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RESEARCH

Health-related physical fitness parameters in women with breast cancer–related lymphedema: a case–control study

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Abstract

Purpose This study aimed to compare health-related physical fitness parameters of women with breast cancer–related lymphedema (BCRL) to a matched control group.

Methods Thirty women with unilateral BCRL (lymphedema group, age = 55.00 (40.00–65.00) years) and 32 healthy women (control group, age = 49.00 (44.00–64.00) years) were included. Cardiorespiratory fitness with the UKK 2-km walk test, grip strength with a hand dynamometer, trunk muscle endurance with the McGill trunk muscle endurance tests, flexibility with the sit and reach test, body composition with a body composition analyzer, and waist-to-hip ratio were assessed.

Results In the lymphedema group, 36.7% of women had mild lymphedema, 36.7% had moderate, and 26.7% had severe lymphedema. It was found that maximal oxygen consumption, physical fitness index, grip strength, trunk extensor and lateral flexor muscle endurance, and flexibility scores were higher in the control group than in the lymphedema group ($p < 0.05$). In addition, body mass index, body fat percentage, and waist-to-hip ratio were found to be lower in the control group compared to the lymphedema group ($p < 0.05$). There was no significant difference between the trunk flexor muscle endurance scores ($p > 0.05$).

Conclusions It was found that the health-related physical fitness parameters were adversely affected in women with BCRL compared to healthy women. The changes of physical fitness may be important for the assessment and the treatment of BCRL.

Keywords Lymphedema · Mastectomy · Breast cancer · Physical fitness · Body composition · Muscle strength

Introduction

Breast cancer is the most common type of cancer among women [1]. Most individuals diagnosed with breast cancer will experience long-term survival. Following initial breast cancer treatments, survivors may experience various physical and psychosocial consequences that may affect overall health [2]. Breast cancer–related lymphedema (BCRL), which is one of breast cancer treatment outcomes, related to axillary lymph node dissection and radiotherapy, is caused by lymphatic system obstruction or disruption [3]. It is a progressive condition, due to protein-rich lymph fluid accumulation within the interstitial tissue localized in upper limb extremity and/or adjacent thoracic quadrant [3]. This condition causes physical deficiencies and psychological stress [3]. Swelling can be accompanied by physical discomfort, pain, paresthesia, fatigue, heaviness of the affected limb, stiffness, impaired upper limb extremity, scapula, and spine structures [4, 5]. The incidence of BCRL ranges between 16 and 21% [6].

Physical fitness is usually defined as the ability to perform the daily life activity without fatigue [7]. It is also defined as the ability a person has to do physical activity or exercise and it brings musculoskeletal, cardiovascular, respiratory,

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endocrine-metabolic, and psychoneurological functions together [8, 9]. Physical fitness is not only sport-specific, including explosive power, speed, agility, coordination, balance, and reaction time, but also health-related components, including cardiorespiratory fitness, muscular fitness, flexibility, and body composition [7].

It was reported that women with BCRL experience more pain and greater restrictions in activity than women without BCRL [10]. These results and the different complications of adjuvant therapies may restrict participation in the physical activity and the health-related physical fitness parameters. There were limited studies on cardiorespiratory fitness in patients with BCRL [11, 12]. These studies stated that the cardiorespiratory fitness decreased in BCRL. The upper extremity strength in patients with BCRL was generally investigated and found to be reduced in patients with BCRL compared to the healthy side [13]. Moreover, trunk asymmetry and postural disorders were observed because of the presence of asymmetric lymphedema, and the symptoms accompanying lymphedema and the removal of breast tissue after mastectomy [5]. Thus, examination of trunk muscular fitness may also be important in patients with BCRL. According to the authors' knowledge, there was no study about this issue.

After breast cancer treatment, changes such as weight gain, decrease in muscle mass, and increase of fat mass may be seen in women. These changes in body composition may increase the risk of recurrence by triggering inflammatory processes and cause various systemic disorders [14, 15]. As a result of obesity, lymphatic function may be impaired, and impaired lymphatic function may lead to fat accumulation [16]. However, there were few studies, investigating the body composition in patients with BCRL [17–19]. Examining the health-related physical fitness parameters in detail in patients with BCRL may be important in planning a comprehensive rehabilitation.

