Physiotherapy Quarterly (ISSN 2544-4395)
© Wroclaw University of Health and Sport Sciences
2023, 31(2)

original paper
doi: https://doi.org/10.5114/pq.2023.11227

The relationship between lymphedema, posture, respiratory functions, exercise capacity, and the quality of life after breast cancer treatment

Eser Kutlu[1], Gulbin Ergin[2], Beraat Alptuğ[3], Didem Karadibak[4]
[1] Physiotherapy and Rehabilitation Center, Lefke/Northern Cyprus, Mersin, Turkey
[2] Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, Izmir Bakircay University, İzmir, Turkey
[3] Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, European University of Lefke, Lefke/Northern Cyprus, Mersin, Turkey
[4] School of Physical Therapy and Rehabilitation, Dokuz Eylul University, İzmir, Turkey

Correspondence address: Beraat Alptuğ, Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, European University of Lefke, Lefke/Northern Cyprus, Mersin 10, Turkey, e-mail: balptug@eul.edu.tr

Abstract
Introduction. To evaluate the relationship between lymphedema, posture, respiratory functions, exercise capacity, and the quality of life after breast cancer treatment.
Methods. This cross-sectional study consisted of 38 women who had unilateral breast cancer treatment. Pulmonary function with a spirometer, functional exercise capacity via 6-minute walking test, postural alignment changes, and quality of life were evaluated. Circumferential measurements were used to determine the severity of lymphedema.
Results. The median age of female participants was 53 years (range, 40–64). The mean body mass index was 26.66 ± 2.96 kg/m^2, of which 76% had lymphedema. The expected changes in posture were moderate. The mean of the 6-minute walking distance decreased, which corresponded to 58.55% of normative values. MIP and MEP values were significantly lower than expected values. An intermediate negative correlation was observed between postural changes and body mass index (r = –0.348; p = 0.05). Moreover, there was a positive correlation between forced expiration volume and forced vital capacity values and walking distance ($p < 0.05$).
Conclusion. After breast cancer treatment, 76% of female patients had lymphedema, the functional exercise capacity, MIP and MEP were below the expected values in all of them, and as functional capacity decreases, respiratory parameters affected negatively.
Key words: breast cancer, spirometric tests, posture, exercise capacity

Introduction

Breast cancer is one of the most common types of cancer. Although, it is more common after the age of 30, worldwide it is seen in one of eight women [1]. The primary treatment method for breast cancer is a surgical operation to remove cancer from the area and to control the stage of the condition. Surgical operation is generally combined with targeted treatment methods such as radiotherapy, hormone therapy, and chemotherapy, which optimise local control and survival [2]. However, with these applications, different complications such as pain, shoulder problems, fatigue, cachexia, respiratory problems (decrease in the expansion of the rib cage), nerve damage, infection and lymphedema may occur, which negatively affect body structure and reduced functional exercise capacity [3–5].

Lymphedema is characterised with the increase in extremity volume with proteins and liquids in the interstitial space. Breast cancer–related lymphedema (BCRL) is the most widely recognized type of lymphedema in the World. Axillary lymph-node dissection and adjuvant radiation therapy have a greater risk. It might happen from the main months to years following breast cancer treatment (BCT). The women who experience lymphedema have to live with a range of problems including changed sensation in the limb, loss of body self-reliance, reduced functional mobility, tiredness, psychosomatic distress, and a general decline in quality of life QoL [6].

There is limited data about the effects of BCT on body posture. But recent articles indicate that BCT especially surgical operation can have destructive results on body composition and the musculoskeletal system like changes in spinal alignment and increased thoracic kyphosis [7].

Patients who have clinically stable breast cancer and remote from treatment interventions, possible contributors to decreased respiratory function and exercise intolerance with the results of the underlying condition, the side effects of treatments (chemotherapy and/or radiotherapy), and deconditioning effects due to decreased physical activity. Some researches have stated the significance of deconditioning and decreased functional capacity in breast cancer survivors, although the part of pulmonary deficiency especially respiratory muscle strength remains unknown [8, 9].

