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Evaluation of muscle strength and range of motion of upper extremity in breast cancer-related lymphedema

Furkan Kadir Gurlek [a], Hande Ozdemir [b],

[a] Trakya University, Health Sciences Institute, Edirne, Türkiye
[b] Trakya University, Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Edirne, Türkiye
*Corresponding author: handeozdemirmd@gmail.com (Hande Ozdemir)

MAIN POINTS

- The study found that lymphedema after breast cancer treatment leads to a notable reduction in shoulder flexion and extension strength, as well as range of motion.
- Elbow flexion muscle strength was also significantly reduced in the affected arm.
- No significant differences were found in elbow extension, wrist flexion and extension strength, or the ROM of the elbow and wrist joints.
- The study's findings can assist clinicians in creating targeted rehabilitation programs that focus on restoring strength and mobility in the areas most impacted by lymphedema.

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ABSTRACT

Aim: The objective of this study was to examine the impact of lymphedema on the muscle strength and range of motion of the upper extremities in breast cancer patients with lymphedema.

Materials and Methods: Thirty-one female breast cancer survivors with lymphedema were evaluated in this cross-sectional study. The measurement of shoulder, elbow, and wrist flexion and extension strength was conducted using a hand-held dynamometer on both affected and unaffected upper extremities. Subsequently, a digital goniometer was utilized to assess the range of motion in both the affected and unaffected upper extremities.

Results: A median age of 61 years (with an interquartile range of 55 to 69 years) was reported for the patients, and dominant right upper extremity was noted for all. The study revealed that the affected extremity exhibited reduced shoulder flexion and extension muscle strength and range of motion, and decreased elbow flexion muscle strength when compared to the unaffected upper extremity ($p<0.05$). However, a lack of statistical significance was observed in the comparison of elbow extension, wrist flexion and extension strength, and elbow and wrist joint range of motion between the two extremities ($p>0.05$).

Conclusion: In cancer-associated lymphedema, limitations in muscle strength and range of motion are primarily localized to the shoulder region. These findings may serve as a guide for clinicians in the development of targeted rehabilitation interventions, with the aim of restoring mobility and strength in the areas most affected by lymphedema.

Keywords: Lymphedema, Muscle strength, Range of motion

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INTRODUCTION

A significant increase in the burden of breast cancer has been detected in middle- and low-income countries, particularly over the last three decades, due to differences in access to health resources [1]. About 20% of patients with breast cancer develop lymphedema, which can be caused by obstruction or disruption in the lymphatic system resulting from cancer treatment [2]. Lymphedema causes swelling of an extremity due to excessive accumulation of a protein-rich fluid [3]. Symptoms include pain, a sense of heaviness, and impaired motor abilities, daily functioning, and quality of life [4,5]. Women undergoing breast cancer treatment are prone to developing upper extremity muscle weakness and range of motion (ROM) limitations, even in the absence of lymphedema [6,7]. These impairments are underpinned by physiological factors such as nerve damage from surgery, fibrotic tissue formation from radiation therapy, and muscle ischemia, as well as behavioral factors such as kinesiophobia, where patients avoid using the affected arm out of fear of worsening lymphedema [8-11].

The majority of studies that have focused on upper extremity function in cases of breast cancer-related lymphedema have concentrated on the measurement of shoulder girth or the assessment of hand grip strength. However, existing literature is either contradictory or deficient in its specific discussion of changes in muscle strength and range of motion (ROM) in more distal joints, including the elbow and wrist. For instance, some studies have identified a correlation between weakness in grip strength and lymphedematous extremities [12], while others have found no significant difference in hand grip strength or dexterity between affected and unaffected sides in lymphedema patients [13,14]. This finding indicates that the functionality of distal joints may be partially preserved, irrespective of the presence of lymphedema or through patients' adaptations to daily activities.

Given these variability in the existing literature and the lack of objective assessments focusing on specific joints, it is crucial to comprehensively examine flexion and extension muscle strength and ROM in the shoulder, elbow, and wrist joints in patients with breast cancer-associated lymphedema. By comparing these parameters between lymphedematous and non-lymphedematous arms, this study aims to further elucidate the specific effects of lymphedema on different regions of the upper extremity, thereby contributing scientifically to the development of rehabilitation strategies.

