JRSR 10 (2023) 49-54

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

The Relationship between the Upper Extremity Volume and Disability, Thoracic Kyphosis, Shoulder Protraction, and Forward Head Posture in Patients with Upper Extremity Lymphedema Following Total Mastectomy

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ARTICLE INFO

Article History:
Received: 10/01/2022
Revised: 31/07/2022
Accepted: 03/09/2022

Keywords:
Breast cancer lymphedema
Kyphosis
Posture
Shoulder
Spine
Disability evaluation

Please cite this article as: Abolahrari-Shirazi S, Meftahi N, Zakeri Z, Jaberolansar D, Taherpour M. The Relationship between the Upper Extremity Volume and Disability, Thoracic Kyphosis, Shoulder Protraction, and Forward Head Posture in Patients with Upper Extremity Lymphedema Following Total Mastectomy. JRSR. 2023;10(1):49-54.

ABSTRACT

Background: Upper extremity (UE) lymphedema, which negatively affects patients' personal and social well-being, is the most common complication after breast cancer treatment. Previous studies have demonstrated the adverse effects of surgical interventions for breast cancer on spinal postures and UE disability; however, no studies have examined the relationships between UE volume and postural changes and between UE volume and UE disability in patients with lymphedema. Furthermore, some spinal postural changes in patients with forward head posture (FHP) remain unassessed in these patients. Therefore, the present study investigated the relationship between the volume of the affected UE with FHP, kyphosis, shoulder protraction, and UE disability in lymphedema patients.

Methods: The present cross-sectional study was carried out on 32 women with unilateral UE lymphedema. UE volume and kyphosis were measured by volumetry and a flexible ruler, respectively. Cervical angle was used to assess FHP. To measure shoulder protraction and FHP, data obtained from markers and photography was analyzed in ImageJ software. The disability of the affected UE was assessed by the Persian version of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. Data analysis was performed using Pearson's correlation test.

Results: Significant positive correlations were observed between UE volume and UE disability as well as kyphosis. Significant negative correlations between UE volume and shoulder as well as cervical angle were also seen. UE disability had a significant negative correlation with shoulder angle but no significant relationship with kyphosis or cervical angle.

Conclusion: An increase in the affected UE volume due to lymphedema is related to an increase in UE disability, kyphosis angle, FHP, and shoulder protraction. In addition to treatments for UE volume reduction in lymphedema patients, accurate posture evaluation is also recommended.

Introduction

According to GLOBOCAN 2020, breast cancer is the most commonly diagnosed cancer among women [1]. Breast cancer patients are treated using surgical procedures such as mastectomy and lumpectomy [2]. Pain, sensory changes in the surgical site, nerve damage, reduced range of motion and shoulder muscle weakness, rotator cuff muscles involvement, and scapular dyskinesis have been reported as complications of breast cancer treatments [3-8].

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Lymphedema, which is associated with chronic or repeated swelling of the affected limb, is the most common complication after breast cancer treatments [9, 10]. It can lead to other complications and ultimately negatively affect people's personal and social life [11]. According to the available reports, lymphedema may develop after treatment in almost 20% of breast cancer patients [12]. While upper extremity (UE) is the most common site affected by lymphedema, breasts and the upper back are also often involved [13]. Lymphedema is characterized by symptoms such as pain and heaviness in the affected limb, movement limitations, postural disorders, changes in spinal alignment, and functional impairments in daily activities [14, 15].

Recent articles have shown that surgical interventions for breast cancer affect the musculoskeletal system and posture [16-18]. Changes in spinal alignment, an increase in thoracic kyphosis, UE involvement, and shoulder depression on the surgical side have been reported after unilateral mastectomy [18]. In addition, Shamley et al. reported significant differences between the affected and non-affected sides in terms of kinematics of the shoulder girdle and scapula [19]. Neck muscles have also been reported to be overactive after mastectomy, which can be associated with neck and shoulder disorders [20].

