Journal of Experimental and Clinical Medicine
https://dergipark.org.tr/omujecm

Research Article

J Exp Clin Med
2023; 40(2): 248-253
doi: 10.52142/omujecm.40.2.9

Comparison of lower extremity lymphedema patients and healthy individuals with plantar pressure sense, balance, and fall risk: A pilot study

Duygu KORKEM YORULMAZ[1,*], Büşra PEHLİVAN[2], Tezel YILDIRIM ŞAHAN[1]

[1]Faculty of Gulhane Physiotherapy and Rehabilitation, University of Health Sciences, Ankara, Türkiye
[2]Institute of Health Sciences, Üsküdar University, İstanbul, Türkiye

Received: 18.10.2022 • **Accepted/Published Online:** 13.02.2023 • **Final Version:** 19.05.2023

Abstract

Plantar pressure is sensed by the receptors on the sole. It is still not clear how the changes after the skin involvement and the effect of this on balance and fall risk in lower extremity lymphedema. To compare patients with lower extremity lymphedema and healthy individuals in terms of plantar pressure sense, balance, and fall risk. A total of 31 participants were included in the study. The plantar pressure sense was evaluated with the Semmes-Weinstein Monofilament Test, the balance was made with the Berg Balance Scale, and the fall risk was assessed with the Tinetti Fall Efficacy Scale. Differences were found when the lower extremity lymphedema group and healthy individuals' plantar pressure sense were compared ($p<0.05$). A significant difference was detected between the groups when the balance and fall values were compared ($p<0.05$). No significant results were detected when the affected and unaffected extremities were compared in terms of plantar pressure sense in patients with lower extremity lymphedema ($p>0.05$). This study showed that patients with lower extremity lymphedema had decreased plantar pressure sense and balance and increased fall risk. Early detection of these parameters in patients with lymphedema and their management is essential for rehabilitation.

Keywords: Lymphedema, plantar pressure sense, balance, fall risk

1. Introduction

Lymphedema causes frequent recurrent infections, psychological stress, and cosmetic deformity, as well as functional limitations such as a feeling of heaviness, decreased joint range of motion, and fatigue because of edema in the affected extremity (1, 2).

The accumulation of protein-rich fluid in the interstitial space results in chronic inflammation and perilymphatic fibrosis over time in lymphedema. The skin thickens and its turgor increases and becomes rough (3). Excessive skin thickness also causes loss of sensation (4). Sensory disturbances and skin sensitivity were observed with the increased volume in the arm with lymphedema in patients with upper extremity lymphedema (5, 6).

Plantar pressure sense stimulates the sensory receptors under the sole directly (7). Mechanoreceptors on the sole carry this vital information to the Central Nervous System, which uses this information during walking and standing. For this reason, this information is critical in maintaining balance. A balance disorder may develop when there is a malfunction in the transmission of this information (8, 9). It was shown that the sensitivity of the sole is also related to the distribution of pressure under the sole (7), and decreased underfoot sensation is associated with falling by changing the plantar pressure distribution during walking and causes an increased body sway (10).

It was also shown in the literature that postural stability and balance are affected negatively in lymphedema, which occurs as a post-surgical complication in cancer patients (11-14). Basar et al. (10) emphasized in their study that postural stability decreased in pre-elderly female patients who had unilateral lymphedema in the upper extremity and that asymmetric fluid distribution may affect postural sway negatively and cause falls in these individuals. Celenay and Kaya (12), on the other hand, reported that balance and posture improved after four weeks in cases when they applied complex unloading physiotherapy after mastectomy. Bowman et al. (14) evaluated the psychosocial well-being and quality of life in individuals with lower extremity lymphedema in their review and stated that the symptoms of lower extremity lymphedema and increased severity of edema were associated with worse quality of life and negative psychosocial well-being. In their study, Doruk and Kaya (15) compared healthy patients with lower extremity lymphedema patients and found that there was a loss of balance in patients with lower extremity lymphedema but showed that it did not increase the risk of falling. However,

*Correspondence: duygukorkem@yahoo.com

to the best of our knowledge, there is no study investigating the sense of plantar pressure sense, balance, and fall risk in patients with lower extremity lymphedema. This study hypothesizes that the determination of plantar pressure sense in patients with lower extremity lymphedema may be necessary in terms of balance and fall variables. This study aimed to compare patients with lower extremity lymphedema and healthy individuals in terms of plantar pressure sense, balance, and fall risk.