BCT could lead to a dramatic decrease in the QoL of patients, especially in the physical and emotional functioning components. Reliance on others for help with their everyday life activities and a negative self-perception identified with lymphedema can affect the people's mental, social, and sexual prosperity, and diminish their QoL [10].

The purpose of this study is to determine the relationship between the severity of lymphedema, posture, respiratory function, functional exercise capacity, and QoL after BCT**.**

Subjects and methods

The study design was cross-sectional. This study was performed on 38 women with breast cancer. These participants were evaluated in the department of Physical Therapy between October 2018 and March 2019. Necessary descriptions were made to our participants and those included gave informed consent. This study was conducted with the approval of the local ethics committee and informed assigned was gained from each individual.

Inclusion criteria were: (a) diagnosed with unilateral breast cancer and at least one-year post-treatment, (b) female, and (c) a volunteer. Exclusion criteria were:(a) presence of known cardiopulmonary chronic disease, (b) underwent an operation that could affect posture and/or movement systems before BCT and/or presence of chronic musculoskeletal, neurological, and/or cardiopulmonary problems, (c) underwent an operation of the upper extremity before BCT, and/or the presence of a chronic musculoskeletal disorder in the upper limb, (d) the presence of infection in the affected side, and (e) the presence of metastatic disease.

Data collection

Sociodemographic and clinical characteristics (age, BMI, education status, smoke alcohol user, exercise habit, dominant and affected side, radiation/chemo/hormone therapy, surgery type, time after surgery and comorbidities) of all participants were obtained in face-to-face meetings with the participants and from their medical record archives.

Circumference measurement

Circumference measurement was used to assess the severity of lymphedema. Half an hour before starting the assessment, participants rested in a supine position with 60° arm elevation. Next, the arm was placed at 30° abduction. The circumference was measured in this position with a tape measure. Measurements with 5 cm intervals started from the styloid process of the ulna and

continuing 40 cm proximally for both limbs. Frustum Formula was used to calculate volume [11]. The severity of lymphedema was identified by comparing bilateral limb volume and classified as "mild" if it was ≤250 mL, "moderate" if between 250 and 500mL, and "severe" if >500 mL [11].

$$V = [h \times (R1^2 + R1.R2 + R^2)]/(N \times л) \text{ [11]}$$

where V is the volume of each conical segment, h is the interval between circumference measurement, R1 (base perimeter measurement of the conical segment), R^2 (top perimeter measurement of the conical segment), and N is the number of the conical segment. For ease of calculations, л = 3 was used [11].

New York Posture Rating (NYPR) Chart

The New York Posture Rating was used to evaluate posture. During the evaluation, attention was paid to ensure that the participants wore suitable attire for the analysis. For correct rating patients were places in front of a specially designed posture paper, can be used for individuals of all ages. The assessor took photographs in anterior, posterior, and lateral (right-left) views for documentation. Posterior view segments (head, shoulders, spine, hips, feet, and arches), lateral view segments (neck, rib cage, shoulders, back, hips, and abdomen) in the NYPR are scored. Each segment had own scores; 5 (correct posture), 3 (slight deviation) to 1 (problematic posture). The total score is between 13–65 points. A higher score represents a better postural alignment [12].

Spirometric tests

Spirometric tests, an objective assessment for respiratory functions, were used. Lung capacity and respiratory muscle strength were assessed according to the criteria of the American Thoracic Society. Tests were carried out with a Cosmed Pony Fx pulmonary function test device. During the assessment, participants were asked to sit with the arms crossed, with the clips on their nose [13].

Assessments were conducted with the filter within the disposable mouthpiece. Assessment of lung capacity started with normal breathing, continued with deep inspirations, and ended with a strong and long expiration from the participant. For the first second of forced expiration volume (FEV1) and forced vital capacity (FVC) values were recorded. The best values were recorded after repeating the assessments three times [13].