MATERIALS AND METHODS

Study design

This cross-sectional study was conducted in Trakya University Faculty of Medicine, Physical Therapy and Rehabilitation Outpatient Clinic Lymphedema Unit between September 2021 and September 2022 with the approval of Trakya University Faculty of Medicine Scientific Research Ethics Committee dated 14.06.2021 with protocol number TÜTF-BAEK 2021/277 and designed in compliance with the 2008 Declaration of Helsinki. All participants in the study have provided written consent.

Participants

The sample size of the study was determined as 34 patients, using an effect size of 0.496, an error rate of 5%, and a power value of 80%, based on the hand grip strength values of lymphedema patients in the study conducted by Erdoğanoğlu et al. [15]. However, only 33 patients were evaluated for eligibility. Women aged 18-75 years with unilateral upper extremity lymphedema associated with breast cancer were included. Patients had to have completed radiotherapy and chemotherapy for breast cancer at least 6 weeks prior and surgical treatment at least 3 months prior. Exclusion criteria were bilateral breast cancer or lymphedema, metastatic or recurrent breast cancer, acute upper extremity infection, or neuromusculoskeletal disease affecting upper extremity tests. After excluding two patients who failed to meet the specified inclusion criteria, the study sample comprised a total of 31 patients.

Assessments

Patients diagnosed with unilateral upper extremity lymphedema were asked to provide information regarding their age, height, body weight, marital status, educational level, and employment status. The body mass index (BMI) was computed as the weight (kg) divided by the height (m) squared. Weight categories : underweight (BMI < 18.5); normal (18.5–24.99); overweight (25–29.99); class 1 obesity (30–34.99); class 2 obesity (35–39.99); and class 3 obesity (40 and above) [16]. Patients were queried about their receipt of chemotherapy and/or radiotherapy. The Visual Analog Scale (VAS) was used to evaluate the average degree of pain in the affected arm over the past week [17]. The International Physical Activity Questionnaire (Short Form) was given to assess physical activity levels [18]. The Edinburgh hand preference questionnaire was used to determine the dominant upper extremities [19]. Upper extremity circumference, muscle strength, and range of motion measurements were performed using validated and reliable methods by a single evaluator [20-22]. The measurement of the patient's upper limb circumference was taken in a supine position with both arms at their sides, using a tape measure. The measurements were obtained at the level of the first and fifth metacarpophalangeal joints, followed by the measurement of 4-centimeter intervals along the limb, commencing at the ulnar styloid process [20]. The lymphedema staging was carried out based on the International Society of Lymphology (ISL) staging system [23]. Muscle strength was assessed in the subjects using a hand-held dynamometer (HHD) (Lafayette Instrument, USA). They were asked to take standard positions and apply resistance against the dynamometer. They were given a trial application, then instructed to reach maximum contraction with the initial warning signal and maintain it until the subsequent signal. The measurement was repeated after a one-minute interval, and the higher value was documented. The strength of the muscles on both sides of the body was measured with the patient lying supine on a stretcher. The HHD was positioned posterior to the forearm, with the shoulder in 90° flexion, the elbow and wrist in a neutral position, and the forearm in pronation to assess the strength of the shoulder flexor muscles. The HHD was positioned anterior to the forearm, with the shoulder in 90° flexion, the elbow and wrist in a neutral position, the forearm pronated to assess the strength of the shoulder extensor muscles. To evaluate the strength of the elbow flexor muscles, the HHD was placed on the anterior aspect of the forearm, with the shoulder and wrist at 0°, elbow in 90° flexion, and forearm supinated. To measure the strength of the elbow extensor muscles, the HHD was placed posterior to the forearm, with the shoulder and wrist at 0°, elbow at 90° flexion, forearm supinated. To evaluate the strength of the wrist flexor muscles, the HHD was placed anterior to the carpal surface, with the shoulder in 30° abduction, the elbow and wrist in 0°, the forearm supinated, the wrist outside the stretcher. To measure the strength of the wrist extensor muscles, the HHD was placed posterior to the carpal surface, with the shoulder in 30° abduction, the elbow and wrist in 0° flexion, the forearm in pronation, the wrist extending beyond

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the stretcher (Figure 1) [21, 24, 25]. The digital goniometer (Baseline Absolute+ Axis, Newyork,USA) was utilized to determine the ROMs of shoulder flexion, shoulder extension, elbow flexion, elbow extension, and wrist flexion and wrist extension of both upper extremities [22, 26].