2. Materials and Methods

Before the study commenced, approval and informed consent form were obtained from all participants, with the decision dated B.08.6.YOK.2.US.0.05.0.06/2017/351. The study was conducted in line with the Declaration of Helsinki Principles.

2.1. Individuals

Sixteen patients (15 female, one male) diagnosed with unilateral lower extremity lymphedema and 15 healthy volunteers (14 female, 1 male) with similar characteristics, aged between 21 and 68 years, were included in the present study. Those with a severe cardiac diagnosis, uncontrollable hypertension, an orthopedic and neurological disease that would impede walking, and cognitive problems were not included (13). Individuals were randomly selected using the closed envelope method among individuals diagnosed with lower extremity lymphedema who applied to the clinic at Uskudar University NP Medical Center between March 2018 and March 2019. The individuals were asked to hit the ball placed in the middle of the feet in the standing position. The extremity on the kicking side was accepted as the dominant side to determine the lower extremity dominance of the individuals included in the study (16).

2.2. Evaluation Methods

Edema Evaluation

The circumference measurement method was used in the evaluation of lymphedema. All patients were rested supine with the affected elevated extremities for 30 minutes before the measurement. Then, when the patients were in the semi-sitting position and the foot-ankle was in the neutral position, circumference measurements were made at 5 cm intervals from the medial malleolus level of the ankle to the proximal. A measuring tape measuring 150 cm long and 7 mm wide was used. The extremity volume was determined by calculating the obtained values with the Frustum formula ((V=) [h x ($R1^2$+R1.R2+$R2^2$)] / (12 x π) (V: Volume of each conical segment, h: Range used in circumference measurement, R1: Base circumference measurement of the conical segment, R2: upper circumference measurement of the conical segment, VT: Leg volume, n: Conical segment number) (17).

According to the severity of the patients' edema in both extremities, less than 250 ml was classified as mild lymphedema, between 250-500 ml as moderate lymphedema, and over 500 ml as severe lymphedema (18, 19).

Plantar Pressure Sense

The Semmes-Weinstein Monofilament Test is a diagnostic test used to detect sensory problems by objectively measuring the touch threshold. In the present study, it was evaluated using the Semmes Weinstein Monofilament Test Kit (SWM) (North Coast Medical, San Jose, CA, USA) from 3 regions of the sole (1st metatarsal head, 5th metatarsal head, and midpoint of the heel). Firstly, the lightest 2.83-number monofilament was used for the test. Monofilaments were tested by touching the test sites for 1.0-1.5 seconds using monofilament numbers between 2.83-6.65 in 3 repetitions in sequence. The number of this monofilament was recorded when individuals correctly sensed two stimuli out of 3 trials. The tester switched to another monofilament when there was no sensation (6, 20).

Balance Evaluation

The balance evaluation was made with the Turkish version of the Berg Balance Scale (BBS) (21). The BBS includes 14 movement parameters for the assessment of balance. The level of proficiency for each activity is scored between "0: The patient cannot do this" and 4: "The patient does this independently and safely" (0-4). In this survey, which has a total of 56 points, high scores indicate good balance, low scores indicate poor balance, 0-20 points indicate balance disorder, 21-40 points indicate an acceptable balance and 41-56 points indicate a good balance (22, 23).

Fall Evaluation

It was evaluated with the Turkish version of the Tinetti Fall Efficiency Scale (TFES) (24). It is asked the person how safe they feel while taking a bath, lying down on a shelf, preparing meals, walking around the house, getting into and out of bed, answering the door or the phone, sitting in or standing up from a chair, dressing or undressing, doing light housework, doing simple shopping. The person is also asked to mark from 1 to 10 (10 completely unsafe, 1 extremely safe), and when all scores are added, a total score between 0 (low fall-related activity) and 100 (high fall-related activity) is obtained (25).

Tinetti VAS

The VAS is a self-reported scale consisting of a horizontal line (10 cm long) with anchor points of "no pain" and "worst possible pain." The patient was asked to put a mark on the line that best describes their pain severity (24, 25).

2.3. Statistical Analysis

The values to be used in power analysis were determined according to the suitability of the study because there is no study in this field in the literature. In the power analysis, alpha significance level [i.e. Type I error (α=0.05)] was taken as the power value desired to obtain [Type II error (β=0.80) (α and β values were similar in articles close to the subject of the study)]. These operations were performed by using the G*Power 3.1.9.2 Software. The effect size was taken as 0.90 as the value that accepts a high degree of difference according to Cohen's ***d*** standards because no detailed article on this subject was conducted before. The groups in the study were

lymphedema patients and healthy controls. The sample size obtained from these variables was 32 individuals (16 lower extremity lymphedema, 16 healthy controls).