For maximal inspiratory pressure (MIP), first, the nose of the participant is closed with a clip, then after the forced expiration, maximal inspiration is recorded. For maximal expiratory pressure (MEP), the long and MEP was recorded after the deep inspiration. The tests were repeated three times and the best value was documented [13]. To calculate expected values [14];

For women participants:

– 20–54 age; MIP = 100 – (age × 0,39) and MEP = 158 – (age × 0,18)
– 55–86 age; MIP = 122 – (age × 0,79) and MEP = 210 – (age × 1,14)

Six Minute Walking Test (6MWT)

The 6MWT is a submaximal test used to determine the functional exercise capacity. The test was conducted by a physiotherapist. Closed flat corridors 30–100 m in length (at 3 m intervals) were used for the test. Blood pressure, oxygen saturation, pulse, and fatigue were assessed before and after the test [15]. The modified Borg scale (MBS) was used to assess dyspnea and fatigue [16]. Participants were allowed to rest during the experiment before time runs out, but should continue walking until the end of the time. The distance measured (in metres) at the end of the test [15]. To calculate expected values [17];

For women participants, 6MWD = (2.11 × height cm) – (2.29 × weight kg) – (5.78 × age) + 667 m.

Short Form 36 (SF-36)

Short Form 36 (SF-36) was used to evaluate QoL. SF-36 is a 36-item scale related to a general concept of health, not a specific condition. The questionnaire has 8 sub-dimensions: physical functioning (PF), physical role functioning (PRF), emotional role functioning (ERF), bodily pain (BP), social functioning (SF), mental health (MH), vitality (V), and general health (GH). Each sub-dimension scores between 0 and 100. QoL is associated with high scores [18].

Sample size

Breast cancer ranks first with 37% among the most common types of cancer in women in the North Cyprus [19]. Based on this, the minimum sample size for the study was calculated as 38 women for the probability the statistical power level as 95% using G*Power Software (Version 3.1.9.2, Düsseldorf University, Düsseldorf, Germany).

Statistical analysis

Statistical Package for Social Sciences (SPSS) software was used for statistical analysis. Frequency analysis was used to determine the distribution of the participants according to their sociodemographic characteristics and breast cancer histories. Descriptive statistics used for physical measurements included circumference measurement (volume) and BMI values, NYPR, SF-36, 6MWT, and spirometric tests of the participants.

The compliance of the data obtained in the study with the normal distribution was analysed using the Shapiro-Wilk test, and it was determined that the data did not correspond to the normal distribution, so nonparametric hypothesis tests were used. The Wilcoxon test was used to compare the circumference (volume) of the participants' affected side and non-affected side. A Spearman test was used to analyse the relationship between the circumference measurement values of participants between the BMI, NYPR, SF-36, and spirometry findings. According to Hills and Fleiss [20], if the correlation coefficient is <0.40, it is considered low, if it is between 0.40–0.75, medium, and if >0.75, high (20).

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the ethics council of the European University of Lefke (ÜEK/30/01/02/1819/04).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

At the beginning of the study we had taken 40 participants but two of the participants withdrew from the research due to not complete the tests. The data obtained from 38 women with breast cancer were analysed. The findings regarding the distribution of the sociodemographic characteristics of the participants assessed in this study are given in Table 1 and Table 2.

When the severity of edema of the participants was evaluated, it was determined that 76% of them had lymphedema (Table 2).

The distance women walked at the end of 6MWT was found to be significantly lower than the expected distance, also MIP and MEP were significantly lower than the expected values (p <0.05) (Table 3).

Table 1. The characteristics of the participants

		n: 38
Age (years, mean ± SD)		53 ± 6.17
BMI (kg/m^2, mean ± SD)		27.36 ± 4.59
	Normal (%)	26,32
	Preobese (%)	60,53
	Obese (%)	13,16
Education status	PE(%)	21.05
	HS(%)	44.74
	Undergrad./Grad.	34.21
Smoker/Alcohol user	Yes(%)	36.84
	No (%)	63.16
Alcohol user	Yes(%)	13.16
	No (%)	86.84
Exercise habit	Yes (%)	65.79
	No(%)	34.21
Dominant/Affected side	Right(%)	76.32 / 26.32
	Left(%)	23.68 / 73.68
Comorbidity	DM/HT(%)	10,5/ 36,8
Treatments (RT/CT/HT)	Yes(%)	94.74 / 34.21 / 97.37
	No(%)	5.26 / 65.79 / 2.63
Surgery type	Lumpectomy(%)	63.16
	TM(%)	13.16
	MRM(%)	23.69
Time after surgery(years)	≤ 2(%)	28.95
	3–5(%)	50
	≥ 5(%)	21.05

