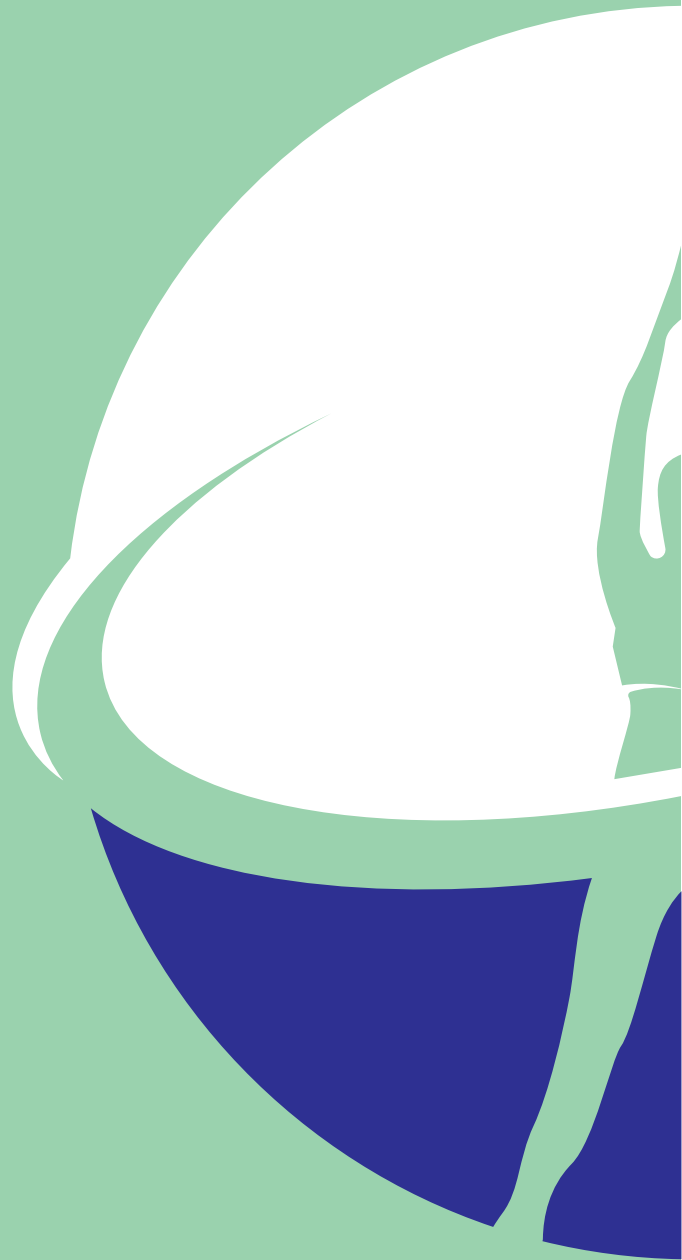




ψysikotherapia

ISSN 2732-9534

Official Scientific Edition by Panhellenic Physiotherapists' Association



Volume 27 Issue 1 January - March 2024

Edition
Panhellenic Physiotherapists Association

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ΦΥΣΙΚΟΘΕΡΑΠΕΙΑ

Επιστημονικό Περιοδικό Εθνικής Αναγνώρισης ΦΕΚ 590 Τεύχος Β, 2009

<http://journal.psf.org.gr/index.php>

ISSN 2732-9534

Association of limb morphometric and biokinetic anatomical changes with quality of life in lymphedema patients undergoing physiotherapy: a systematic review

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<https://doi.org/10.55742/KBDC1416>

ABSTRACT

Introduction: Lymphedema is a common complication of patients receiving cancer treatment. It has serious effects on mobility, self-care, functionality and quality of life. The purpose of this review was to show the effect of lymphedema on the morphometric and biokinematic characteristics of the limb and the quality of life of the patients.