Sensitivity analysis

To evaluate the robustness of the findings given the modest shortfall in sample size (31 instead of 34 patients), a leave-one-out sensitivity analysis was performed for all paired outcomes. Each Wilcoxon signed-rank test was repeated after sequentially excluding one participant at a time, and the resulting range of p-values was recorded.

Statistical analysis

The study's data were processed using Statistical Software Package for Social Sciences (SPSS) for Windows, version 20.0 (license number 10240642). Continuous variables were expressed as mean ± standard deviation and median (IQR 25-75), while categorical variables were expressed as number and percentage. In statistical evaluations, the conformity of the data to normal distribution was evaluated by one sample Kolmogorov Smirnov test. Wilcoxon signed rank test was used to compare affected and unaffected upper extremity muscle strength and ROMs of the participants. Any $p<0.05$ was considered as statistical significance.

RESULTS

This study included 31 female patients, aged 55 to 69, with unilateral upper extremity lymphedema. Among these participants, 77% were overweight or obese, and 93% were minimally active or physically inactive. The dominant arm for all patients was the right, while the lymphedema-affected extremity was the non-dominant arm in 71% of cases. The majority of patients presented with stage 1 lymphedema, followed by stage 2 and stage 3. Patient demographics and clinical characteristics are detailed in Table 1.

A comparison of muscle strength between the affected and unaffected upper extremities revealed statistically significant deficits in the affected arm for shoulder flexion, shoulder extension, and elbow flexion (Table 2). Sensitivity analyses confirmed the robustness of these findings; leave-one-out p-value ranges remained below 0.05 for shoulder flexion (<.001–.002), shoulder extension (.009–.051), and elbow flexion (.005–.031). No significant differences were observed for elbow extension or wrist flexion and extension, and sensitivity analyses confirmed the stability of these null results.

The range of motion of the affected and unaffected extremities is compared in Table 3. Shoulder flexion and extension were significantly reduced on the affected side ($p = .008$ and $p = .035$, respectively). Sensitivity analyses confirmed these findings were robust (p-value ranges of .001–.013 and .009–.059, respectively). No significant differences were observed for elbow or wrist ROMs, and these null findings were again supported by the sensitivity results.

DISCUSSION

Among individuals with unilateral lymphedema following breast surgery, this study identified decreased muscle strength in shoulder flexion, shoulder extension, and elbow flexion, as well as reduced ROM in shoulder flexion and extension in the affected extremity compared to the unaffected one. However, no significant differences were found in elbow extension strength, wrist flexion/extension strength, or elbow and wrist joint ROMs between the two extremities. These findings are consistent with some reports in the literature but contradict others.

Arm weakness is a commonly reported complication, affecting 23-28% of patients after breast surgery [27, 28]. It is well-established that women undergoing treatment for breast cancer are susceptible to developing muscle weakness and impaired mobility, even without lymphedema [6, 7]. In a 5-year follow-up, Belmonte et al. [7] found that breast cancer patients who underwent axillary lymph node dissection—a procedure associated with a higher lymphedema incidence than sentinel lymph node biopsy—experienced significant strength loss in the internal rotators of the affected shoulder. This muscle weakness can be attributed to several factors, including nerve damage during axillary dissection, radiation-induced fibrosis, and sensory impairment [8-10]. Furthermore, scapular rhythm disturbances and the overworking of compensatory muscles can negatively affect muscle strength and endurance [9]. Consistent with our findings, previous studies have also noted decreased strength in shoulder abduction, adduction, external rotation, and trapezius muscles [6], as well as in shoulder internal and external rotation [9], in women with lymphedema.