BMI – body mass index, PE – primary education, HS – high school,
Undergrad/Grad – undergraduate/graduate, DM – diabetes mellitus,
HT – hypertesion, CT – chemotherapy, RT – radiotherapy, TM – total mastectomy,
MRM – modified radical mastectomy

Table 2. The outcomes of the participants

Variables	mean± SD
Severity of Lymhedema (%)	
None	24
Mild	10
Modarete	58
Severe	8
Total Lymphedema	76
Spirometric Test mean± SD	
FEV1/FVC (%)	88.76 ± 11.45
FEV1 (L/sec)	77.82 ± 10.98
FVC (L)	80.16 ± 11.26
MIP (cm H_2O)	50.47 ± 12.70
MIP (cm H_2O)	52.21 ± 8.82
Functional Exercise Capacity mean± SD	
6MWT (m)	317.63 ± 51.59
Quality of life- SF 36 (score)	
Physical functioning (score)	86.18 ± 11.05
Role physical (score)	75.66 ± 34.13
Bodily pain (score)	65.64 ± 20.27
General health (score)	71.18 ± 13.23
Vitality (score)	72.37 ± 12.07
Social functioning (score)	67.43 ± 18.73
Role emotional (score)	87.74 ± 31.39
Mental health (score)	73.82 ± 12.32
Posture (score)	
NYPR	45.42 ± 6.56

NYPR – New York Posture Rating; FEV1 – the first second of forced expiration volume; FVC – forced vital capacity; MIP – maximal inspiratory pressure; MEP – maximal expiratory pressure; SF-36 – Short Form 36; 6MWT – Six Minute Walk Test

Table 3. Comparison of results of participants between the 6-min walking distance and the expected distance

		Mean	SD	Lower	Upper	*Z*	*p*
6MWT (m)	Walking Distance	317.63	51.59	210.00	480.00	–5573.000	*p*<0.001*
	Expected Distance	542.42	47.65	459.06	637.93		
MIP (cm H_2O)	MIP	50.47	12.70	28	78	–5.373	*p* <0.001*
	Expected MIP (%)	78.66	3.20	71.44	84.4		
MEP (cm H_2O)	MEP	52.21	8.82	26	67	–5.373	*p* <0.001*
	Expected MEP (%)	146.48	3.52	137.04	150.8		

*p < 0.05 for 6MWT – Six Minute Walking Test

There was no significant relationship between the affected side volume values with BMI, the NYPR, respiratory functions, and distance walked at 6 minutes and QoL ($p > 0.05$, Table 4).

Table 4. Correlation of all parameters to each other

Correlation between severity of lymhedema (volume) and other assessments	*r**	*p*
Body Composition		
BMI (kg/m^2)	-,014	,935
Posture		
NYPR (Score)	-,041	,808
Quality of life- SF 36 (score)		
Physical functioning (score)	,146	,383
Role physical (score)	,239	,149
Bodily pain (score)	,083	,620
General health (score)	-,013	,938
Vitality (score)	-,139	,405
Social functioning (score)	,197	,235
Role emotional (score)	,178	,284
Mental health (score)	-,074	,660
Functional Exercise Capacity		
Distance of 6MW (m)	-,302	,065
Spirometric Tests		
FEV1/FVC (%)	-,041	,805
FEV1(L/sec)	,309	,059
MIP (cmH2O)	-,211	,202
MEP (cmH2O)	-,173	,300
Correlation between Spirometric tests and Walking Distance	*r**	*p*
Spirometric Tests		
FEV1/FVC(%)	0.368	**0.023***
FEV1(L/sec)	-0.046	0.783
MIP (cmH2O)	0.276	0.093
MEP (cmH2O)	0.288	0.080

*p <0.05, BMI – body mass index; NYPR – the New York Posture Rating chart; SF-36 – Short Form 36; 6MWT – Six Minute Walking Test; FEV1 – the first second of forced expiration volume; FVC – forced vital capacity; MIP – maximal inspiratory pressure; MEP – maximal expiratory pressure

A significant negative correlation was found between BMI values and NYPR values of the participants ($r = –0.348$, $p = 0.05$). As the participants' BMI values increased, the NYPR values decreased (Figure 1).