Thus, this study aimed to compare the health-related physical fitness parameters of women with BCRL to a matched control group. Our hypothesis was that there were differences in health-related physical fitness parameters in women with and without BCRL.

Material and methods

Study design

This is a case–control study. The study was approved by the Ethics Committee of the Ankara Yildirim Beyazit University (Approval number: 2022–713-03) and conducted in compliance with the Declaration of Helsinki. The study was carried out at Physical Therapy and Rehabilitation outpatient clinic in Kirsehir Ahi Evran Training and Research Hospital between April 2022 and January 2023.

Participants

The women with BCRL, completed cancer treatments, having unilateral upper extremity BCRL, aged between 18–65 years, who volunteered to participate to the study, were included in the lymphedema group. For the control group, volunteered women without a history of lymphedema or any chronic diseases or injury, aged between 18 and 65 years from the relatives of patients, were included. Since body composition and waist-to-hip ratio ratios were used as outcome criteria, all patients participating in the study were examined for lipedema before the study. Sparing of the hands and feet, the tenderness of the medial fat pad of the knee with palpation, and the accumulation of adipose tissue in the retromalleolar sulci were investigated. Patients with these findings were excluded from the study with the diagnosis of lipedema [20]. Having previous spine and abdominal surgery, spinal pain or a spinal deformity (such as scoliosis), any physical disability that may prevent walking performance, history of orthopedic surgery, diagnosis of chronic venous insufficiency, neurological and/or rheumatologic diseases, and morbid obesity were excluded from the study. Written consent forms were obtained from participants.

Assessments

Physical characteristics, dominant side, and smoking, alcohol, and exercise habits were collected by face-to-face interviews. The type and duration of surgery, the number of chemotherapy cycles, the number of radiotherapy sessions, affected side related to lymphedema, and location and duration of lymphedema of all patients were questioned. The same physiotherapists conducted all assessments.

In the lymphedema severity, circumferential measurements on bilateral upper extremities at 5-cm intervals from wrist to the axilla were measured while the patient was in the supine position. Next, the volume of the extremities was calculated using these circumference measurements with Frustum Formula [21]. The lymphedema severity was classified according to the volume difference between the two extremities as follows: mild lymphedema, < 250 ml; moderate lymphedema, 250–500 ml; and severe lymphedema, > 500 ml [22]. Moreover, the severity of the lymphedema-related symptoms such as pain, paresthesia, fatigue, and heaviness was assessed with Visual Analog Scale (VAS). The VAS is a 10-cm line with no marks along them, anchored with the words "no pain" on one hand, and "the most severe pain" on the other. Patients were simply instructed to place a mark along the line at a level

representing the intensity of their pain, paresthesia, fatigue, and heaviness [23].

Cardiorespiratory fitness was assessed with the UKK 2 km walk test. Women were asked to walk as fast as possible and at a continuous speed (without running) on the 2-km track, where the starting and ending points were determined. At the end of the test, the women's time to complete the 2 km and their heart rate at the end of test were recorded. Maximal oxygen consumption (VO2 max) and fitness index scores were calculated using total time to complete the test, heart rate at the end of the test, age, and body mass index (BMI) values [24]. The test was declared as a reasonably accurate field test to predict changes in VO2 max in healthy nonathletic adults [24].

