, weight, and BMI. A one-way analysis of variance (ANOVA) was conducted to evaluate the functional outcome measure scores on the DASH and PSS between the BCS and CON. A one-way multivariate analysis of variance (MANOVA) was conducted to determine if differences existed between the BCS and CON groups on the dependent variables of affected shoulder girdle ROM, and affected shoulder girdle strength. Analyses of variance (ANOVA) were conducted as follow-up tests to the MANOVA. SPSS® statistical software (version 16.0, SPSS Inc., Chicago, IL) was used to analyze all data. Statistical significance levels for all comparisons was set a priori of alpha=0.05.

Results

A total of 24 BCS aged 50.8±9.51 years and 24 CON aged 50.4±9.97 years participated in this study, participant demographics can be seen in Table 1. Eight BCS underwent lumpectomy; seven received both chemotherapy and radiation. Sixteen BCS underwent a mastectomy; twelve of these received both chemotherapy and radiation, and two of the BCS received radiation. One BCS did not complete the DASH or PSS. A second BCS PSS was unable to be scored due to missing data. Corresponding matched controls were dropped from analysis on the DASH and PSS. Analysis of the PSS included a total of 22 BCS and 22 CON and a total of 23 BCS and 23 CON for the DASH. One BCS was unable to lie prone to complete passive and active extension ROM measures as well as the prone strength measure of scapula depression and adduction. Therefore, a total of 23 BCS and 23 CON were used in the analysis for the ROM and strength data.

The ANOVA revealed a statistical significant difference between groups for the DASH ($F_{1,45}$=27.90, $p<0.001$) and PSS ($F_{1,44}$=30.54, $p<0.001$) with significantly greater shoulder disability on both outcome measures in the BCS group (DASH=19.35; PSS=77.10) as compared to the CON group (DASH=1.16; PSS=97.50) as shown in Table 2. There was a statistically significant difference found between groups on all 3 PSS subscales which are depicted in Table 3.

Significant differences in active and passive ROM were found between the groups Wilks's Λ=0.57 ($F_{10,35}$=2.67, p=0.015). A one-way analysis of variance (ANOVA) on each of the dependent variables for active and passive shoulder

Table 1 Participant demographic data

	BCS (n=24)	CON (n=24)
Age (years)	51.0±9.5	50.4±10.0
Height (cm)	65.2±2.7	65.2±2.9
Weight (kg)	76.0±15.1	73.2±15.1
BMI (kg/m^2)	28.0±5.5	27.0±5.5

Table 2 Mean, SD, 95% CI, *p* value, and effect size for the DASH and PSS

	BCS (DASH n=23, PSS n=22)			CON (DASH n=23, PSS n=22)				
	Mean	SD	95% CI	Mean	SD	95% CI	P	ES
DASH	19.4	17.0	14.4,24.3	1.6	1.7	-3.1,6.0	<0.001*	1.1
PSS	77.1	18.0	72.0,83.0	96.0	3.4	92.3,103.0	<0.001*	1.2

*significant differences

ROM was conducted as follow-up tests to the MANOVA; results are presented in Tables 4 and 5. Both active ($F_{1,46}$= 20.95, $p<0.001$), and passive ($F_{1,46}$=18.06, $p<0.001$) shoulder flexion were significantly decreased in the BCS group. It was also found that both active ($F_{1,46}$=5.79, p= 0.020) and passive ($F_{1,46}$=6.84, p=0.012) 90° ER were significantly decreased in the BCS group, and significantly less active shoulder extension ($F_{1,46}$=9.90, p=0.004) in the BCS group.

Significant differences were found between the groups on the dependent measures, Wilks's Λ=0.60 ($F_{7,40}$=3.81, p= 0.003) revealing decreased upper extremity strength in the BCS group when compared to the CON group. Analyses conducted for affected shoulder girdle strength were conducted as follow-up tests to the MANOVA. All seven of the shoulder strength measures were different between groups and are displayed in Table 6; scapular abduction and upward rotation ($F_{1,46}$=8.45, p=0.006), scapular depression and adduction ($F_{1,46}$=9.20, p=0.001), flexion ($F_{1,46}$=19.37, $p<$ 0.001), external rotation (F1,46=12.05, p=0.004), internal rotation ($F_{1,46}$=9.91, p=0.001), scaption ($F_{1,46}$=15.07, $p<$ 0.001), and adduction ($F_{1,46}$=20.55, $p<0.001$).