Methods: A systematic review of the literature was performed using the PRISMA statement. The search included studies from online databases, PubMed, Scopus and Google Scholar, which were published from 2000 to 2022. Studies assessed outcome variables such as range of motion, strength, sensation, body composition, quality of life. The screening process resulted in a total of 23 studies that met the inclusion criteria.

The clinical diagnosis of secondary lymphedema is mainly based on the comparison of the anatomic morphometric characteristics of the affected area with the equivalent area on the unaffected side^(2, 10).

The therapeutic approach to secondary lymphedema is based on conservative treatment with physiotherapy, specifically complete decongestive physiotherapy (CDT), which is <the gold standard> and is a combination of four methods (manual lymphatic drainage, lymphedema rehabilitation exercises, compression therapy, skin care)^(7, 11). Complete decongestive physiotherapy (CDT), in addition to significantly reducing volume from 50% to 70%, relieves symptoms, reduces fibrosis, improves functionality and increases the quality of life of patients⁽¹³⁻¹⁴⁾.

According to international literature, secondary lymphedema occurs in approximately 30.2% of patients treated for cancer, permanently affecting the mobility of the limb, the patient's autonomy and, consequently, the quality of life^(2,5,12). Its impact on the quality of life becomes more substantial as the survival of these patients increases, as it is a chronic condition that has an effect on the functionality, physical, psychological, social and emotional status of individuals⁽¹⁶⁻¹⁹⁾. In the systematic review by Pusic et al. 2013 the majority of studies reported reduced quality of life in patients with lymphedema and the areas most affected were body image, physical, psychological and social functioning⁽²⁰⁾. Also, the review by Fu et al. 2013 reported poorer social well-being in patients with lymphedema, which included negative perceptions of body image, appearance, sexuality, while the negative psychological impact of lymphedema was mainly expressed as emotional disturbance and psychological distress, and the negative social impact was described as marginalization and social isolation⁽²¹⁾.

It is a fact that lymphedema can adversely affect the quality of life of patients, as in addition to aesthetic concerns, it is associated with feelings of discomfort and heaviness, functional limitation, which hinders the ability to perform daily activities, limits the ability to self-care, and the autonomy of patients⁽⁵⁻⁶⁾.

The aim of this review was firstly to show the effect of lymphedema on the morphometric and biokinematic characteristics of the limb with lymphedema and the quality of life of patients with lymphedema. Second, to show the correlation of morphometric and biokinematic changes with the quality of life of these patients.

Results: Of the 23 studies that met the inclusion criteria, seventeen referred to upper extremity lymphoedema and six referred to lower extremity lymphoedema. There was a variety of methods for identifying lymphedema between studies. Studies have shown reduced grip strength, range of motion, sensory perception, changes in body composition have been observed with fat tissue being increased compared to muscle tissue. The majority of studies reported reduced patient quality of life. The areas most affected were body image, role, mental health and sociability.

Conclusions: Findings indicate that lymphedema has a high incidence among people treated for cancer, and has a significant impact on patients functionality and quality of life.

Key words: upper and lower limb lymphedema, range of motion, strength, sensation, body composition, quality of life.

INTRODUCTION

Lymphedema is a chronic swelling resulting from the accumulation of lymphatic fluid in the interstitial spaces of the tissues and occurs mainly due to an imbalance between capillary filtration and the draining capacity of the lymph nodes⁽¹⁾. Disturbance in the function of the lymphatic system can occur, either after lymphatic insufficiency or lymphatic obstruction, and results in a decrease in the ability to transport lymph and accumulation of lymphatic fluid, in the interstitial space, and ultimately leads to skin changes, fibrosis of the subcutaneous tissue, pain, numbness, discomfort and heaviness in the affected limb, loss of normal sensation, reduced functionality, stiffness of the limb, and cellular alterations⁽²⁻³⁾.

The most common cause of secondary lymphedema is cancer treatment especially after surgical removal of lymph nodes and radiation therapy⁽⁴⁾. It is a frequent complication of modern oncological treatments, which drastically affects the biokinematic characteristics of the affected limb, its volume and weight, and in combination with anatomical and morphological disorders affects the daily life of the patient⁽⁵⁻⁶⁾. It reduces functionality and the ability to perform daily activities with a final consequence significant impact on the psychology and quality of life of the patients⁽⁸⁻⁹⁾.