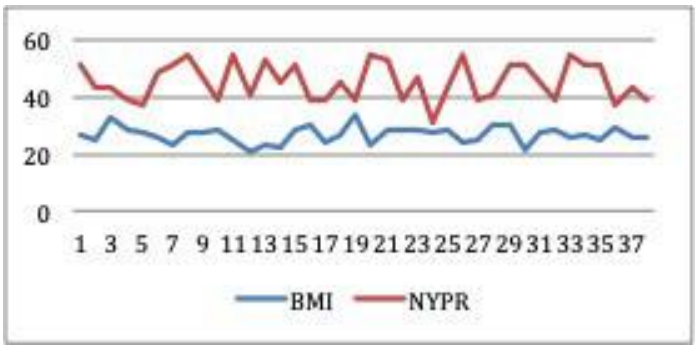

Figure 1. Relationship between participants' BMI values and the NYPR values.BMI: Body Mass Index; NYPR: The New York Posture Rating chart

When the relationship between the participants' spirometry results and walking distance at 6 min was analysed, there was a significant correlation between FEV1/ FVC values and walking distance (p <0.05). As the participants' FEV1/FVC values increased, the distance they walked at the end of 6MWT increased (Table 4).

Discussion

As far as we know, this is the first study, which examined the relationship between exercise capacity, posture, respiratory functions, the severity of lymphedema, and QoL after BCT. According to the data obtained our main findings; after BCT, as FEV1/FVC decreases, the walking distance decreases. Also, a significant correlation was detected between BMI and postural alignment. However, there was no relationship between the severity of lymphedema and posture, respiratory functions, functional exercise capacity, or QoL. In other respects, we determined that 66% of women had lymphedema and moderate postural malalignment, the functional exercise capacity and respiratory muscle strength were substantially underneath the expected value in all of them.

In the studies performed, the results show that lymphedema increased, if BMI was exceeded 25 kg/m^2. Quirion et al. determined that the risk of lymphedema amplified three times in patients with BMI >30 kg/m^2 [21]. Sagen et al. found in a randomised control study of 204 cases that BMI greater than 25 kg/m^2 significantly increased the development of lymphedema [22]. In our study, 73.69% of the individuals were >25 kg/m^2 and the results are consistent with those reported in the published studies.

It is known that lymphedema is an important complication seen in many women after BCT [23]. Pasket and Stark, conducted a study about general information given to people diagnosed with cancer, treatment, and effects on participants that survive and reached the conclusion that the use of the affected arm after surgery increased lymphedema by 40% [24]. Another study evaluated 100 women diagnosed with lymphedema after breast cancer and concluded that 66% of the participants developed lymphedema in the arm they actively used, 71% of the lymphedema developed in the arm and hand, and 36% experienced moderate lymphedema [25]. In this study, lymphedema was detected in 76% of the individuals; however, lymphedema was higher in the arm that was not actively used. The right extremity of most of our cases was dominant, but we think such an outcome occurred because the left breast was more affected than the right breast, thus the development of lymphedema in the left limb was high.

After BCT, it is possible to see mechanical disorders in the upper body and shoulder region, loss of muscle strength, stiffness in soft tissue, and restrictions in the joint movement. These symptoms can be reflected in the posture of the person and cause a variety of postural malalignment [26]. Stout et al. stated that there is a statistically significant disorder in the body posture of participants after mastectomy [27]. Kabala et al. determined that the sagittal plane body composition could change as a result of mastectomy surgery. According to this, there is an increase in thoracic kyphosis and lumbar lordosis among women who had BCT [28]. Although it was concluded that the posture of 31% of the participants was affected, there was no control group in our study for indicating this result absolutely related to BCT. Similarly, in our study is the average score of the participants from the NYPR after BCT.