Lymphedema can aggravate the occurrence of changes in posture and deformities following mastectomy [16]. Pinto et al. stated that lymphedema affects UE function and related activities [21], and UE disorders occurred at a significantly higher rate in lymphedema patients who underwent breast cancer surgery than in patients who developed no lymphedema after the same surgery [22].

To the best of our knowledge, no study has examined the relationship between UE volume and postural changes, including forward head posture (FHP), in these patients. Moreover, no study has assessed the relationship between UE volume and the level of UE disability. Therefore, the present study aimed to investigate the relationship of the affected UE volume with kyphosis, shoulder protraction, FHP, and UE disability in patients with UE lymphedema following total mastectomy. Abnormal changes in the spinal posture and UE, including FHP, increased thoracic kyphosis, and increased shoulder protraction, can accelerate the occurrence of neck pain, headache, shoulder and spinal pain, and other musculoskeletal disorders in these patients. Therefore, more comprehensive treatment programs can be considered in the rehabilitation treatments of this group of patients when the relationships between these postural disorders and lymphedema are known.

Methods

This cross-sectional study was conducted on patients referring to the Lymphedema Clinic of Shahid Motahari Clinic in Shiraz, Iran. The study population included 32 women aged 20-60 years who were selected using convenience sampling. The study was approved by Shiraz University of Medical Sciences (project number: 8912-06-01-93). Inclusion criteria were having unilateral lymphedema in the dominant UE following unilateral modified radical mastectomy in the 3 months prior to inclusion in the study, stage 2 lymphedema [23], and no history of previous treatment for lymphedema. All patients had completed chemotherapy and radiotherapy. Exclusion criteria were having a nervous system or rheumatic disease, heart or kidney failure, bilateral breast cancer, infection, or an open UE wound. All participants provided written informed consent to participate.

To determine the presence of lymphedema, water displacement volumetry was used as a standard and valid tool [24, 25]. For this measurement, each patient was asked to remove any jewelry and/or watch and then slowly immersed the UE into a water tank. The amount of overflowing water was measured. The same procedure was repeated for the unaffected side, and the difference between the two measurements was then calculated. Patients with a volume difference greater than or equal to 200 ml were included in the study [25, 26]. Circumference measurements were also performed for both UEs on predetermined areas, which included metacarpophalangeal joints, the first web, the wrist, 7.5 and 15 cm below the elbow, the elbow joint, and 7.5, 15, and 22.5 cm above the elbow joint. Patients were placed in a sitting position with straight elbows for circumference measurements [27]. If the circumference difference in these determined areas was ≥2 cm, the patient was included in the study [23]. the procedure was explained fully to the patients before measurements were taken.

To investigate UE function, the cross-culturally adapted and validated Persian version of the disabilities of the arm, shoulder and hand (DASH) questionnaire was used in this study [28].

Kyphosis was measured using a flexible ruler. Patients were asked to stand upright with feet shoulder-width apart and to distribute their weight evenly on both legs. The examiner stood behind the patients to determine the spinous processes of the T2 and T12 vertebrae. The flexible ruler was placed between the spinous processes of T2 to T12, and their locations were marked on the ruler accordingly. The same pressure was applied along the ruler length, so that there was no space between the ruler and the person's skin and the ruler took the shape of the arc of that spinal area. Then, the ruler was placed on a millimeter paper, and the arc was accurately drawn. When the two ends of the curves were connected, a vertical line was connected to the middle of the curve (line H) from the middle of the resulting length (L). The kyphosis angle was calculated by using the formula $\Theta=4(\text{Arctang } 2H/L)$ [29].

FHP and shoulder protraction were evaluated using photography. To this end, subjects were photographed from the side view in a standing position using a photographic camera. The camera settings, position, and distance were considered the same in all subjects. Reflective markers were placed on anatomical markers, including the tragus, the spinous process of the 7th cervical vertebra (C7), and the middle of the humerus. FHP was measured using the cervical angle, which is formed by the horizontal line that passes the 7th cervical vertebra and the line that connects the tragus, when the subject is staring at the horizon, or the head is in a natural position. The smaller the cervical

angle is, the more severe the FHP will be. The angle formed after connecting the middle point of the humerus to the C7 spinous process and the horizontal line shows the shoulder protraction. Shoulder protraction is present if this angle is less than 52°. The smaller the shoulder angle with the horizon is, the greater the shoulder protraction will be [30, 31]. ImageJ software was used to measure these angles. This method is reported to have high validity and reliability [32].