The data were analyzed using the IBM SPSS Statistics 22 Software. The conformity of the variables to the normal distribution was examined using the analytical method Kolmogorov-Smirnov, and the mean and standard deviation and minimum-maximum values of these variables were given in the representation of descriptive statistics. Also, number (n) and percentage values were given for categorical variables such as gender, dominant extremity, and lymphedema severity. The demographic data of lymphedema patients and healthy individuals were compared using the Independent-T Test. Since the plantar pressure sense, balance, and fall data of lymphedema patients and healthy individuals did not comply with the normal distribution, they were evaluated using the Mann-Whitney U Test. The Plantar pressure sense of the affected and unaffected sides of the lower extremity lymphedema patients was compared with the Chi-Square Test (26).

3. Results

The mean age of the lower extremity lymphedema patients was 38.63±11.53 years, their Body Mass Index (BMI) was 29.82±6.84 kg/m², and the diagnosis time of lymphedema was 13.50±10.90 years in the present study. According to the severity of lymphedema, 18.75% of the patients had mild lymphedema, 18.75% moderate lymphedema, and 62.5% severe lymphedema. Furthermore, 75% of the dominant sides of lymphedema patients were right, 25% were left, 62.5% of the affected extremities were right and 37.5% were left extremities. The mean age of the healthy individuals in the control group was 34.93±9.32 years, the mean BMI was 24.90±3.74 kg/m², and 73% of the dominant sides were on the right and 27% on the left. No significant differences were detected between the lower extremity lymphedema group and the control group in terms of gender, age, BMI, and dominant extremities (p>0.05) (Table 1).

When the dominant and non-dominant plantar pressure senses of the lower extremity lymphedema group and healthy individuals in the control group were compared (1st metatarsal head, 5th metatarsal head, and heel midpoint), differences were detected between the two groups in terms of other senses except for the heel midpoint on the dominant and non-dominant sides (p<0.05). Also, a significant difference was found between the groups when the balance and fall values were compared (p<0.05) (Table 2).

However, when the plantar pressure senses of the affected and unaffected extremities (1st metatarsal head, 5th metatarsal head, and midpoint of the heel) of lower extremity lymphedema patients were compared, no significant differences were detected (p>0.05), (Table 3).

Table 1. Demographic and clinical characteristics of patients with lower extremity lymphedema and healthy individuals

Evaluation Features		Patients with Lower Extremity Lymphedema (mean±SD)	Healthy Individuals (mean±SD)	p
Age (years)		38.63±11.53	34.93±9.32	0.826
Gender n (%)	**Female** **Male**	15 (93.75) 1 (6.25)	14 (93.33) 1 (6.66)	0.928
Height (cm)		165.25±7.33	166.92±6.13	0.976
Body Weight (kg)		81.07±17.88	68.80±9.97	0.076
BMI (kg/m²)		29.82±6.84	24.90±3.74	0.176
Dominant Limb n (%)	**Right** **Left**	12 (75.00) 4 (25.00)	11 (73.33) 4 (26.66)	0.839
Lymphedema Diagnosis Time (years)		13.50±10.90		
Lymphedema Severity n (%)	**Light** **Middle** **Severe**	3 (18.75) 3 (18.75) 10 (62.50)		

p>0.05; Independent T test; Mann-Whitney U Test

Table 2. Comparison of dominant and non-dominant sides plantar pressure sensation, balance and fall risk in patients with lower extremity lymphedema and healthy individuals

Evaluation Features	Patients with Lower Extremity Lymphedema Median (min-max)	Healthy Individuals Median (min-max)	p
Dominant Side Plantar Pressure Sense			
1. Metatarsal Head	4.31 (2.83-4.31)	2.83 (2.44-4.08)	**0.001****
5. Head of Metatarsal	4.31 (2.83-4.31)	3.61 (2.36-3.84)	**0.001****
Heel Midpoint	4.31 (3.61-4.56)	4.31 (2.83-4.56)	0.358
Non-Dominant Side Plantar Pressure Sense			
1. Metatarsal Head	4.31 (2.83-5.07)	3.22 (2.44-3.61)	**0.001****
5. Head of Metatarsal	4.31 (2.83-5.07)	3.22 (2.36-3.84)	**0.002****
Heel Midpoint	4.31 (2.83-5.07)	4.08 (2.83-4.56)	0.417
Berg Balance Scale Total Score	3.50 (30-35)	56.00 (54-56)	**0.000****
Tinetti Fall Activity Scale Total Score	90.00 (64-100)	10.00 (10-14)	**0.000****
Tinetti VAS	1.50 (0-6.50)	0.00 (0-0)	**0.000****