The clinical diagnosis of secondary lymphedema is mainly based on the comparison of the anatomic morphometric characteristics of the affected area with the equivalent area on the unaffected side^(2, 10).

The therapeutic approach to secondary lymphedema is based on conservative treatment with physiotherapy, specifically complete decongestive physiotherapy (CDT), which is <the gold standard> and is a combination of four methods (manual lymphatic drainage, lymphedema rehabilitation exercises, compression therapy, skin care)^(7, 11). Complete decongestive physiotherapy (CDT), in addition to significantly reducing volume from 50% to 70%, relieves symptoms, reduces fibrosis, improves functionality and increases the quality of life of patients⁽¹³⁻¹⁴⁾.

According to international literature, secondary lymphedema occurs in approximately 30.2% of patients treated for cancer, permanently affecting the mobility of the limb, the patient's autonomy and, consequently, the quality of life^(2,5,12). Its impact on the quality of life becomes more substantial as the survival of these patients increases, as it is a chronic condition that has an effect on the functionality, physical, psychological, social and emotional status of individuals⁽¹⁶⁻¹⁹⁾. In the systematic review by Pusic et al. 2013 the majority of studies reported reduced quality of life in patients with lymphedema and the areas most affected were body image, physical, psychological and social functioning⁽²⁰⁾. Also, the review by Fu et al. 2013 reported poorer social well-being in patients with lymphedema, which included negative perceptions of body image, appearance, sexuality, while the negative psychological impact of lymphedema was mainly expressed as emotional disturbance and psychological distress, and the negative social impact was described as marginalization and social isolation⁽²¹⁾.

It is a fact that lymphedema can adversely affect the quality of life of patients, as in addition to aesthetic concerns, it is associated with feelings of discomfort and heaviness, functional limitation, which hinders the ability to perform daily activities, limits the ability to self-care, and the autonomy of patients⁽⁵⁻⁶⁾.

The aim of this review was firstly to show the effect of lymphedema on the morphometric and biokinematic characteristics of the limb with lymphedema and the quality of life of patients with lymphedema. Second, to show the correlation of morphometric and biokinematic changes with the quality of life of these patients.

METHOD

Data and search sources

Preferred Reporting for Systematic Reviews (PRISMA) was used to conduct this review ⁽¹⁵⁾. A literature review was performed from 2000 to 2022 using PubMed, Scopus and Google Scholar databases. Search terms included a combination of terms and keywords, including: upper extremity lymphedema, lower extremity lymphedema, range of motion, strength and handgrip strength, sensation, body composition, quality of life with lymphedema, and health-related quality of life.

A total of 5592 articles were found from the search (Scopus 3111), (PubMed 2362), (Google Scholar 119), systematic reviews, abstracts, and duplicate articles were removed this resulted in 314 articles, after reading the titles and abstracts 58 studies full texts were retrieved , of these 27 studies were considered suitable for evaluation of which, one study was excluded because the existence of lymphedema was not reported at the time of the study, one study was rejected because patients with negative lymph nodes were evaluated, and two because complex decongestive therapy was not used as an intervention, finally 23 studies met the inclusion criteria and were included in the review (Figure 1).

The inclusion criteria

Studies that assessed lymphedema-related outcome variables such as range of motion, strength, sensation, body composition, quality of life were included.

All participants were patients with stage I-III lymphedema. Cross-sectional and longitudinal studies published from 2000 to 2022 and in the English language were included.

Exclusion criteria

Systematic reviews and meta-analyses were excluded. Studies that do not refer to lymphedema symptoms but to cancer in general. Abstracts and doctoral theses were excluded.