Statistical Analysis

Because of the normal distribution of the studied variables assessed by Kolmogorov-Smirnov test, Pearson's correlation test was used to investigate the relationship between the volume of UE lymphedema and disability, the relationship between the UE volume and postural disorders, including thoracic kyphosis, shoulder protraction, and FHP and the relationship between UE disability and these postural disorders.

Results

A total of 32 women with unilateral UE lymphedema participated in the present study. The mean and standard deviations of the studied variables in these patients are shown in Table 1.

Table 1: Demographic characteristics, upper quadrant posture, and upper extremity disability

Variables	Mean±SD
Age (year)	49.22±9.51
Body Mass Index	29.49±3.39
Limb volume difference (ml)	459.37±308.81
Cervical angle (degree)	40.89±8.79
Shoulder angle (degree)	51.47±13.76
Kyphosis angle (degree)	46.13±17.91
Upper extremity disability	44.03±24.57

The results showed a moderately significant positive correlation between UE volume and UE disability (P=0.001, r=0.55) and between UE volume and thoracic kyphosis angle (P=0.001, r=0.58). These findings indicate that UE disability and thoracic kyphosis angle increase with increasing UE volume. There was also a strong significant negative correlation between UE volume and shoulder angle (P<0.001, r=-0.93) and a moderately significant negative correlation between UE volume and cervical angle (P=0.001, r=-0.57) (Table 2). That is, as the UE volume increases, the cervical and shoulder angles decrease. It is necessary to explain that shoulder protraction and FHP become more severe when these angles are reduced.

The results showed a significant negative relationship between upper extremity disability and shoulder angle (P=0.01, r=-0.57) (Table 3). That is, shoulder protraction increases with an increase in upper extremity disability. However, there was no significant relationship between upper extremity disability and thoracic kyphosis or cervical angle (P>0.05).

Discussion

Lymphedema is a common and debilitating health problem which occurs after breast cancer and related treatments which negatively affect the functional status of patients [33-35]. The present study investigated the relationship of the volume of UE lymphedema with UE disability and upper quadrant postural disorders in women with unilateral UE breast cancer-related lymphedema.

The results of the present study showed a relationship between the lymphedema volume in the affected UE and UE disability, such that increasing lymphedema volume led to more UE disability. Previous studies have also shown more UE disability in women with lymphedema compared to healthy women [15, 17, 22, 26, 36, 37]. Several disorders frequently occur in people with breast cancer-related lymphedema, including reduced shoulder range of motion, weakness of UE muscles (especially the shoulder girdle), sensory disorders, skin and tissue fibrosis, pain, peripheral neuropathy, frozen shoulder, and shoulder and elbow tendonitis, all of which can lead to UE functional limitations [16, 38-41]. Abnormal movement patterns and various injuries in the affected UE, especially shoulder involvement, may occur more frequently when there is more severe or late diagnosed lymphedema [26, 42, 43]. Such problems can be caused by long-term increases in lymphedema volume and tissue adaptations.

The findings of the present study showed the negative effect of lymphedema on UE function and were consistent with the findings of Dawes et al. [36]. Surmeli et al., however, reported that despite the negative effect of UE lymphedema on body posture and UE function, there was no relationship between postural changes and UE function [37]. They measured posture using the New York Posture Rating Chart, which measures body posture in the forms of overall scores based on observation and qualitative assessment. In this method, posture is divided

Table 2: Investigating the relationship of upper extremity volume with disability and upper quadrant posture

	Pearson Correlation coefficient	Upper extremity disability	Thoracic kyphosis angle (degrees)	Shoulder angle (degrees)	Cervical angle (degrees)
Upper extremity volume (ml)	P value	0.55	0.58	-0.93	-0.57
		0.001*	0.001*	<0.001*	0.001*

*The significance level was P value<0.05.