Discussion

Introduction

We examined differences between BCS and healthy age, matched, and gender controls for upper extremity function, strength, shoulder active ROM, and shoulder passive ROM. Because BCS reported significant fatigue during pilot data collection, matched controls were used for comparisons. Breast cancer survivors who had finished their primary treatment within the past 6 months demonstrated decreased function as evidenced by scores on the DASH and PSS, limited shoulder ROM, and decreased strength.

Function (DASH/PSS)

Previous research has focused on comparing shoulder function, strength, and ROM to the unaffected side in BCS. Using the unaffected side of a BCS might not be an accurate representation of a healthy/normal shoulder due to the systemic effects of treatments such as chemotherapy and radiation. The findings in this study indicate that compared to healthy, matched participants, the BCS group had significantly lower shoulder function on the DASH and PSS, decreased shoulder ROM (of active and passive shoulder flexion and 90° ER ROM), active extension ROM, and less shoulder strength (scapular abduction and upward rotation, scapular depression and adduction, flexion, external rotation, internal rotation, scaption, and adduction).

Because of modern treatment options for breast cancer, more women are becoming long term survivors, therefore assessing upper extremity disability is an increasingly important issue [13, 31, 32]. There is no set standard for the DASH that indicates shoulder disability, although it has been suggested that scoring≥20/100 may represent a significant loss of function [33]. The mean DASH score for the BCS in our study was slightly below 20; at 19.35 (0=no disability). Further analysis reveals 11 of the 23 BCS had DASH scores greater than 20, with an average score of 32.60. All but one of these BCS underwent a mastectomy. The minimal clinically important difference (MCID) for the DASH is 10.2 points [34]. Our mean difference in DASH scores between the BCS (19.35) and CON (1.56) of 17.79 is greater than the MCID. Also, the percentage of pairs in our study (BCS–CON) who had greater than the 10.2 MCID was 56%, suggesting a clinically important difference between groups

A recent study by Crosbie et al. (2010) examined shoulder function utilizing the DASH on 53 women who were at least 12 months post-surgery for a unilateral mastectomy [35]. Results showed an average DASH score

Table 3 Mean, SD, 95% CI, *p* value, and effect size for subscales of PSS (scores)

	BCS (n=22)			CON (n=22)				
	Mean	SD	95% CI	Mean	SD	95% CI	P	ES
Pain	25.0	5.11	24.0, 28.0	29.4	1.2	28.0,31.0	0.000*	0.8
Satisfaction	5.7	2.9	4.8, 6.7	9.4	1.4	8.5,10.3	0.000*	1.3
Function	49.0	9.4	46.0, 52.0	57.0	1.6	56.0,61.4	0.000*	1.1

*significant differences

Table 4 Mean, SD, 95% CI, p value, and effect size for active shoulder ROM (degrees)

	BCS (n=23)			CON (n=23)				
	Mean	SD	95% CI	Mean	SD	95% CI	P	ES
Flexion	157.0	10.3	153.1,60.0	168.2	6.0	165.0, 173.0	<0.001*	1.1
0° ER	75.7	16.0	70.4, 81.0	78.0	9.3	72.4, 83.0	0.588	0.1
90° ER	87.6	19.3	81.3, 94.0	99.0	10.3	92.0, 105.0	0.020*	0.6
90° IR	60.7	12.0	56.0, 66.0	66.4	12.0	61.7, 71.2	0.095	0.5
Extension	25.8	7.0	23.1, 29.0	32.0	6.2	28.9, 34.2	0.004*	0.9

*significant differences

of 10.12 and 12.97 for the dominant and non-dominant arms respectively post mastectomy [35]. Our BCS demonstrated greater upper extremity disability (DASH=19.35), however our subjects were on average 4 months post-surgery and were homogenous with respect to the type of surgery for breast cancer. It is also important to note that participants who were unable to raise their arm to at least 150° were excluded, making comparisons to our study difficult as we did not restrict participation based on arm elevation. Approximately 22% of the BCS (n=5) in our study had less than 150° of humeral elevation.

Hayes et al. conducted a study on 258 women 6 months after treatment for unilateral breast cancer, and found low levels of shoulder disability with an average DASH score of 10.8 (range 0–71.7)[10]. The reason for the difference in results between Hayes et al. and our study may be attributed to the type of surgery the BCS underwent. In the Hayes et al. study, only 28% of the BCS had undergone a mastectomy, while in our study more than half (68%) of the BCS had undergone a mastectomy [10]. Further analysis of the 8 BCS in this present study who received a lumpectomy scored an average of 9.88 on the DASH compared to the average of 24.40 for those who received a mastectomy. Other studies have revealed less shoulder dysfunction for a lumpectomy when compared to modified radical mastectomy [36–38]. In 67 BCS, 58 (86.6%) received a modified radical mastectomy and had an average 32.2 on the DASH [13]. It appears the more invasive the breast cancer surgery, the greater the impact on upper extremity disability, although further research is needed to explore this topic.