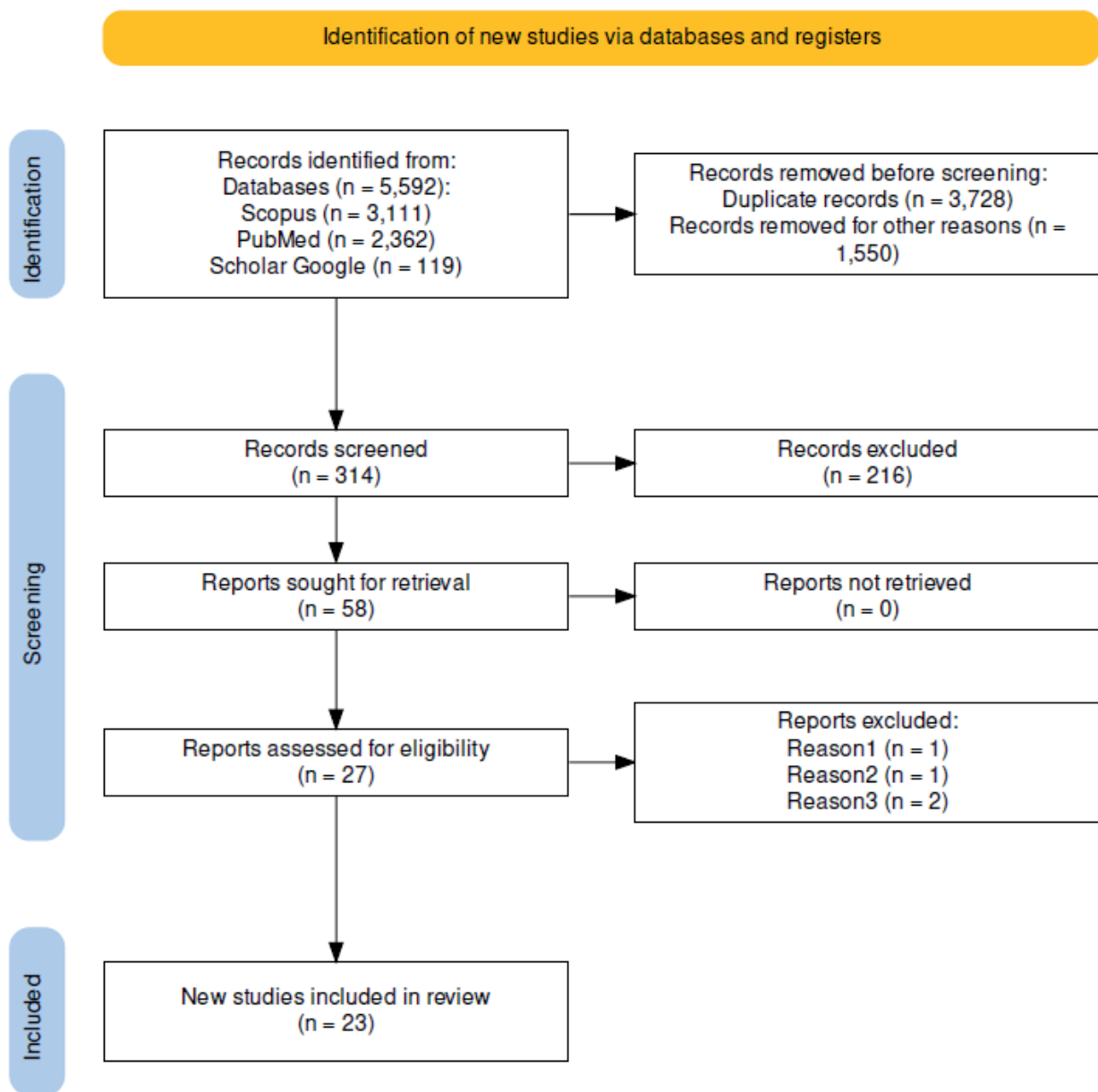


Figure 1: Flowchart of systematic review article selection

RESULTS

General characteristics of the studies

All studies focused on patients with diagnosed upper and lower extremity lymphedema⁽²²⁻⁴⁴⁾. Among the 23 studies, seventeen refer to upper extremity lymphedema^(22-24, 26-27, 29-38, 40-41). Six reported lower extremity lymphedema^(25,28,34,39,41,43) (Table 1).