*: p<0.05, **: p<0,01; Mann- Whitney U test; VAS: Visual Analogue Scale

Table 3. Comparison of plantar pressure sense of affected and unaffected extremities in patients with lower extremity lymphedema

Evaluation Features	Affected Extremity Median (min-max)	Unaffected Extremity Median (min-max)	p
Plantar Pressure Sense			
1. Metatarsal Head	4.31 (2.83-5.07)	4.31 (2.83-4.31)	0.515
5. Head of Metatarsal	4.31 (2.83-5.07)	4.31 (2.83-4.31)	0.515
Heel Midpoint	4.31 (3.61-5.07)	4.31 (2.83-4.56)	0.239

P<0.05* Chi-Square Test

4. Discussion

A comparison of the plantar sense, balance, and risk of falling of patients with lymphedema in the lower extremities and healthy individuals revealed that patients with lower extremity lymphedema had lower plantar pressure sense and balance levels, and the risk of falling increased. No difference was found when the affected side and intact side plantar pressure senses of the individuals with lower extremity lymphedema were compared. These results can be a guide for healthcare staff working with lymphedema patients. This study is the first to examine the effect of plantar pressure sense on balance and falling in patients with lower extremity lymphedema.

Lymphedema is a severe condition threatening lifestyles and reducing the quality of life by causing cosmetic deformities, functional losses, and psychological disorders in individuals (27, 28). Sensory disturbances in the extremities, pain, loss of strength, flexibility, movement limitation, susceptibility to infection, and skin sensitivity develop because of the chronic nature of lymphedema (29). It was shown that edema-related sensory disorders and skin sensitivity develop in patients with upper extremity lymphedema (5, 6). Baran et al. (30) reported in their study that there was a decrease in sensory perception in patients with upper extremity lymphedema. Dai et al. (31) showed that the use of compression stockings against skin problems decreased the sense of temperature in patients with lower extremity lymphedema. To the best of our knowledge, no study was conducted in the literature in which plantar sensory pressure evaluation was performed in patients with lower extremity lymphedema. As a result of the present study, lower extremity lymphedema patients showed a decrease in Plantar pressure sense compared to healthy individuals. This can be explained by reasons such as volume increase, swelling, and cellulite caused by lower extremity lymphedema.

Previous studies showed that postural stability is affected, and spinal posture and balance are impaired in patients with upper extremity lymphedema (11, 12). The decreased balance of lower extremity lymphedema patients included in the present study was consistent with the results of patients with upper extremity lymphedema in the literature (5, 15). Doruk and Kaya (15) reported in their study that postural sway increased, and there was a loss of balance in patients with lower extremity lymphedema. This study showed that balance losses occur in patients with lower extremity lymphedema compared to healthy individuals. We think that the cause of balance loss is because of decreased mobility and musculoskeletal disorders.

The risk of falling, which was investigated in different patient groups, negatively affects physical, functional, and psychological status, leading to a limitation of activities of daily living, decreased independence, and limitation of social activities (14, 32). Altas and Demirdal (32) reported that the risk of falling was increased in patients with upper extremity lymphedema. In their study on patients with lower extremity lymphedema, Doruk and Kaya (15) found no differences in the risk of falling, although there was increased postural sway and balance loss of the patients compared to the healthy group. The present revealed that the risk of falling was high in patients with lower-extremity lymphedema, which showed that falls should be evaluated holistically in patients with lower-extremity lymphedema, regardless of the plantar pressure sense factor. Patients with lower extremity lymphedema should also be evaluated, considering that the increased risk of falling may have physical and psychological reflections (14, 33).

It is already known that the presence of cellulitis causing lymphedema, ulcer, and lymphorrhea negatively affects patients' skin quality and flexibility (13). Fluid retention in lymphedema and consequent tissue swelling stemming from the lymphatic system causes skin thickening. Skin fibrosis is a clinically severe pathological secondary lymphedema process. In their study, Sun et al. (33) showed that early examination of skin fibrosis could reveal significant skin changes in patients with lower extremity lymphedema. Based on this, the present study considered that the plantar pressure sense would be affected in patients with lower extremity lymphedema. However, no differences were detected between the affected and unaffected extremities in patients with lymphedema. Although there was a difference when compared to healthy individuals, the absence of a difference in the unaffected extremity suggests a decrease in the plantar pressure sense in the intact extremities of individuals with lower extremity lymphedema.