Muscular fitness consisted of grip strength related to global muscle strength [25], trunk muscle endurance, and flexibility parameters. Grip strength, in the standard position recommended by the American Society of Hand Therapists, was measured with a hand dynamometer (Gahome Digital LCD Hand Grip Strength Dynamometer) with the elbow flexed to 90° and the forearm and wrist in the neutral position. Women were asked to grip the dynamometer with all their strength for 3 s and then release it. Each evaluation was repeated 3 times and average score was calculated. Women rested for 1 min between the evaluations [26]. Grip strength was evaluated from both the affected and unaffected sides of the patients and the dominant sides of the healthy controls. Trunk muscle endurance was evaluated with the McGill trunk muscle endurance tests (trunk flexion, extension, and lateral flexion endurance tests). Women were stated how to perform the positions by demonstrating them in advance. Then, they were asked to repeat these positions once and to recognize the evaluation positions. Women were encouraged to maintain isometric postures for each test position as long as possible. The time that women could maintain the correct position was recorded in seconds [27]. Trunk flexibility was also assessed with the sit and reach test. Women sat with their feet against the testing box. They kept their knees extended and reached forward as far as they could by sliding their hands along the measuring board. Each evaluation was repeated 3 times and the highest distance was recorded in centimeters [28].

Body composition was assessed with a body composition analyzer (Omron BF-511, Japan) [29]. The women were told not perform heavy physical activity before 24–48 h, not consume alcohol before 24 h, and not eat and consume too much liquid before 2 to 4 h. First of all, the height measurement was measured without shoes, standing upright and looking straight ahead. Then, the weight measurement was made with very thin clothes and these measurements were entered into the device. Lastly, women stood on the device with bare hands and feet. The BMI and body fat percentage were reported by the software of the device. And also, waist circumference was measured from the narrowest circumference between iliac crista and last costae and hip circumference was measured from the widest part of the hip while women were standing. An inflexible tape was used in all measurements and waist-to-hip ratio was also calculated [30].

Sample size and statistical analyses

G*Power (Ver. 3.0.10, Germany) package program was used for sample size [31]. According to the VO_2 max results of the pilot study conducted before our study, it was calculated that a total of 52 individuals, at least 26 individuals for each group, should be included in this study in order to obtain 80% power with an effect size of 0.795, $\alpha = 0.05$ and $\beta = 0.20$. Considering the possible data losses, it was decided to add at least 10% more individuals and thus to reach a total of at least 58 individuals for the study.

The normal distribution of the data was examined with using histograms, probability plots, and Shapiro–Wilk test. Descriptive statistics were calculated for all variables. Normally distributed data, non-normal distributed data, and categorical data were presented as mean ± standard deviation (SD), median (minimum (min)-maximum (max)), and frequency (*n*) and percentage (%), respectively. In the comparison of numerical variables in lymphedema and control groups, the independent samples *t*-test and the Mann–Whitney *U* test were used; in the comparison of categorical variables, the Fisher's exact test were used. Furthermore, the Kruskal–Wallis test was used to compare the grip strength values of the affected and unaffected side of lymphedema group and the dominant side of the control group. Mann–Whitney *U* test was used to test the significance of pairwise differences using Bonferroni correction to adjust for multiple comparisons. For statistical analysis, IBM SPSS Statistics 22.0 (Armonk, NY: IBM Corp.) was used. Statistical significance level was accepted as $p < 0.05$.

Results

Thirty-two women with lymphedema and 35 healthy women participated in the study. The study was completed with 30 women with lymphedema and 32 healthy women (Fig. 1). The characteristics of the groups were similar ($p > 0.05$, Table 1). In the lymphedema group, most of the patients had mild (36.7%) and moderate lymphedema (36.7%). It was found that these patients had more left extremity lymphedema (53.3%). In addition, the most severe lymphedema-related symptoms was a feeling of heaviness. The characteristics related to surgery, chemotherapy, radiotherapy, and edema of the lymphedema group are presented in Table 2.