Table 1. Characteristics of studies

Author	Goal/Planning	Specimen/Age/Leaf	Identification of lymphedema	Evaluation of biometric/morphometric characteristics / quality of life	Results
Gomes et.al. 2014	To investigate changes in body composition, grip strength in breast cancer patients with and without lymphedema, compared to healthy controls. Contemporary study	n= 95 women, aged 51-54 years <ul style="list-style-type: none">o n= 46 healthyo n= 49 with breast cancer<ul style="list-style-type: none">▪ n= 10 with lymphedema▪ n= 39 without lymphedema	Circumference measurements	Hydraulic Hand Dynamometer SH5001 Dual Energy X-ray Absorptiometry (DEX)	Compared between the two groups, handgrip strength was lower in the breast cancer group than in the control group (p=0.0001). Trunk lean mass was decreased in the breast cancer group compared to the control group (p=0.04). Total lean mass was influenced by the type of surgery and was higher in women who underwent right mastectomy compared to those with left (p=0.04). However, in women with lymphedema total lean mass (p=0.004), trunk fat mass (p=0.05), trunk lean mass (p=0.005), right arm lean mass (p=0.03) and left arm lean mass (p=0.01) increased six months after breast cancer surgery, while handgrip strength remained unchanged regardless of the presence or absence of lymphedema.
Baklaci et.al. 2019	To show whether CDT contributes to volume and handgrip strength change in patients with lymphedema	n=74 patients with lymphedema, mean age 56 years	Circumference measurements	Hand dynamometer JAMAR	The unaffected arm was stronger than the arm with lymphedema (p < 0.01). Patients had lower grip strength in the limb with lymphedema than in the healthy limb, and this difference persisted after treatment.
Mistry et.al. 2021	The assessment of grip strength and functionality in patients with lymphedema. Cross-sectional study	n= 62 women, mean age 55 years <ul style="list-style-type: none">▪ n=31 with lymphedema▪ n=31 without lymphedema	Is not mentioned	Hand dynamometer test Jebsen-Taylor hand function test (JTHFT).	There were significant decreases in both strength and precision grip strength (p < 0.05) in the lymphedema patients compared to healthy controls. Hand functions were significantly reduced in all activities in women with lymphedema compared to healthy women (p < 0.05).
Giray & Akyüz 2019	To assess the relationships between caregiver burden, quality of life, arm disability, grip strength, and lymphedema symptoms in women with lymphedema after mastectomy. Cross-sectional study	n=52 women with lymphedema who were divided into three groups according to lymphedema stage (0-I, II, II), mean age 48 years	Circumference measurements	Disabilities of the Arm, Shoulder, and Hand (DASH) European Organization for Research and Treatment of Cancer Core Quality of Life Questionnaire (EORTC QLQ-30 and EORTC QLQ BRE-23). VAS Dynamometer JAMAR	Patients in stage 0 -I, II and III were found to be similar in grip strength of the affected and unaffected side. Stage III patients showed lower EORTC QOL-30 scores, indicating a lower quality of life in patients with lymphedema. They also had worse functioning, more disability, in stage III than the other two stages. Stage III patients experience greater disability and worse health-related quality of life, and lymphedema symptoms were found to be highly correlated with lymphedema patients' quality of life.