Table 3: Relationship between upper extremity disability and upper quadrant postural disorders

	Pearson Correlation coefficient	Thoracic kyphosis (degree)	Shoulder angle (degree)	Cervical angle (degree)
Upper extremity disability	P value	0.15	-0.57	-0.22
		0.42	0.01*	0.22

into three categories: good, moderately impaired, and severely impaired. However, quantitatively more precise methods were used in the present study, which specifically investigated the posture of the head and neck, shoulder girdle, and thoracic kyphosis. Furthermore, to measure UE function, Surmeli et al. emphasized investigating the dexterity of the upper extremity, but DASH was used in the present study. In Surmeli et al.'s study, most subjects had mild lymphedema and also had a heterogeneous distribution in terms of surgery type [37]. All patients in the present study, however, had undergone mastectomy.

The results of the present study showed a relationship between lymphedema volume and upper quadrant postural disorders in lymphedema patients, such that kyphosis angle, shoulder protraction, and FHP increased with an increase in lymphedema volume. Following the occurrence of lymphedema, factors such as heaviness, an increase in the lymphoedema volume of the affected UE compared to the opposite side, and stiffness and numbness in the involved UE can disturb the standing body posture [33]. As an increase in UE volume leads to asymmetric loading of the limbs, a postural change is observed in the CoG towards the affected UE [33, 37]. Increased UE weight caused by lymphedema can cause tensioning in the muscles of the neck and shoulder girdle, more intense heaviness discomfort sensation level, lower threshold of pressure pain tolerance in the shoulder girdle muscles of the affected UE [22], and change in the head and shoulder posture [16]. These postural changes can be related to pain, skin retraction and surgical scars or psychological reactions [44]. Changes in muscle activity and kinematics of the shoulder joint following mastectomy and lymphedema can ultimately cause scapular dyskinesia and disruption of the scapulothoracic rhythm [22, 45, 46]. Fibrosis of subcutaneous tissues, muscle spasm and adhesion, especially in pectoral muscles after breast cancer surgery, can affect pain incidence and dysfunction in the shoulder girdle [47]. This issue can also affect the position of the scapula. Because the scapula plays a key and significant role in all functional aspects of the shoulder joint, scapular postural changes can affect UE stability and change the ability and function of UE in performing various movement tasks. A scapular postural change can be caused by an abnormal alignment in the cervical and thoracic spine. Studies have also shown that thoracic kyphosis and HFP can be interrelated [48]. According to the present study, more severe thoracic kyphosis was observed in patients with larger UE volume. There is a possibility that because of the increase in UE volume and the displacement of the center of gravity, the back muscles are stretched and weakened, and the posterior cervical muscles are shortened to compensate for these problems, which in turn leads to more severe FHP.

Increased thoracic kyphosis in women with lymphedema can lead to scoliosis, balance disorders, problems in thoracic cage mobility, and lung function. This phenomenon, in turn, may affect whole-body posture and the ability of the spine to transfer loads and function properly [14]. The observed head and neck postural changes in these patients can also aggravate these disorders.

Balzarini et al. studied the biomechanical posture of the shoulder girdle and spine and showed that lymphedema did not change spinal posture [49]; their results may be attributable to the small sample size and the non-homogeneousness of the patients in terms of type of surgery and lymphedema severity.

The results of the present study showed a significant positive relationship between UE disability and the degree of shoulder protraction; however, no such relationship was observed in the case of other postural disorders, such as thoracic kyphosis and FHP.

One of the limitations of the present study is that pain severity was not investigated. Considering the effect of pain on UE function, it is suggested that lymphedema patients be evaluated in terms of pain (severity, type, duration) in future studies. A second limitation is that the patients were not homogeneous in terms of time passed since surgery and lymphedema severity.

It is suggested that future studies focus not only on treatments to reduce lymphedema volume, but also on performing exercises to prevent or eliminate postural disorders in the spine, head and neck, and shoulders in these patients. Based on the results of the present study, future studies could examine the effect of postural correction treatments on UE volume changes or investigate the effect of lymphedema reduction treatments on postural changes, which seem to be useful in creating an effective treatment plan.