A notable finding from our study, which aligns with existing literature, is the decreased elbow flexor strength in the lymphedematous limb. Smoot et al. [14] similarly reported reduced elbow flexor strength on the affected side in women with lymphedema, who also experienced significant difficulty carrying objects heavier than 4.5 kg. These findings suggest that lymphedema is not merely a volumetric issue but one that directly impairs upper extremity muscle function. The development of muscle strength deficits after breast surgery is multifactorial and not solely determined by lymphedema volume. Lee et al. [11] proposed that weakness in the affected arm may not be a direct result of the disease itself but rather from a reluctance to use the arm due to a fear of movement, a phenomenon known as kinesiophobia. This fear can trigger "use-avoidance" behaviors, leading to muscle atrophy and functional decline. Therefore, all patients with lymphedema post-breast surgery should undergo a comprehensive evaluation of upper extremity muscle strength and function. Multidisciplinary interventions, including specialized rehabilitation with resistance exercises, are crucial for managing the condition and have been shown to improve functional capacity and quality of life [29].

In contrast to some reports, our finding that wrist flexion and

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Table 1. Demographic and clinical characteristics of the patients.

Variables		All cases (n=31)
Age, years	Mean (SD) Median (IQR)	60.81 (9.46) 61 (55-69)
Height, cm	Mean (SD) Median (IQR)	158.06 (4.75) 156 (155-161)
Body weight, kg	Mean (SD) Median (IQR)	79 (17.15) 79 (67-88)
BMI, kg/m²	Mean (SD) Median (IQR)	31.70 (7.31) 31.25 (25.20-35.15)
Weight status category	n (%)	
Underweight		0
Normal		7 (22.6)
Overweight		6 (19.4)
Class 1 obesity		10 (32.3)
Class 2 obesity		4 (12.9)
Class 3 obesity		4 (12.9)
Marital status	n (%)	
Married		27 (87.1)
Single		1 (3.2)
Widowed		3 (9.7)
Educational Level	n (%)	
Illiterate		1 (3.2)
Primary School		15 (48.4)
Middle School		6 (19.4)
High School		6 (19.4)
Undergraduate		3 (9.7)
Employment Status	n (%)	
Housewife		23 (74.2)
Retired		5 (16.1)
Employed		3 (9.7)
History of receiving chemotherapy and/or radiotherapy	n (%)	
None		1 (3)
Chemotherapy		4 (13)
Chemotherapy and radiotherapy		26 (84)
VAS (1-10)	Mean (SD) Median (IQR)	2.45 (3.02) 1 (0-4)
Physical activity level (MET-min/week)	Mean (SD) Median (IQR)	1349.27 (1995.35) 693 (396-1386)
Physical activity category	n (%)	
Low		12 (38.7)
Moderate		17 (54.8)
High		2 (6.5)
Distribution of lymphedema according to upper extremity dominance	n (%)	
Lymphedema in the dominant upper extremity		9 (29)
Lymphedema in the non-dominant upper extremity		22 (71)
Lymphedema Stage	n (%)	
Stage 1		12 (38.7)
Stage 2		11 (35.5)
Stage 3		8 (25.8)

BMI: body mass index , MET: metabolic equivalent of task, VAS: visual analogue scale.

extension strength in the lymphedematous extremity was similar to the unaffected side offers a more nuanced view of upper extremity weakness. Smoot et al. [14] found a decline in wrist flexion strength in the affected arm, and Baklacı et al. [12] demonstrated that hand grip strength was diminished in the lymphedematous arm, even after complete decongestive therapy. However, the latter study also noted that changes in hand grip strength can occur regardless of surgery type or the presence of lymphedema [12]. Supporting our results, a study by Civelek [13] revealed no statistically significant difference in hand grip strength or function between the affected and unaffected sides of patients with lymphedema. This sug-

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Table 2. Comparison of affected and unaffected upper extremity flexion and extension muscle strengths.

Muscle strength (kg)	Affected upper extremity Mean (SD) Median (IQR) (n=31)	Unaffected upper extremity Mean (SD) Median (IQR) (n=31)	p*	Sensitivity p-value (LOO range)**
Shoulder flexion	7.16 (2.18) 7.20 (5.4-8.9)	8.29 (1.83) 8.4 (7.2-9.2)	.002	<.001-.002
Shoulder extension	7.93 (2.05) 8.3 (7.3-8.8)	8.72 (1.72) 8.4 (8.0-9.9)	.028	.009-.051
Elbow flexion	12.57 (3.67) 13.10 (9.8-15.1)	13.77 (2.91) 13.3 (11.7-15.5)	.018	.005-.031
Elbow extension	10.09 (2.71) 10 (8.8-11.4)	10.89 (2.25) 10.9 (9.6-12.3)	.225	.137-.336
Wrist flexion	6.64 (2.07) 6.0 (5.1-8.0)	6.87 (1.77) 6.4 (5.6-7.8)	.239	.124-.349
Wrist extension	7.68 (2.36) 7.7 (5.6-9.6)	7.26 (1.87) 7.2 (5.8-8.2)	.156	.076-.256

*p value by Wilcoxon Signed Ranks Test. Statistically significant p–value < 0.05. ** Sensitivity p-values indicate the range observed in leave-one-out analysis.