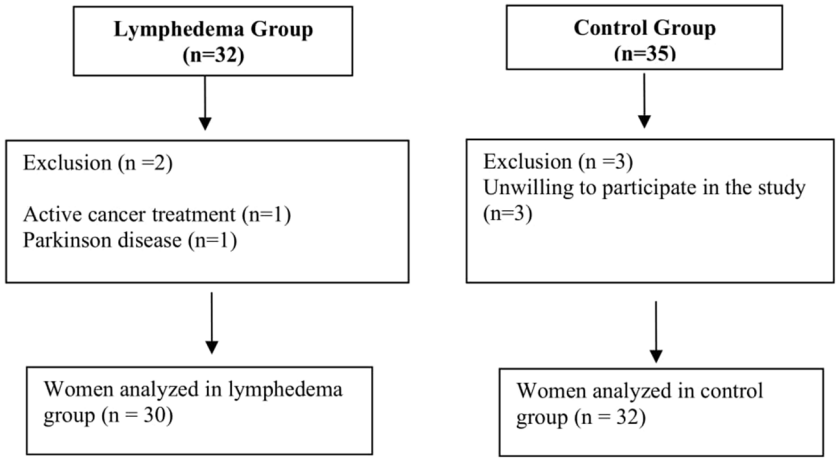

Fig. 1 Flow chart of participants

Table 1 Comparison of the characteristics of the groups

	Lymphedema group ($n=30$)	Control group ($n=32$)	p
Age (years, median (min–max))	55.00 (40.00–65.00)	49.00 (44.00–64.00)	0.058[a]
Dominant side (n, %) Right Left	29 (96.7) 1 (3.3)	29 (90.6) 3 (9.4)	0.613[b]
Smoking (n, %) Yes No	0 (0.0) 30 (100.0)	3 (9.4) 29 (90.6)	0.238[b]
Alcohol (n, %) Yes No	0 (0.0) 30 (100)	0 (0.0) 30 (100.0)	–
Exercise habits (n, %) Yes No	0 (0.0) 30 (100.0)	3 (9.4) 29 (90.6)	0.238[b]

min minimum, *max* maximum, *n* number, % percentage

[a]Mann-Whitney *U* test

[b]Fisher's Exact test

When the health-related physical fitness parameters of the groups were examined, it was found that VO2 max, physical fitness index, trunk extensor, right and left lateral flexor muscle endurance, and flexibility scores were higher in the control group than in the lymphedema group ($p<0.05$). Furthermore, BMI, waist-to-hip ratio, and body fat percentage were found to be lower in the control group compared to the lymphedema group ($p<0.05$). There was no significant difference between the trunk flexor muscle endurance score ($p>0.05$, Table 3).

In addition, there was a difference between the grip strength values of the affected side and unaffected side of the lymphedema group and the dominant side of the control group ($p<0.05$). Grip strength values of both the affected and unaffected side of the lymphedema group were less than those of the dominant side of the control group ($p<0.05$). In the lymphedema group, it was also detected that the grip strength values of the affected side were less than those of the unaffected side ($p<0.05$) (Table 4).

Discussion

This study was seen that women with BCRL had lower cardiorespiratory fitness, grip strength, trunk muscle endurances (except flexor muscle endurance), and flexibility in comparison to controls. The grip strength values of the affected side were less than those of the unaffected side in women with BCRL. Moreover, women with BCRL had higher BMI, body fat percentage, and waist-to-hip ratio than healthy controls.

Centers for Disease Control stated that having appropriate physical fitness makes the individual feel good physically, physiologically, and psychologically [1]. Breast cancer survivors may experience avoidance of activity and fear of movement due to different reasons such as pain, restricted arm/shoulder range of motion, and risk of lymphedema [32]. Kabak et al. also explained that the physical activity level was lower in individuals with BCRL compared to healthy controls [33]. Moreover, the long-term effects of cancer and its treatment, including chronic

Table 2 Characteristics of the lymphedema group

Parameter	Lymphedema group ($n=30$)
Type of surgery, *n* (%) Modified radical mastectomy Partial mastectomy	18 (60) 12 (40)
Duration of surgery (years), $X \pm SD$	7.60 ± 3.51
Number of chemotherapy cycles, *n* (%) 1–3 4–6 7 and above	5 (16.7) 13 (43.3) 12 (40)
Number of radiotherapy sessions, median (min–max)	24 (18–25)
Affected upper extremity, *n* (%) Right Left	14 (46.7) 16 (53.3)
Duration of lymphedema (months), median (min–max)	36 (4–150)
Lymphoedema severity, *n* (%) Mild Moderate Severe	11 (36.7) 11 (36.7) 8 (26.7)
Severity of the lymphedema-related symptoms	
Pain (VAS, cm), median (min–max)	1.71 (0–6.50)
Paresthesia, (VAS, cm), $X \pm SD$	2.28 ± 1.65
Fatigue, (VAS, cm), $X \pm SD$	4.00 ± 2.48
Heaviness, (VAS, cm), $X \pm SD$	4.37 ± 2.89