It has been determined that functional exercise capacity and cardiorespiratory fitness decrease with all types of cancer that affect the cardiopulmonary system, directly or indirectly [9, 29]. In our study, it was observed that participants' functional capacities were low, reaching up to 58% of the expected value. In the literature, according to the 6MWT results, the mortality risk is determined 350m for patients with cardiopulmonary diseases [30], but the shortest distance in our study was 210m. Also noted, although not statistically significant, as the walking distance decreased, the limb volume increased. Also considering the absence of exercise habits of 34.21% of breast cancer patients in our study, this situation reveals the need for comprehensive studies on the determinants of functional exercise capacity in individuals with breast cancer.

To the best of our knowledge, there are limited researches evaluating respiratory muscle strength in breast cancer patients. In our study, it was determined that participants' MIP and MEP results were significantly lower than the expected values. Parallel to our study, Abreu et al. [31], evaluated MIP and MEP scores on 20 breast cancer patients before mastectomy. Results were was 43% and 40%, however, after mastectomy surgery, these results dropped significantly. In the same study, they observed patients who underwent neoadjuvant treatment had a decrease of pulmonary function in the values of FVC and FEV1 [31]. Respiratory muscle strength measurement methods are generally evaluated together with FVC, VC and other spirometric tests parameters [32]. Odynets et al. studied respiratory parameters compared to the control group in breast cancer patients, found that decreased all parameters [9]. Considering that spirometric tests, because we did not have a control group, a definite interpretation cannot be made about respiratory muscle strength. Considering the limitations in the literature, studies planned to determine the severity and course of muscle weakness are needed if MIP and MEP tests are performed correctly and other factors that may affect it are excluded.

Breast cancer can lead to different losses of function due to radical surgical interventions and radiotherapy after treatment [23]. Loss of function may include pain limitations in the shoulder area, loss of muscle strength in the upper limb, and locomotor system disorders such as lymphedema and psychological and cosmetic problems. As a result, a decrease in the QoL can be expected [23, 33]. Bouyo et al. conducted a systematic review designed to assess the QoL of Iranian women with breast cancer and indicated a moderate level [33]. Joo Ho et al. showed that in Asia, patients with breast cancer have lower QoL than the overall population. Comorbidities, chemotherapy, lower social support and neglected requirements are related to decreased QoL [34]. Taghian et. al. told that lymphedema affects many important aspects of a woman's life, including patients physical, psychological, and emotional health [35]. In our study, there is no relationship between QoL and severity of lymphedema. This situation reveals that there is more than one factor related to the QoL and also may relate to our sample number.

Limitation

A review of the literature found limited studies related to posture, functional capacity, and respiratory function tests after BCT. Our study is important in terms of investigating the relationship between these parameters and lymphedema and common problems. However, the fact that the sample number was low, there was no control group, and the evaluations cannot be compared with healthy participants and these are important limitations in this study. More studies need with more details and objective assessments especially posture and exercise capacity. As a result, disorders related to BCT such as lymphedema often occur in women, respiratory functions can be adversely affected, and functional capacity may be reduced. Evaluation and follow-up of these parameters after BCT is important for the establishment of preventive rehabilitation programs and/or design of appropriate physiotherapy programs.

Conclusion

This study shows that walking distance and respiratory muscle strength lower than normative values. BMI in women with breast cancer can be increased by worsening postural alignment. Future studies with increased sample size would clarify the predictors and relationships of all these parameters in women with breast cancer.

Acknowledgements
This research did not receive any financial or technical support.

Conflict of interest
Authors state no conflict of interest.

Disclosure statement
No author has any financial interest or received any financial benefit from this research.