Table 3. Comparison of affected and unaffected upper extremity range of motions.

Range of motion (°)	Affected upper extremity Mean (SD) Median (IQR) (n=31)	Unaffected upper extremity Mean (SD) Median (IQR) (n=31)	p*	Sensitivity p-value (LOO range)**
Shoulder flexion	144.61 (24.51) 146 (130-160)	156.10 (22.02) 160 (150-170)	.008	.001 -- .013
Shoulder extension	56.26 (12.24) 55 (49-67)	60.19 (11.18) 60 (50-70)	.035	.009 -- .059
Elbow flexion	132.23 (9.71) 135 (130-140)	135.10 (8.32) 135 (130-140)	.267	.188 -- .439
Elbow extension	1.06 (2.59) 0 (0-3)	-0.35 (4.05) 0 (0-0)	.068	.027 -- .151
Wrist flexion	67.61 (9.15) 65 (60-75)	67.93 (10.47) 69 (62-75)	.909	.665 -- 1.000
Wrist extension	64.71 (12.36) 63 (60-75)	61.39 (12.36) 65 (54-70)	.243	.144 -- .386

*p value by Wilcoxon Signed Ranks Test. Statistically significant p–value < 0.05. **Sensitivity p-values indicate the range observed in leave-one-out analysis.

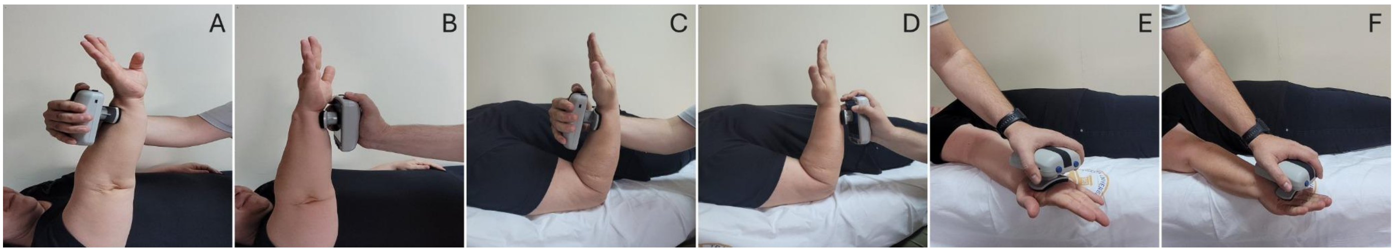

Figure 1. Isometric strength testing positions using the handheld dynamometer. (A) shoulder flexion, (B) shoulder extension, (C) elbow flexion, (D) elbow extension, (E) wrist flexion, (F) wrist extension.

gests that while surgical and therapeutic interventions impact overall upper extremity function, the adaptive capacity of distal joints like the wrist may mask these deficits. Patients may maintain fine motor skills in their hands and wrists for daily activities despite the severity of or apprehension about their lymphedema [13]. Additionally, kinesiophobia may primarily limit proximal movements at the shoulder and elbow, while less-feared movements of the wrist remain relatively unaffected.