Conclusion

Based on the results of the present study, it can be concluded that the increase in UE volume in breast cancer-related unilateral lymphedema is related to UE disability. Moreover, the severity of thoracic kyphosis, shoulder protraction, and FHP is also related to the volume of the affected UE; that is, with an increase in the volume of the affected UE, the severity of the mentioned postural disorders increases.

Acknowledgment

The current study was based on thesis work done by Donya Jaberolansar and Maryam Taherpour, which was financially supported by Shiraz University of Medical Sciences, Shiraz, Iran (project number: 8912-06-01-93). The authors would like to express their appreciation to the Shiraz Namazi Hospital Clinical Research Development Center for statistical consulting.

Funding

This study was financially supported by Shiraz University of Medical Sciences.

Conflict of Interest: None declared.

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of

incidence and mortality worldwide for 36 cancers in 185 countries. CA: a cancer journal for clinicians. 2021;71(3):209-49.
2. Emiroğlu M, Inal A, Sert İ, İlhan E, Peker K, Gürçelik MA, et al. How do surgeons approach breast cancer surgery in Turkey? A national survey. 2015;22(4):421-6.
3. Lang AE, Murphy M, Dickerson CR, Stavness I, Kim SY. Shoulder Dysfunction in Breast Cancer Survivors: Can Treatment Type or Musculoskeletal Factors Identify Those at Higher Risk? Rehabilitation Oncology. 2021;39(3):143-51.
4. Kootstra JJ, Dijkstra PU, Rietman H, de Vries J, Baas P, Geertzen JH, et al. A longitudinal study of shoulder and arm morbidity in breast cancer survivors 7 years after sentinel lymph node biopsy or axillary lymph node dissection. Breast cancer research and treatment. 2013;139(1):125-34.
5. Yang EJ, Park WB, Seo KS, Kim SW, Heo CY, Lim JY. Longitudinal change of treatment-related upper limb dysfunction and its impact on late dysfunction in breast cancer survivors: a prospective cohort study. Journal of surgical oncology. 2010;101(1):84-91.
6. Ebaugh D, Spinelli B, Schmitz KH. Shoulder impairments and their association with symptomatic rotator cuff disease in breast cancer survivors. Medical hypotheses. 2011;77(4):481-7.
7. Lang AE, Milosavljevic S, Dickerson CR, Trask CM, Kim SY. Evidence of rotator cuff disease after breast cancer treatment: scapular kinematics of post-mastectomy and post-reconstruction breast cancer survivors. Annals of Medicine. 2022;54(1):1058-66.
8. Miguel-Andrés I, García-González SB, de Jesús Mayagoitia-Vázquez J, Barrera-Beltrán K, Samayoa-Ochoa D, León-Rodríguez M, et al. Effect of the Unilateral Breast Cancer Surgery on the Shoulder Movement: Electromyographic and Motion. Mexican Journal of Biomedical Engineering. 2022;43(1):40-51.
9. DiSipio T, Rye S, Newman B, Hayes SJTlo. Incidence of unilateral arm lymphoedema after breast cancer: a systematic review and meta-analysis. 2013;14(6):500-15.
10. Soyder A, Taştaban E, Özbaş S, Boylu Ş, Özgün HJTjobh. Frequency of early-stage lymphedema and risk factors in postoperative patients with breast cancer. 2014;10(2):92.
11. Taghian NR, Miller CL, Jammallo LS, O'Toole J, Skolny MNJCrioh. Lymphedema following breast cancer treatment and impact on quality of life: a review. 2014;92(3):227-34.
12. 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. 2012;118(S8):2237-49.
13. Cheville AL, McGarvey CL, Petrek JA, Russo SA, Taylor ME, Thiadens SR, editors. Lymphedema management. Seminars in radiation oncology; 2003: Elsevier.
14. Celenay ST, Ucurum SG, Kaya DO. Comparison of spinal alignment and mobility in women with and without post modified radical mastectomy unilateral lymphoedema. Clinical breast cancer. 2020;20(3):e295-e300.
15. 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. Journal of cancer survivorship. 2010;4(2):167-78.
16. Haddad CAS, Saad M, Perez MdCJ, Miranda Júnior F. Assessment of posture and joint movements of the upper limbs of patients after mastectomy and lymphadenectomy. Einstein (Sao Paulo). 2013;11:426-34.
17. 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. BioResearch open access. 2019;8(1):121-8.
18. Serel S, Tuzlalı ZY, Akkaya Z, Uzun Ç, Kaya B, Bayar S. Physical effects of unilateral mastectomy on spine deformity. Clinical breast cancer. 2017;17(1):29-33.
19. Shamley D, Srinaganathan R, Oskrochi R, Lascurain-Aguirrebeña I, Sugden E. Three-dimensional scapulothoracic motion following treatment for breast cancer. Breast cancer research and treatment. 2009;118(2):315-22.
20. Galiano-Castillo N, Fernández-Lao C, Cantarero-Villanueva I, Fernández-de-Las-Peñas C, Menjón-Beltrán S, Arroyo-Morales M. Altered pattern of cervical muscle activation during performance of a functional upper limb task in breast cancer survivors. American journal of physical medicine & rehabilitation. 2011;90(5):349-55.