Further analysis of each individual DASH item revealed 36% of the BCS in this study agreed or strongly agreed with feeling less capable, less confident or less useful because of their arm, shoulder or hand problem (question 30). Moreover, 36% of the BCS in this study reported moderate to severe difficulty, or the inability to perform recreational activities (golf, hammering, tennis, etc.) which take some force or impact through the arm, shoulder, or hand (question 18). Thirty-six percent of the BCS in this study also reported moderate to severe difficulty with performing question # 19, recreational activities in which the arm is moved freely (Frisbee, badminton, etc.). Assessing the response of each DASH item could help to identify specific deficits and guide an individual rehabilitation program for the specific function of each BCS.

This is the first study to use the PSS to investigate shoulder function in BCS. The PSS provides additional information that cannot be found in the DASH including three questions regarding pain, and one question about an individual's satisfaction with their current level of shoulder function. The mean difference in PSS scores in this study was 20.34 between the BCS (77.12) and CON (97.46) group. This difference of 20.34 is substantially greater than the MCID for the PSS score of 11.4 points [27]. A wide range in PSS scores (35–100) was observed for the BCS, which may be due to a variety of factors such as: stage of breast cancer, type of surgery (mastectomy or lumpectomy),

Table 5 Mean, SD, 95% CI, p value, and effect size for passive shoulder ROM

	BCS (n=23)			CON (n=23)				
	Mean	SD	95% CI	Mean	SD	95% CI	P	ES
Flexion	161.0	10.8	157.0, 164.0	172.0	5.3	168.4, 175.3	<0.001*	1.1
0° ER	78.9	14.7	74.1, 83.6	80.5	7.5	75.7, 85.3	0.620	0.1
90° ER	91.6	16.9	85.9, 97.4	102.2	10.1	96.4, 108.0	0.012*	0.6
90° IR	65.1	10.2	60.8, 69.4	70.10	10.7	65.8, 74.4	0.104	0.5
Extension	32.4	16.5	24.2, 40.5	40.5	21.9	32.4, 48.6	0.162	0.4

ER external rotation, IR internal rotation

*significant differences

Table 6 Mean, SD, 95% CI, *p* value, and effect size for shoulder girdle strength (normalized to body weight)

	BCS (n=23)			CON (n=23)				
	Mean	SD	95% CI	Mean	SD	95% CI	P	ES
Abd & UR	0.12	0.04	0.10, 0.13	0.15	0.04	0.13, 0.17	0.006*	0.82
Dep & Add	0.11	0.05	0.09, 0.13	0.16	0.03	0.14, 0.18	<0.001*	1.10
Flexion	0.13	0.04	0.12, 0.15	0.17	0.04	0.15, 0.18	0.004*	0.82
ER	0.09	0.02	0.08, 0.10	0.12	0.03	0.11, 0.13	0.001*	0.88
IR	0.14	0.04	0.13, 0.16	0.19	0.05	0.17, 0.21	0.003*	0.87
Scaption	0.13	0.04	0.12, 0.15	0.18	0.05	0.16, 0.19	<0.001*	1.02
Horiz Add	0.13	0.04	0.12, 0.15	0.18	0.04	0.17, 0.20	<0.001*	1.29

Abd abduction, *UR* upward rotation, *Dep* depression, *Add* adduction, *ER* external rotation, *IR* internal rotation, *Horiz* horizontal, *Add* adduction

*significant differences

reconstruction, radiation, and chemotherapy. These variables were recorded but not separately analyzed in this study due to a small sample size. The wide range of scores on the PSS can be further explained by the fact that the PSS examines additional domains that the DASH does not, including more pain questions and questions regarding satisfaction. The domains of pain and satisfaction in the PSS may make the questionnaire more specific when compared to the DASH [39].

ROM

Shoulder flexion appears to be the most commonly studied motion in the BCS population. Our study found the mean flexion active ROM in BCS to be 156.5°. Hayes et al. found limitations in active shoulder flexion in 214 BCS with a mean of 143° [10]. Other studies have revealed average active shoulder flexion in BCS to be 152° [13], 155° [5], 163° [7], 163° [11], and 168° [7]. Caution needs to be utilized when comparing the results of these studies to each other, as well as against our results of flexion ROM because several different testing methodologies were used. These include differing length of time since diagnosis of breast cancer, a wide range of ages, various treatments for the breast cancer, and differing testing positions utilized (standing, seated, and supine) during the measurements of shoulder flexion.