Baran et.al. 2021	The comparison of three-dimensional scapular kinematics after breast cancer surgery in moderate and severe lymphedema groups and in patients without lymphedema. Secondary objectives were to compare shoulder range of motion and upper extremity function between groups as well as correlations between scapular kinematics and upper extremity function. Contemporary study	n=67 women, aged 42-68 years <ul style="list-style-type: none"> n=22 without lymphedema n=18 moderate lymphedema n=27 severe lymphedema 	Water displacement	Asension Technology Corporation, Burlington, Vermont Baseline Digital Inclinometer Quick-DASH	The no or moderate lymphedema group had significantly higher range of motion in active shoulder abduction than the severe lymphedema group ($p = 0.005$ and $p = 0.007$) The affected shoulder of the patients had lower active range of motion values than the values of the unaffected shoulder for all measurements ($p < 0.05$).
Crescenzi et.al. 2022	Assessment of subcutaneous adipose tissue in women with lymphedema.	n = 46 women, average age 50 years <ul style="list-style-type: none"> n = 22 women with stage I-II lymphedema n=24 healthy women 	Bioimpedance Spectroscopy Perometry (L-Dex)	MRI	Muscle tissue was similar between groups on average, but the fat-to-muscle fraction was significantly increased on the affected side of participants with lymphedema relative to healthy participants. It was observed that the fat-to-muscle fraction was increased on the affected side relative to the contralateral side of participants with increasing severity of lymphedema. Also, areas of nodular adipose tissue with fluid and fibrosis appear more often in advanced stages of lymphedema.
Borri et.al. 2017	To propose a magnetic resonance imaging acquisition and analysis protocol using image segmentation that measures and visualizes fluid, fat, and muscle volumes in the limb with lymphedema and the comparison of affected and unaffected arms with lymphedema, providing an analysis of both volume as well as the distribution of the different tissue components.	n =13 women with lymphedema, aged 34-77 years.	MRI	MRI	Measurements showed that most of the swelling was within the fascial volume. The fascial volume showed an increase (overall, 94% of the excess volume) that constituted the gross edema, and fat was the major component of the edema in the total fascial volume, (the total excess fat volume summed across all patients and was 2.1 times greater than that of the liquid). Total volume was significantly different ($P < 0.0005$) between affected and unaffected limbs, with greater volume in affected limbs. Muscle volume was not significantly different between the two arms. In the results, it was found that lymphedema does not uniformly affect the arm, the fluid mainly collects around the area of the forearm and elbow, while the fat mainly surrounds the upper part of the arm.

Smoot et.al. 2010	To compare differences in upper extremity lesions between women who developed lymphedema after breast cancer treatment and those who did not develop lymphedema. Also, to determine the impact of these impairments on self-reported limitations and daily activities.	n=144 women, average age 56 years <ul style="list-style-type: none"> ▪ n=73 with lymphedema ▪ n=73 without lymphedema 	Circumference measurements bioimpedance Impedimed (SPF7) DASH	Purdue Pegboard (North Coast Medical, Morgan Hill, CA) Finger Tapper Test (Psychological Assessment Resources, Inc, Lutz, FL) MicroFET2 dynamometer γωνιόμετρο Semmes-Weinstein monofilaments (North Coast Medical, Morgan Hill, CA)	Significant differences in strength, range of motion, and sensation were found between affected and unaffected upper limbs and between patients with and without lymphedema. In the non-lymphedema group, the affected side showed less shoulder abduction strength and lower shoulder flexion, abduction, and external rotation range of motion, as well as total ROM score ($p < 0.05$) compared to the unaffected side. For the lymphedema group, the affected side had less strength in elbow flexion, wrist flexion, and 2 of 3 grip tests, resulting in an overall reduction in upper extremity strength compared to the unaffected side. There was less sensitivity in the Semmes-Weinstein monofilament test on the medial side of the arm, forearm, and index finger in the lymphedema group. In addition, there was less ROM of the affected shoulder (flexion, abduction, and external rotation), wrist, index, and proximal interphalangeal joint flexion, and a lower total ROM score ($p < 0.05$).
Baran et.al. 2021	To investigate whether and how the presence of lymphedema affects upper extremity sensation and to assess whether Complex Decongestive Physiotherapy (CDP) has a favorable impact on sensory testing.	n= 27 women with stage II lymphedema, mean age 59 years	Circumference measurements	Ultrasound with 5–12 MHz linear probe (Logiq P5, GE Medical Systems, Milwaukee, WI, USA) Semmes–Weinstein monofilaments (SWMs), esthesiometer algometer (JTech Algometer Commander) tactile localization test with pencil and ruler.	Before treatment, the volume, thickness of the skin, epidermis and subcutaneous fat were found higher values ($p < 0.05$) in the affected limbs compared to those in the unaffected limbs. Also, affected sides had significantly higher values for SWM ($p < 0.001$), static ($p = 0.002$) and moving ($p = 0.011$) two-point discrimination, PPT pressure pain threshold measurement ($p = 0.001$) and touch detection ($p < 0.001$) study results showed that sensory perception of the upper limb on the affected side is reduced in women with lymphedema.
Jørgensen et.al. 2021	To investigate the effect of lymphedema on health-related quality of life (HRQoL) up to 10 years after breast cancer treatment.	n=1067 women, mean age 65 years <ul style="list-style-type: none"> ▪ n=288 with lymphedema ▪ n=823 without lymphedema 	Circumference measurements	LYMPH-ICF DASH SF-36	Patients with lymphedema reported worse physical functioning, general mental health, social role functioning, reduced recreational, social and household activities, reduced physical role, general health perception, reduced occupational activity and increased physical pain compared to patients without lymphedema. Increased severity of lymphedema was associated with more severe symptoms.