Reference

1. Yuste Sánchez MJ, Lacomba MT, Sánchez BS, Merino DP, da Costa SP, Téllez EC, et al. Health related quality of life improvement in breast cancer patients: Secondary outcome from a simple blinded, randomised clinical trial. Breast. 2015;24(1):75–81.
2. Waks AG, Winer EP. Breast cancer treatment. JAMA. 2019 22;321(3):288; doi: 10.1001/jama.2018.19323
3. Khan JS, Ladha KS, Abdallah F, Clarke H. Treating Persistent Pain After Breast Cancer Surgery. Drugs. 2020;80(1):23–31; doi: 10.1007/s40265-019-01227-5
4. Brandão S, Da T, Ramos RI, Mascarenhas T. Women's Health and Biomechanics. 2018. 95–143. Available from: http://www.springer.com/series/8910
5. Avis NE, Levine B, Goyal N, Crawford SL, Hess R, Colvin A, et al. Health-related quality of life among breast cancer survivors and noncancer controls over 10 years: Pink SWAN. Cancer. 2020;cncr.32757; doi: 10.1002/cncr.32757
6. Executive Committee. The diagnosis and treatment of peripheral lymphedema: 2016 consensus document of the International Society of Lymphology. Lymphology. 2016;49(4):170–184.
7. Mangone M, Bernetti A, Agostini F, Paoloni M, De Cicco FA, Capobianco SV, et al. Changes in Spine Alignment and Postural Balance After Breast Cancer surgery: a rehabilitative point of view. Biores Open Access. 2019;8(1):121–8; doi: 10.1089/biores.2018.0045
8. Espinosa-López AM, Daza-Arana JE, Pinzón-Sanabria LM, Perdomo-Quiroga Y, Ruiz-Jiménez JP. Effects of muscle energy technique for quadratus lumborum on respiratory muscle strength in patients with breast cancer. Rev Fac Med. 2019;67(4):469–475.
9. Odynets T, Briskin Y, Ikkert O, Todorova V, Yefremova A. Cardiopulmonary function in breast cancer patients versus healthy control women. Physiother Quart. 2020;28(1):6–10; doi: 10.5114/pq.2020.89810
10. Pasyar N, Barshan Tashnizi N, Mansouri P, Tahmasebi S. Effect of yoga exercise on the quality of life and upper extremity volume among women with breast cancer related lymphedema: a pilot study. Eur J Oncol Nurs. 2019;42(July 2018):103–9; doi: 10.1016/j.ejon.2019.08.008
11. SITZIA J. Volume measurement in lymphoedema treatment: examination of formulae. Eur J Cancer Care (Engl). 1995;4(1):11–16; doi: 10.1111/j.1365-2354.1995.tb00047.x
12. McRoberts LB, Cloud RM, Black CM. Evaluation of the New York Posture Rating Chart for assessing changes in postural alignment in a garment study. Cloth Text Res J. 2013;31(2):81–96.
13. Miller MR, Crapo R, Hankinson J, Brusasco V, Burgos F, Casaburi R, et al. General considerations for lung function testing. Eur Respir J. 2005;26(1):153–61.
14. Hyatt RE, Black LF. Maximal respiratory pressures: normal values and relationship to age and sex. Am Rev Respir Dis. 1969;99:696–702.
15. Weisman IM, Weisman IM, Marciniuk D, Martinez FJ, Sciurba F, Sue D, et al. ATS/ACCP Statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med. 2003;167(2):211–77.
16. Borg GA V. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14(5):377–381.
17. Jay SJ, Enright P. Reference equations for the six-minute walk in healthy adults [1] (multiple letters). Am J Respir Crit Care Med. 2000;161(4 I):1396.
18. Perry S, Kowalski TL, Chang CH. Quality of life assessment in women with breast cancer: Benefits, acceptability and utilization. Health Qual Life Outcomes. 2007;5:1–14.
19. Gökçora N, İnce FG, Hocaoğlu MB, Akçay Nİ, Eker ÖC. KKTC 2012 Yılı Kanser İstatistikleri Raporu. 2018. Available from: https://medicine.emu.edu.tr/Documents/Programs/RAPORLAR/KKTC%20Kanser%20Kay%C4%B1t%202012%20Raporu.pdf [02.02.2021].