SD standard deviation, *min* minimum, *max* maximum, *VAS* visual analog scale, *cm* centimeter

X mean

pain, fatigue, sleep problems, and cardiovascular toxicity, suggest the necessity of physical activity for breast cancer survivors [2]. Moreover, the link between cardiorespiratory fitness and physical activity was well established [34]. Smooth et al. investigated cardiorespiratory fitness using symptom-limited treadmill testing in those with and without BCRL. They found that the peak oxygen consumption (VO2 peak) was lower in women with BCRL than women without BCRL [11]. Kim et al. stated that metabolic equivalent tasks, VO2 peak, and anaerobic threshold in patients with BCRL were lower than healthy controls [12]. In our study, the cardiorespiratory fitness was evaluated with a field test, an easy, practical, and valid method. We found that women with BCRL had a lower cardiorespiratory fitness compared to healthy women. These findings may be due to the characteristics of lymphedema and its accompanying problems. According to these results, the cardiorespiratory fitness should be taken into account for the assessment and the rehabilitation processes in patients with BCRL.

The trunk is a significant part of body in terms of proprioceptive stimuli, postural stability, and energy transfer between the extremities [35]. In the literature, it was reported that the sagittal thoracic curve and the frontal inclination angle towards the unaffected side increased in patients with BCRL [5]. Correct movement occurs when both stability and mobility of the trunk are in harmony [36]. According to

Table 3 Comparison of the health-related physical fitness parameters of the groups

Parameters	Lymphedema group Median (min–max) $X \pm SD$ ($n=30$)	Control group Median (min–max) $X \pm SD$ ($n=32$)	*p*
Cardiorespitatory fitness	36.65 (25.01–60.03)	43.50 (33.98–68.78)	0.001[a]*
VO_2 max	77.68 (43.73–126.59)	102.53 (65.77–157.36)	< 0.001[a]*
Physical fitness index			
Muscular fitness	25.50 (6.00–73.00)	30.50 (5.00–78.00)	0.481[a]
Trunk flexor muscle endurance (sec)	5.00 (1.00–26.00)	42.50 (3.00–120.00)	< 0.001[a]*
	6.00 (2.00–17.00)	15.50 (1.00–130.00)	0.004[a]*
Trunk extensor muscle endurance (sec)	3.00 (2.00–18.00)	10.50 (2.00–55.00)	0.001[a]*
	−6.64 ± 7.14	8.90 ± 6.60	< 0.001[b]*
Trunk lateral flexor muscle endurance (right) (sec)	30.48 (26.60–38.00)	27.85 (21.67–34.95)	< 0.001[a]*
	0.85 ± 0.05	0.82 ± 0.03	0.034[b]*
Trunk lateral flexor muscle endurance (left) (sec)	38.80 (33.90–43.60)	34.00 (18.70–48.20)	0.006[a]*
Flexibility (cm)			
Body composition			
BMI (kg/m^2)			
Waist-hip ratio			
Body fat percentage			

SD standard deviation, *min* minimum, *max* maximum, *kg* kilogram, *sec* second, *cm* centimeter, *m* meter

X mean

*$p < 0.05$

[a]Mann-Whitney *U* test

[b]Independent sample *t* test

Table 4 Comparison of the grip strength parameters of the groups

Parameters	Lymphedema group ($n=30$) Affected side / Unaffected side Median (min–max) Median (min–max)	Control group ($n=32$) Dominant side Median (min–max)	p^1	p^2	p^3
Muscular fitness Grip strength (kg)	16.72 (13.00–21.15) / 18.47 (16.40–25.03)	23.50 (19.70–36.00)	0.001[b]*	<0.001[b]*	<0.001[b]*
p	<0.001[a]*				

min minimum, *max* maximum, *kg* kilogram

p^1: comparison of affected and unaffected side of lymphedema group; p^2: comparison of the affected side of lymphedema group and the dominant side of the control group; p^3: comparison of the unaffected side of lymphedema group and the dominant side of the control group