The number of individuals participating was small because the present study was a pilot scheme, so further studies on this subject on a larger population are needed. Also, the exposure levels of different lymphedema intensities can be compared by increasing the sample size. Since postural swing disorder may affect balance and fall risk, these changes should be considered.

In conclusion, the present study evinced that the plantar pressure sense decreased, the balance was negatively affected, and the risk of falling was increased in patients with lower extremity lymphedema. Patients with lower extremity lymphedema should be evaluated in more detail, and plantar pressure sense, balance, and falling parameters should also be

considered during the treatment and rehabilitation process. Sensory training should be added to the existing physiotherapy and rehabilitation program, considering that the decreased sense of plantar pressure sense will prevent the activities of the individual in daily life in the future.

Ethical Statement

This study was approved ethically, and informed consent forms were obtained from all participants, with the decision dated B.08.6.YOK.2.US.0.05.0.06/2017/351. The study was conducted in line with the Declaration of Helsinki Principles

Conflict of interest

The authors declare no conflict of interest.

Funding

None to declare.

Acknowledgments

None to declare.

Authors' contributions

Concept: D.K.Y., Design: D.K.Y., B.P., Data Collection or Processing: B.P., D.K.Y., Analysis or Interpretation: T.Y.S., D.K.Y., Literature Search: B.P., T.Y.S., Writing: D.K.Y., T.Y.S.