20. Hills M, Fleiss JL. The design and analysis of clinical experiments. J Royal Stat Soc. Series A (General). 1987;150:400.
21. Quirion E. CE ARTICLE: Recognizing and treating upper extremity lymphedema in postmastectomy/lumpectomy patients: A guide for primary care providers. J Am Acad Nurse Pract. 2010 3;22(9):450–459; doi: 10.1111/j.1745-7599.2010.00542.x
22. Sagen Å, Kåresen R, Risberg MA. Physical activity for the affected limb and arm lymphedema after breast cancer surgery. A prospective, randomized controlled trial with two years follow-up. Acta Oncol (Madr). 2009;48(8):1102–10; doi: 10.3109/02841860903061683.
23. Imamoğlu N, Karadibak D, Ergin G, Yavuzşen T. The Effect of Education on Upper Extremity Function in Patients with Lymphedema after Breast Cancer Treatments. Lymphat Res Biol. 2016;14(3):142–147.
24. Paskett ED, Stark N. Lymphedema: Knowledge, treatment, and impact among breast cancer survivors. Breast J. 2000;6(6):373–8.
25. Yıldız A, Karayurt Ö. Dıfficultıes experıenced by the women wıth breast cancer experıence due to lymphedema. J Breast Heal. 2011; 7(3):154–62.
26. Malicka I, Hanuszkiewicz J, Stefańska M, Barczyk K, Woźniewski M. Relation between trunk muscle activity and posture type in women following treatment for breast cancer. J Back Musculoskelet Rehabil. 2010;23(1):11–9.
27. Stout NL, Binkley JM, Schmitz KH, Andrews K, Hayes SC, Campbell KL, et al. A prospective surveillance model for rehabilitation for women with breast cancer. Cancer. 2012;118(Suppl.8):2191–200.
28. Kabała MM, Jasek P, Wilczyński J. Assessment of body posture in women after radical mastectomy using the DIERS formetric III 4D device. Med Stud. 2020;36(2):103–9; doi: 10.5114/ms.2020.96789
29. O'Donnell DE, Webb KA, Langer D, Elbehairy AF, Neder JA, Dudgeon DJ. Respiratory factors contributing to exercise intolerance in breast cancer survivors: a case-control study. J Pain Symptom Manage. 2016;52(1):54–63; doi: 10.1016/j.jpainsymman.2016.01.004
30. Rasekaba T, Lee AL, Naughton MT, Williams TJ, Holland AE. The six-minute walk test: a useful metric for the cardiopulmonary patient. Intern Med J. 2009;39(8):495–501; doi: 10.1111/j.1445-5994.2008.01880.x.
31. Monteiro Abreu AP, Endres D, Bortoluzzi Costa A, Cecagno Zanini SC, Ribeiro Martini R, Pereira Leguisamo C. Pulmonary Function and Respiratory Muscle Strength in Patients Undergoing Oncologic Breast Surgery [in Portuguese]). Rev Bras Cancerol. 2014;60(2):151–157.
32. Ulubay G. Respiratory Mass Physiology and Muscle Power Measurement [in Turkish]. Toraks Cerrahisi Bul. 2017;10(1):37–46.
33. Bouya S, Koochakzai M, Rafiemanesh H, Balouchi A, Taheri S, Badakhsh M, et al. Health-related quality of life of Iranian breast cancer patients: a meta-analysis and systematic review. Breast Cancer Res Treat. 2018;170(2):205–12; doi: 10.1007/s10549-018-4750-x.
34. Ho PJ, Gernaat SAM, Hartman M, Verkooijen HM. Health-related quality of life in Asian patients with breast cancer: A systematic review. BMJ Open. 2018;8(4).
35. Taghian NR, Miller CL, Jammallo LS, O'Toole J, Skolny MN. Lymphedema following breast cancer treatment and impact on quality of life: a review. Crit Rev Oncol Hematol. 2014;92(3):227–234; doi: 10.1016/j.critrevonc.2014.06.004.