*$p<0.05$

[a]Kruskal-Wallis test

[b]Mann-Whitney *U* test

the authors' knowledge, there was no study examining trunk muscle strength, endurance, and flexibility in individuals with BCRL. Grip strength, which is a determinant of total muscle strength in the upper extremity, has a negative correlation with the life quality of individuals after breast cancer surgery, and is also used as a reliable assessment tool for mortality in the cancer population [37, 38]. Furthermore, it was found that grip strength was correlated to trunk muscle flexor and extensor strength [25]. In a previous study, grip strength was detected to be reduced in patients with BCRL compared to the healthy side; however, no difference was between right-left grip strength in individuals without upper extremity lymphedema [10]. In another study, it was reported that grip strength decreased in women with BCRL compared to healthy controls [13]. In our study, women with BCRL had lower grip strength, trunk muscle endurance, and flexibility compared to healthy controls. Moreover, the grip strength of the affected side was less than that of the unaffected side in women with BCRL. These findings may be due to lymphedema and its accompanying postural problems and physical inactivity, and cancer treatments [5, 33]. In these patients, attention should be paid to trunk rehabilitation as well as edema treatment.

Changes in body composition related to breast cancer and its treatment are a significant risk factor for the development of lymphedema. As a result of obesity, lymphatic function may be impaired, and impaired lymphatic function may lead to fat accumulation [16]. However, studies evaluating body composition in patients with BCRL are limited and have inconsistent results. Nakipoglu et al. assessed body composition with the TANITA bioimpedance analysis and anthropometric measurements in individuals with and without BCRL. BMI and body fat percentage were not different in those with BCRL than in those without BCRL. However, waist circumference was detected to be significantly higher in patients with BCRL [19]. In the study of Gomes et al., body composition was measured through the dual energy X-ray absorptiometry. Total fat percentage was found to be similar between patients who have undergone breast cancer surgery and healthy individuals, but the trunk fat mass was higher in those with lymphedema [39]. In our study, women with BCRL had higher BMI, waist-to-hip ratio, and body fat percentage compared to healthy controls. Differences in results may be due to evaluation methods. However, in individuals with lymphedema or at risk of developing lymphedema, it may be important to try to keep the values related to body composition within the norm values. In this context, these individuals should be directed to regular physical activity/exercise programs and dietary recommendations during rehabilitation processes.

The strengths of our study were considering health-related physical fitness parameters, reaching a sufficient sample size, and using valid and reliable evaluation methods. However, we did not investigate patients according to the characteristics of lymphedema such as the lymphedema severity and duration, the lymphedema-related symptoms (pain etc.), and having radiotherapy and chemotherapy all might affect the results. Further studies should consider these issues. Moreover, body composition could not be documented as segmentally for regional observations.

Conclusion

In this study, decreased cardiorespiratory fitness, grip strength, trunk muscle endurances, and flexibility and increased BMI, body fat percentage, and waist-to-hip ratio were observed in women with BCRL. The changes of

health-related physical fitness parameters should be taken into account for the assessment, treatment, and the long-term survivorship of BCRL.

Author contribution STC: The conception and design of the study, analysis and interpretation of data, drafting the manuscript or revising it critically for important intellectual content.

OB: Acquisition of data, drafting the manuscript or revising it critically for important intellectual content.

EBD: Acquisition of data, drafting the manuscript or revising it critically for important intellectual content.

BCK: Acquisition of data, drafting the manuscript or revising it critically for important intellectual content.

DOK: The conception and design of the study, drafting the manuscript or revising it critically for important intellectual content. All the authors read and approved the version for submission.

Declarations

Ethics approval The study was approved by the Ethics Committee of the Ankara Yildirim Beyazit University (Approval number: 2022–713-03) and performed in accordance with the rules of the Declaration of Helsinki.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Competing interests The authors declare no competing interests.

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