21. Pinto M, Gimigliano F, Tatangelo F, Megna M, Izzo F, Gimigliano R, et al. Upper limb function and quality of life in breast cancer related lymphedema: a cross-sectional study. Eur J Phys Rehabil Med. 2013;49(5):665-73.
22. Korucu TS, Ucurum SG, Tastaban E, Ozgun H, Kaya DO. Comparison of shoulder-arm complex pain, function, and scapular dyskinesia in women with and without unilateral lymphedema after breast cancer surgery. Clinical Breast Cancer. 2021;21(3):e285-e93.
23. Zuther JE, Norton S. Lymphedema management: the comprehensive guide for practitioners: Thieme; 2017.
24. 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.
25. Sander AP, Hajer NM, Hemenway K, Miller AC. Upper-extremity volume measurements in women with lymphedema: a comparison of measurements obtained via water displacement with geometrically determined volume. Physical therapy. 2002;82(12):1201-12.
26. Baran E, Yildiz Tİ, Gursen C, Üzelpasaci E, Özgül S, Düzgün İ, et al. The association of breast cancer-related lymphedema after unilateral mastectomy with shoulder girdle kinematics and upper extremity function. Journal of Biomechanics. 2021;121:110432.
27. Nafisi S, Bagheri H, Arab Kheradmand A, Razavi F, Mousavi S. Comparive Effect of Complex Decongestive Physical Therapy Alone and Along with Intermittent Pneumatic Compression Pump on Shoulder Range of Motion, Heaviness, and Upper Extremity Circumfference in Patients with Secondary Upper Extremity Lymphedema Post Breast Cancer Tretments. The Scientific Journal of Rehabilitation Medicine. 2017;6(4):76-83.
28. Mousavi SJ, Parnianpour M, Abedi M, Askary-Ashtiani A, Karimi A, Khorsandi A, et al. Cultural adaptation and validation of the Persian version of the Disabilities of the Arm, Shoulder and Hand (DASH) outcome measure. Clinical rehabilitation. 2008;22(8):749-57.
29. Mirbagheri S-S, Rahmani-Rasa A, Farmani F, Amini P, Nikoo M-R. Evaluating kyphosis and lordosis in students by using a flexible ruler and their relationship with severity and frequency of thoracic and lumbar pain. Asian spine journal. 2015;9(3):416.
30. Ruivo RM, Pezarat-Correia P, Carita AI. Cervical and shoulder postural assessment of adolescents between 15 and 17 years old and association with upper quadrant pain. Brazilian journal of physical therapy. 2014;18:364-71.
31. Silva AG, Punt TD, Sharples P, Vilas-Boas JP, Johnson MI. Head posture and neck pain of chronic nontraumatic origin: a comparison between patients and pain-free persons. Archives of physical medicine and rehabilitation. 2009;90(4):669-74.
32. Lee JJ, You JH. Movement measurement validity and reliability of the image J program for kinematic analysis. Journal of Mechanics in Medicine and Biology. 2016;16(08):1640028.
33. Angin S, Karadibak D, Yavuzşen T, Demirbüken İ. Unilateral upper extremity lymphedema deteriorates the postural stability in breast cancer survivors. Contemporary Oncology. 2014;18(4):279.
34. Brach M, Cieza A, Stucki G, Fussl M, Cole A, Ellerin B, et al. ICF Core Sets for breast cancer. Journal of Rehabilitation Medicine. 2004;36(0):121-7.
35. Bani HA, Fasching PA, Lux MM, Rauh C, Willner M, Eder I, et al. Lymphedema in breast cancer survivors: assessment and information provision in a specialized breast unit. Patient education and counseling. 2007;66(3):311-8.
36. Dawes DJ, Meterissian S, Goldberg M, Mayo NE. Impact of lymphoedema on arm function and health-related quality of life in women following breast cancer surgery. Journal of rehabilitation Medicine. 2008;40(8):651-8.
37. Surmeli M, Ozdemir OC. Examination of the relationship between upper limb function, posture and quality of life in patients with and without lymphedema after breast cancer surgery. Konuralp Medical Journal. 2019;11(3):432-9.
38. Stubblefield MD, Custodio CM. Upper-extremity pain disorders in breast cancer. Archives of physical medicine and rehabilitation. 2006;87(3):96-9.
39. Erickson VS, Pearson ML, Ganz PA, Adams J, Kahn KL. Arm edema in breast cancer patients. Journal of the National Cancer Institute. 2001;93(2):96-111.
40. Armer JM, Ballman KV, McCall L, Armer NC, Sun Y, Udmuangpia T, et al. Lymphedema symptoms and limb measurement changes in breast cancer survivors treated with neoadjuvant chemotherapy and axillary dissection: results of American College of Surgeons Oncology Group (ACOSOG) Z1071 (Alliance) substudy. Supportive Care in Cancer. 2019;27(2):495-503.
41. Collins LG, Nash R, Round T, Newman B. Perceptions of upper-body problems during recovery from breast cancer treatment. Supportive Care in Cancer. 2004;12(2):106-13.
42. Jeong HJ, Sim Y-J, Hwang KH, Kim GC. Causes of shoulder pain in women with breast cancer-related lymphedema: a pilot study.