Several other studies complement the results from this study reporting limitations of active ROM for 90° ER in BCS to range from 80° [6], 82° [11], 82° [13], and 86° [7]. Reviewing normative data for active shoulder ROM at 90° ER reveals an average of 101° for healthy females [40], This is approximately 13° greater than the averages in this study for the BCS. It is believed when ROM measures differ by greater than 10° between extremities, a clinical significance exists [18]. The results from this study reveal a 10.7° difference for active ER ROM and 10.5° difference for passive ROM measures [18].

Cho et al. examined fifty-five women who had completed their breast cancer treatment approximately 1 year prior, and found active extension to average 41° [6]. One of the difficulties in making comparisons between this study and the present study is that Cho and colleagues did not discuss the methodology regarding how the ROM was measured. Box et al. assessed active extension in the seated position in sixty-five BCS and found this motion to average 45° seven months after the primary surgical procedure [5]. The methodological differences between studies may explain the 15°–20° variation found between the present study and those conducted by Box et al. [5] and Cho et al. [6].

Passive extension did not differ between the BCS and CON in our study. This might be explained by the positioning as participants were required to lie prone and perform extension against gravity in this study. In future studies, a modification of this position, such as having the patient seated or standing, could be used to eliminate performing this motion entirely against gravity in order to gain a better understanding of whether this ROM is truly limited.

Upper extremity strength

Subjectively, is has been reported that BCS have decreased muscle strength on the affected extremity, however very few studies have quantified these actual deficits [22]. We found a decrease peak muscle strength using a HHD in scapular and shoulder musculature of scapular abduction and upward rotation, scapular depression and adduction, flexion, external rotation, internal rotation, scaption, and adduction. Shamley and colleagues (2006) found a decrease in muscle activity of the upper trapezius, rhomboids, and serratus anterior during arm elevation in the plane of the scapula in BCS when their affected extremity was compared to their unaffected extremity [23]. The study revealed decreased levels of EMG activity in muscles which are not in the direct field of breast cancer surgery or radiotherapy [23]. Lee et al. conducted a study to examine upper extremity strength using a HHD in sixty-four BCS [21]. The results of the study were reported in Newtons, did not appear to be normalized to body weight, and different testing positions were used in this study making comparisons difficult. A study conducted by Merchant et al. evaluated upper extremity strength in 40 women who averaged 28 months since initial treatment [22]. Dynamic concentric strength was measured using a 1-repetition maximum (RM) comparing the affected side to the unaffected side. Significant differences were found for the 1RM measures between sides for the shoulder protractors, retractors, and extensors. Comparisons again are difficult to make regarding the results from this study to the study conducted by Merchant et al. because of the different method utilized to assess strength, different muscles assessed, and a significant longer period, 22 months versus 6 months, since initial treatment.

Summary and clinical relevance

Findings from this study suggest there is in fact a difference in function, ROM, and strength when BCS are compared to healthy, matched controls. Women who have recently completed their primary breast cancer treatment have functional deficits as revealed in this study on the DASH and PSS. Impairments of humeral flexion and humeral ER at 90° ROM were limited and all seven of the strength measures assessed in this study were found to be decreased in the BCS when compared to healthy participants. The results from this study demonstrate the clinical importance of examining shoulder function, ROM, and strength in BCS. Outcomes from this study could be used to guide the development of evidenced based guidelines to provide the directed and effective treatment when rehabilitating BCS.

Recommendations for future research

Future research involving BCS should be standardized in order for more definitive conclusions since a variety of methodologies are currently used. With this information, conclusions that have solid guidelines can be developed. A valid and standardized protocol should be developed for assessing function, ROM, and strength in BCS. Future research should utilize a larger sample size, examine both the affected and unaffected side, blinding the researcher, and take into account factors such as surgical and systemic treatment so more specific rehabilitation strategies can be implemented.

Conclusions

The present study utilized a unique approach to examine shoulder function in BCS by comparing these individuals to healthy, matched controls. Significant differences were found in function, ROM, and strength in BCS who have recently completed their treatment (≤6 months). This study also used common clinical measurements providing valuable information regarding shoulder active and passive ROM, upper extremity strength, and shoulder function for BCS who have recently completed their primary cancer treatments. The results of this study add to the current body of literature by providing clinicians with information regarding common upper extremity impairments BCS demonstrate following recent treatment. Finally, this information provides qualitative data to help with the design of future intervention studies involving BCS.

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