Our observation of limited shoulder flexion and extension

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in the affected extremity is consistent with the literature. Postoperative shoulder limitations are documented in 28.3% of patients after breast surgery and are correlated with increased upper extremity disability [14, 27]. Lymphedema can exacerbate these limitations. Rezende et al. [6] observed that women who underwent mastectomy had more restricted shoulder flexion, abduction, and rotation ROMs on the affected side, with limitations being more pronounced in those with lymphedema. These shoulder limitations can be attributed to factors such as scar tissue formation, radiation-induced fibrosis, protective posturing, and prolonged immobility or pain [14]. Our findings on distal joint ROM, however, reveal some discrepancies with previous research. The similar elbow ROM we observed between extremities is consistent with Smoot et al. [14]. Yet, while they noted a greater limitation in wrist flexion on the affected side, our study found comparable wrist ROM in both arms. This discrepancy may be due to differences in patient populations. In the study by Smoot et al., 52% of patients had lymphedema in their dominant extremity, whereas this figure was only 29% in our study. It is plausible that when the dominant hand is affected, patients may use it less out of concern for worsening symptoms, leading to reduced strength and mobility. Since the majority of our patients had lymphedema in the non-dominant limb, this effect may not have been present. However, this explanation should be interpreted cautiously, as Smoot et al. [14] found that limb dominance did not significantly affect functional disability scores. Methodological differences, such as goniometer sensitivity, measurement techniques, or sample size, could also contribute to these divergent results [14].

In our cohort, the affected extremity was the non-dominant (left) arm in 71% of patients, which aligns with the higher incidence of left-sided breast cancer in the general population [30]. This suggests that the prevalence of lymphedema may mirror the anatomical distribution of breast cancer. This finding is clinically significant, as some data indicate that left-sided breast cancers may have a more aggressive biological profile and less favorable long-term outcomes [31]. The literature is conflicting regarding the relationship between the treated side's dominance and lymphedema risk. Hayes et al. [32] reported an 80% higher risk of lymphedema in patients treated on the non-dominant side, suggesting that greater use of the dominant arm in daily life may be protective. Conversely, Bulley et al. [33] found no association between limb dominance and the development of lymphedema or upper extremity dysfunction. Future research should investigate the complex interplay between lymphedema localization, surgical factors, and long-term patient outcomes.

Limitations

This study has several limitations. First, its cross-sectional design precludes the establishment of causal relationships. Nonetheless, the data provide clinicians with valuable observational findings to guide patient evaluations. Second, the final sample size of 31 patients was slightly below our target of 34. Although a sensitivity analysis was performed to assess the robustness of the findings, the reduced sample size may still limit generalizability. Third, the absence of a healthy control group makes it difficult to ascertain whether the observed impairments are solely attributable to lymphedema or are influenced by confounding factors such as age-related decline. However, the within-subject comparison design is a strength, as it minimizes the impact of inter-individual factors like general health and lifestyle. Finally, due to a lack of data, we could not assess clinical parameters such as the specific type of malignancy, whether axillary dissection was performed, or the surgical procedure used. This prevented an analysis of how different treatments might affect upper extremity outcomes. Future longitudinal studies with more comprehensive data collection are needed to elucidate causal relationships and refine clinical practice.

CONCLUSION

In conclusion, this study demonstrates that patients with upper extremity lymphedema following breast cancer treatment have significant deficits in shoulder flexion/extension (both strength and ROM) and elbow flexion strength in the affected limb. These impairments appear to be localized to the proximal joints, which provides a clear rationale for targeted rehabilitation. Treatment programs should focus on addressing the pronounced limitations around the shoulder while leveraging the preserved function of the elbow and wrist. This targeted approach allows clinicians to prioritize interventions to restore mobility and strength where it is most needed.

Data Availability Statement: The underlying data presented in this publication are available upon reasonable request to the corresponding author.

Ethics Committee Approval: The study was approved by the Trakya University Scientific Research Ethics Committee (Decision No: TÜTF-BAEK:2021/277 Date: 14.06.2021).

Informed Consent: The authors stated that they obtained informed consent from the participants in the study.

Peer-review: Externally peer-reviewed.