Tamam et.al. 2021	To assess quality of life and sleep quality in Saudi Arabian women at different stages of lymphedema after breast cancer treatment. Contemporary study	n=163 women with stage I-III lymphedema, mean age 42 years	Is not mentioned	EORTC QLQ-C30 PSQI 19	Patients with stage I lymphedema (n = 27) reported the best values on functional status, physical status, role-related, emotional, cognitive and social scales (64.2 ± 9.4 , 66.3 ± 10 ,2, 71.6 ± 11.4, 68.5 ± 10.8 and 65.4 ± 9.8 respectively), followed by symptom scales including loss of appetite, fatigue, dyspnea, nausea/vomiting, pain, insomnia, constipation,74,5 ± 10,6, 70,6 ± 9,7, 73,2 ± 10,4, 68,4 ± 9,5, 71,5 ± 9,8, 74,7 ± 10,2, 45,3 ± 7,5, 45,3 ± 7,5, 53,7 ± 7,5, 53,7 ± 7 and ± 8, respectively the overall quality of life. ± 7.4). Patients with stage II lymphedema (n = 84) showed lower mean values compared to those with stage I on the functional and physical status and role-related scales. Stage III (n = 52) lymphedema patients showed the lowest quality of life values compared to stage I and stage II lymphedema patients on all scales (p<.001).
Bojinović-Rodić et.al. 2016	The assessment of health-related quality of life (HRQoL) in patients with breast cancer-related lymphedema and its association with upper extremity function and edema size. Contemporary study	n=54 patients with lymphedema, mean age 56 years. 90.74% had mild or moderate lymphedema and 9.26% had severe lymphedema.	Circumference measurements	SF-36 Quick DASH	A higher HRQoL score was reported for mental health (47.0 ± 12.2) than physical health (42.2 ± 7.5) (p<0.05). The highest SF-36 values were found in the Mental Health (67.7 ± 22.9) and Social Functioning (70.1 ± 23.1) domains. The lowest scores were recorded in the Physical Role (46.9 ± 39.1) and General Health (49.3 ± 20.1) domains.
Anbari et.al. 2021	To examine women with newly diagnosed breast cancer-related lymphedema (BCRL) regarding their quality of life over seven years. Qualitative longitudinal study.	n=97 women with lymphedema, mean age 53 years	Circumference measurements, perometry	Lymphedema and Breast Cancer Questionnaire (LBCQ).	Initially lymphedema had an impact on physical function, including pain, fatigue and reduced functionality. Second, lymphedema has an impact on daily life and social functioning (participants feel and are restricted in their jobs and roles, while also expressing concerns about body image). Finally, it has an impact on the psychology of patients with feelings of frustration, depression and they are more irritable.
Togawa et.al. 2021	To investigate which symptoms of lymphedema affect the quality of life of patients with lymphedema. Contemporary study	n= 499 women, aged 35-64 years. o n= 362 without lymphedema o n= 137 with lymphedema ▪ n= 40 without symptoms of lymphedema ▪ n= 97 with at least one symptom of lymphedema	Self-reference	SF-36 Perceived Stress Scale Fear of Recurrence Scale Cancer Rehabilitation Evaluation System's Sexual Functioning Summary Scale Lymphedema-specific HRQoL	Women reporting lymphedema with or without symptoms had worse scores on the functioning, physical role, physical pain, general health, and social functioning subscales (all P values ≤ 0.01) of the SF-36 than women without lymphedema (all P-values P < 0.05). In the physical functioning and general health scales of the SF-36 there were differences only between women without lymphedema and those who reported at least one symptom of lymphedema (P-values ≤ 0.03). All symptoms except dry skin were associated with poorer quality of life (all P-values ≤ 0.0002). Lymphedema-specific quality of life was lower in women with at least one