References

1. Wang CM, Lee SY, Hsu KF, Lin CF, Ma MC, Hsu YY. Psychometric evaluation of a Chinese version of Lymphoedema Functioning, Disability and Health Questionnaire for Lower Limb Lymphoedema in women with gynaecological cancer surgery. Eur J Cancer Care. 2018;27(6):e12940.
2. Iwersen LF, Sperandio FF, Toriy AM, Palu M, Medeiros da Luz C. Evidence-based practice in the management of lower limb lymphedema after gynecological cancer. Physiother Theory Pract. 2017;33(1):1-8.
3. Strzalkowski ND, Triano JJ, Lam CK, Templeton CA, Bent LR. Thresholds of skin sensitivity are partially influenced by mechanical properties of the skin on the foot sole. Physiol Rep. 2015;3:pii:e12425.
4. Surmeli M, Cinar Ozdemir O. The effect of upper limb lymphedema in posture of patients after breast cancer surgery. J Back Musculoskelet Rehabil (Preprint). 2021;1-9.
5. Voogd AC, Ververs JM, Vingerhoets A, Roumen H, Coebergh JW, Crommelin MA. Lymphoedema and reduced shoulder function as indicators of quality of life after axillary lymph node dissection for invasive breast cancer. Br J Surg. 2003;90:76-81.
6. Citaker S, Gunduz AG, Guclu MB, Nazliel B, Irkec C, Kaya D. Relationship between foot sensation and standing balance in patients with multiple sclerosis. Gait Posture. 2011;34(2):275–8.
7. Kars HJ, Hijmans JM, Geertzen JH, Zijlstra W. The effect of reduced somatosensation on standing balance: a systematic review. J Diabetes Sci Technol. 2009;3:931–43.
8. Eils E, Behrens S, Mers O, Thorwesten L, Völker K, Rosenbauma D. Reduced plantar sensation causes a cautious walking pattern. Gait Posture. 2004;20:54–60.
9. Zhang S, Li L. The differential effects of foot sole sensory on plantar pressure distribution between balance and gait. Gait Posture. 2013;37(4):532–5.
10. Basar S, Bakar, Keser İ, Kaba H, Güzel NA, Özdemir ÖÇ, et al. Does Lymphedema Affect the Postural Stability in Women After Breast Cancer? Top Geriatr Rehabil. 2012;28(4):287–94.
11. Angin S, Karadibak D, Yavuzşen T, Demirbüken I. Unilateral upper extremity lymphedema deteriorates the postural stability in breast cancer survivors. Contemp Oncol (Pozn). 2014;18(4):279–84.
12. Çelenay Toprak Ş, Kaya Özer D. Effects of Complex Decongestive Physiotherapy on Function, Posture and Balance in a Case with Lymphedema after Mastectomy. İzmir Kâtip Çelebi Üniversitesi Sağlık Bilimleri Fakültesi Dergisi. 2016;1(2): 41-5.
13. Payette MC, Belanger C, Léveillé V, Grenier S. Fall-related psychological concerns and anxiety among community-dwelling older adults: Systematic review and meta-analysis. PLoS one. 2016;11(4):1-17.
14. Bowman C, Piedalue K A, Baydoun M, Carlson LE. The quality of life and psychosocial implications of cancer-related lower-extremity lymphedema: a systematic review of the literature. J Clin Med. 2020;9(10):3200.
15. Doruk Analan P, Kaya E. Postural stability in patients with lower limb lymphedema. Lymphatic Res Biol. 2019;17(6):647-50.
16. Gabbard C, Hart S. A question of foot dominance. The Journal of General Psychology. 1996;123(4):289–96.
17. Kaulesar Sukul DM, den Hoed PT, Johannes EJ. Direct and indirect methods for the quantification of leg volume: Comparison between water displacement volumetry, the disk model method and the frustum sign model method, using the correlation coefficient and the limits of agreement. J. Biomed. Eng. Res. 1993;15:477-480.
18. Cordero FI, Langa MJ, Cordero AF, Jimeno JM. Predictive factors of response to decongestive therapy in patients with breast-cancer-related lymphedema. Ann Surg Oncol. 2010;17(3):744-51.
19. International Society of Lymphology Executive Committee. The diagnosis and treatment of peripheral lymphedema, consensus document of the International Society of Lymphology. Lymphology. 2016;49:170-84.
20. Bell-Krotoski J, Tomancik E. The repeatability of testing with Semmes-Weinstein monofilaments. J Hand Surg Am. 1987;12(1):155-161.
21. Sahin F, Yilmaz F, Ozmaden A, Kotevolu N, Sahin T, Kuran B. Reliability and validity of the Turkish version of the Berg Balance Scale. J Geriatr Phys Ther. 2008;31(1):32-7.
22. Bogle Thorbahn LD, Newton RA. Use of the Berg Balance Test to predict falls in elderly person. Phys Ther. 1996;76:576-85.
23. Lajoie V, Girard A, Guay M. Comparison of the reaction time, The Berg Scale and The ABC in non-fallers and fallers. Arch Gerontol Geriat. 2002;35:215-22.
24. Ulus Y, Durmus D, Akyol Y, Terzi Y, Bilgici A, Kuru O. Reliability and validity of the Turkish version of the falls efficacy scale international (FES-I) in community-dwelling older persons. Arch Gerontol Geriatr. 2012;54:429-33.
25. Yardley L, Beyer N, Hauer K, Kempen G, Piot-Zeiger C, Todd C. Development and Initial Validation of the Falls Efficacy Scale-International. Age and Aging. 2005;34:614-19.
26. Rossi RJ.Applied biostatistics for the health sciences. John Wiley & Sons. 2022.
27. Passik SD, McDonald MV. Psychosocial aspects of upper extremity lymphedema in women treated for breast carcinoma. Cancer. 1998;83:2817-20.
28. Sakorafas GH, Peros G, Cataliotti L, Vlastos G. Lymphedema

following axillary lymph node dissection for breast cancer. Surg Oncol. 2006;15:153-65.

29. Ergin G, Karadibak D, Sener HO, Gurpinar B. Effects of Aqua-Lymphatic Therapy on Lower Extremity Lymphedema: A Randomized Controlled Study. Lymphat Res Biol 2017;15(3)8.

30. Baran E, Özçakar L, Özgül S, Aksoy S, Akbayrak T. Upper limb sensory evaluations and ultrasonographic skin measurements in breast cancer–related lymphedema receiving complex decongestive physiotherapy. Supportive Care in Cancer. 2021;29(11):6545-53.

31. Dai M, Minematsu T, Ogawa Y, Takanishi Y, Sugama J, Sanada, H. Subjective thermal sensation effect of cool feeling compression stocking for patients with lower limb lymphedema: a preliminary pre-post study. Journal of Japanese Society of Wound, Ostomy and Continence Management. 2021;25(1):10-17.

32. Altas EU, Demirdal ÜS, The effects of post-mastectomy lymphedema on balance, Kinesiophobia and fear of falling. J Community Health Nurs. 2021;38(2):130-138.

33. Sun D, Yu Z, Chen J, Wang L, Han L, Liu, N. The value of using a SkinFibroMeter for diagnosis and assessment of secondary lymphedema and associated fibrosis of lower limb skin. Lymphatic Res Biol. 2017;15(1):70-76.