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REFERENCES

1. Cai Y, Dai F, Ye Y, Qian J. The global burden of breast cancer among women of reproductive age: a comprehensive analysis. *Sci Rep*. 2025;15(1):9347. doi: 10.1038/s41598-025-93883-9.
2. DiSipio T, Rye S, Newman B, Hayes S. Incidence of unilateral arm lymphoedema after breast cancer: a systematic review and meta-analysis. *Lancet Oncol.* 2013;14(6):500-15. doi: 10.1016/S1470-2045(13)70076-7.
3. Cheville AL, McGarvey CL, Petrek JA, Russo SA, Thiadens SR, Taylor ME. The grading of lymphedema in oncology clinical trials. *Semin Radiat Oncol.* 2003: 13(3):214-25. doi:10.1016/S1053-4296(03)00038-9.
4. Hayes SC, Johansson K, Stout NL, Prosnitz R, Armer JM, Gabram S, et al. Upper-body morbidity after breast cancer: incidence and evidence for evaluation, prevention, and management within a prospective surveillance model of care. *Cancer.* 2012;118(S8):2237-49. doi: 10.1002/cncr.27467.
5. Shaitelman SF, Cromwell KD, Rasmussen JC, Stout NL, Armer JM, Lasinski BB, et al. Recent progress in the treatment and prevention of cancer-related lymphedema. *CA Cancer J Clin.* 2015;65(1):55-81. doi: 10.3322/caac.21253.
6. Rezende MS, Rossi DM, de Lima AMR, Clemente GS, de Oliveira AS, de Oliveira Guirro EC. Shoulder and scapulothoracic impairments in women with breast cancer-related lymphedema in the upper limb: a cross-sectional study shoulder and breast cancer-related lymphedema. *J Bodyw Mov Ther.* 2024;37:177-82. doi: 10.1016/j.jbmt.2023.11.055.
7. Belmonte R, Messaggi-Sartor M, Ferrer M, Pont A, Escalada F. Prospective study of shoulder strength, shoulder range of motion, and lymphedema in breast cancer patients from pre-surgery to 5 years after ALND or SLNB. *Support Care Cancer.* 2018;26(9):3277-87. doi: 10.1007/s00520-018-4186-1.
8. Lebel S, Tomei C, Feldstain A, Beattie S, McCallum M. Does fear of cancer recurrence predict cancer survivors' health care use? *Support Care Cancer.* 2013;21(3):901-6. doi: 10.1007/s00520-012-1685-3.
9. Zabit F, Iyigun G, Malkoc M. Assessment of proprioception, muscle strength and endurance during dynamic isokinetic test in patients with breast cancer-related lymphedema. *Clin Biomech.* 2023;110:106100. doi: 10.1016/j.clinbiomech.2023.106100.
10. Belmonte R, Monleon S, Bofill N, Alvarado ML, Espadaler J, Royo I. Long thoracic nerve injury in breast cancer patients treated with axillary lymph node dissection. *Support Care Cancer.* 2015;23(1):169-75. doi: 10.1007/s00520-014-2338-5.
11. Lee D, Hwang JH, Chu I, Chang HJ, Shim YH, Kim JH. Analysis of factors related to arm weakness in patients with breast cancer-related lymphedema. *Support Care Cancer.* 2015;23(8):2297-304. doi: 10.1007/s00520-014-2584-6.
12. Baklaci M, Eyigör S, Tanıgör G, Özgür İnbat M, Çalışkan Kabayel S. Assessment of muscle strength and volume changes in patients with breast cancer-related lymphedema. *Oncol Res Treat.* 2020;43(11):584-91. doi: 10.1159/000509672.
13. Civelek GM. Effects of breast cancer related lymphedema on hand muscle strength, hand functions and sensory loss of hand. *Cukurova Med J.* 2016;41(2):208-16. doi: 10.17826/cutf.200040.
14. Smoot B, Wong J, Cooper B, Wanek L, Topp K, Byl N, et al. Upper extremity impairments in women with or without lymphedema following breast cancer treatment. *J Cancer Surviv.* 2010;4(2):167-78. doi: 10.1007/s11764-010-0118-x.
15. Erdoğanoğlu Y, Çalık M, Vural M. Functional evaluation of patients with mastectomy lymphedema. *Turk J Phys Med Rehabil.* 2021;67(1):56. doi: 10.5606/tftrd.2021.4616.
16. Douketis JD, Paradis G, Keller H, Martineau C. Canadian guidelines for body weight classification in adults: application in clinical practice to screen for overweight and obesity and to assess disease risk. *CMAJ.* 2005;172(8):995-8. doi: 10.1503/cmaj.045170.