Yonsei medical journal. 2011;52(4):661-7.
43. Hayes S, Battistutta D, Newman B. Objective and subjective upper body function six months following diagnosis of breast cancer. Breast cancer research and treatment. 2005;94(1):1-10.
44. Kisner C, Colby LA, Borstad J. Therapeutic exercise: foundations and techniques: Fa Davis; 2017.
45. Crosbie J, Kilbreath SL, Dylke E, Refshauge KM, Nicholson LL, Beith JM, et al. Effects of mastectomy on shoulder and spinal kinematics during bilateral upper-limb movement. 2010;90(5):679-92.
46. Shamley DR, Srinanaganathan R, Weatherall R, Oskrochi R, Watson M, Ostlere S, et al. Changes in shoulder muscle size and activity following treatment for breast cancer. Breast cancer research and treatment. 2007;106(1):19-27.
47. Adriaenssens N, Van Parijs H, Miedema G, Reynders T, Versmessen H, De Ridder M, et al. Preliminary analysis of a randomized clinical trial comparing shoulder-arm morbidity between early breast cancer patients treated with short course image guided radiation therapy and conventional post surgery radiation therapy. Meme Sagligi Dergisi/Journal of Breast Health. 2012;8(2).
48. Singla D, Veqar Z. Association between forward head, rounded shoulders, and increased thoracic kyphosis: a review of the literature. Journal of chiropractic medicine. 2017;16(3):220-9.
49. Balzarini A, Lualdi P, Lucarini C, Ferla S, Galli M, Crivellini M, et al. Biomechanical evaluation of scapular girdle in patients with chronic arm lymphedema. Lymphology. 2006;39(3):132-40.