17. Kahl C, Cleland JA. Visual analogue scale, numeric pain rating scale and the McGill pain Questionnaire: an overview of psychometric properties. *Physical Therapy Reviews.* 2005;10(2):123-8. doi: 10.1179/108331905X55776.
18. Saglam M, Arikan H, Savci S, Inal-Ince D, Bosnak-Guclu M, Karabulut E, et al. International physical activity questionnaire: reliability and validity of the Turkish version. *Percept Mot Skills*. 2010;111(1):278-84. doi: 10.2466/06.08.PMS.111.4.278-284.
19. Uysal SA, Ekinci Y, Çoban F, Yakut Y. Edinburgh el tercihi anketi Türkçe güvenirliğinin araştırılması. *JETR.* 2019;6(2):112-8.
20. Meijer RS, Rietman JS, Geertzen JH, Bosmans JC, Dijkstra PU. Validity and intra- and interobserver reliability of an indirect volume measurements in patients with upper extremity lymphedema. *Lymphology.* 2004;37(3):127-33. PMID: 15560108.
21. Rheault W, Beal JL, Kubik KR, Nowak TA, Shepley JA. Intertester reliability of the hand-held dynamometer for wrist flexion and extension. *Arch Phys Med Rehabil.* 1989;70(13):907-10. PMID: 2596965.
22. Carey MA, Laird DE, Murray KA, Stevenson JR. Reliability, validity, and clinical usability of a digital goniometer. *Work.* 2010;36(1):55-66. doi: 10.3233/WOR-2010-1007.
23. Executive Committee of the International Society of Lymphology. The Diagnosis and Treatment of Peripheral Lymphedema: 2016 Consensus Document of the International Society of Lymphology. *Lymphology.* 2016;49(4):170-84. PMID: 29908550.
24. Nepomuceno Júnior BRV, Menezes MPdS, Santos KRBd, Gomes Neto M. Comparison of methods for evaluating upper limb strength by hand-held dynamometry. *Rev Bras Med Esporte.* 2021;27:42-8. doi: 10.1590/1517-8692202127012020_0008.
25. Douma RK, Soer R, Krijnen WP, Reneman M, Van Der Schans CP. Reference values for isometric muscle force among workers for the Netherlands: a comparison of reference values. *BMC Sports Sci Med Rehabil.* 2014;6(1):10. doi: 10.1186/2052-1847-6-10.
26. Norkin CC, White DJ. Measurement of joint motion: a guide to goniometry. 5th ed. Philadelphia: *FA Davis*; 2016.
27. Mollaoglu MC, Mollaoğlu M, Akın EB, Karadayı K. Meme Kanseri Cerrahisi Sonrası Üst Ekstremite Sorunları ve Yeti Yitimi. *IGUSABDER.* 2024(23):750-66.
28. Lee TS, Kilbreath SL, Refshauge KM, Herbert RD, Beith JM. Prognosis of the upper limb following surgery and radiation for breast cancer. *Breast Cancer Res Treat.* 2008;110(1):19-37. doi: 10.1007/s10549-007-9710-9.
29. Lin Y, Wu C, He C, Yan J, Chen Y, Gao L, et al. Effectiveness of three exercise programs and intensive follow-up in improving quality of life, pain, and lymphedema among breast cancer survivors: a randomized, controlled 6-month trial. *Support Care Cancer.* 2023;31(1):9. doi: 10.1007/s00520-022-07494-5.
30. Badru F, Chianakwalam C, Stevenson V. Laterality of Breast Cancer-is it true? *Eur J Surg Oncol.* 2011;37(11):987. doi: 10.1016/j.ejso.2011.08.044.
31. Abdou Y, Gupta M, Asaoka M, Attwood K, Mateusz O, Gandhi S, et al. Left sided breast cancer is associated with aggressive biology and worse outcomes than right sided breast cancer. *Sci Rep.* 2022;12(1):13377. doi: 10.1038/s41598-022-16749-4.
32. Hayes S, Cornish B, Newman B. Comparison of methods to diagnose lymphoedema among breast cancer survivors: 6-month follow-up. *Breast Cancer Res Treat.* 2005;89(3):221-6. doi: 10.1007/s10549-004-2045-x.

33. Bulley C, Coutts F, Blyth C, Jack W, Chetty U, Barber M, et al. Prevalence and impacts of upper limb morbidity after treatment for breast cancer: a cross-sectional study of lymphedema and function. *Cancer and Oncology Research.* 2013;1(2):30-39. doi: 10.13189/cor.2013.010203.