					lymphedema symptom than in women without lymphedema symptoms (P-value < 0.0001).
Lee et.al. 2012	To determine the effect of lymphedema on health-related quality of life (HRQOL) over one year after breast cancer surgery. Contemporary study	n=200 women, average age 53 years. <ul style="list-style-type: none"> o n=104 healthy o n=96 with breast cancer <ul style="list-style-type: none"> ▪ n=58 with lymphedema ▪ n=38 without lymphedema 	Circumference measurements	SF-36	Between patients with and without lymphedema, there were no statistically significant differences in all scales of the SF-36. There were differences only when comparing breast cancer survivors with the healthy population, in all scales of the SF-36 except the vitality and mental health.
Popović-Petrović et.al. 2018	To identify the differences in quality of life in women with breast cancer-related lymphedema and in women without lymphedema and to determine the contribution of psychological support. Contemporary study	n = 64 women, average age 60 years. <ul style="list-style-type: none"> ▪ n= 34 with lymphedema ▪ n= 30 without lymphedema 	Circumference measurements	Functional Assessment of Cancer Therapy – Breast (FACT-B+ 4) Brief Illness Perception Questionnaire (BIPQ) Depression Anxiety Stress Scale (DASS-21) General Self-Efficacy Scale (SGSE)	There was no statistically significant difference both in the overall quality of life of women with lymphedema and those without lymphedema, but also in individual subscales (t-test, Mann Whitney U test, p > 0.05) with illness perception and depression being important predictor of quality of life.
Ridner 2005	To compare quality of life and symptoms between breast cancer survivors who developed chronic lymphedema and received treatment, with those who did not develop lymphedema. Descriptive study	n = 128 women, mean age 57 years. <ul style="list-style-type: none"> ▪ n = 64 with lymphedema ▪ n = 64 without lymphedema 	bioelectric impedance device (Impedimed Mansfield Australia)	Functional Assessment of Cancer Therapy – Breast (FACTB) Wesley Clinic Lymphedema Scale (WCLS) Symptom checklist Skin/arm condition short-form Center for Epidemiologic Studies of Depression (CESD) Scale Profile of Mood States-Short Form (POMS-SF)	Women with lymphedema scored significantly lower on all quality of life instruments
Carter et.al. 2021	To assess the quality of life in patients who developed lower extremity lymphedema after gynecological cancer surgery. Cohort study	n = 768 women, aged 30-80 <ul style="list-style-type: none"> ▪ n = 338 with lymphedema ▪ n= 430 without lymphedema 	Circumference measurements	FACT-G GCLQ IES Body Image subscale Sexual and Vaginal subscale LEFS	Women living with symptoms of lower extremity lymphedema reported lower health-related quality of life (p<0.01), higher cancer distress (IES) (p<0.001), and more lower extremity dysfunction (LEFS)(p <0.001), highlighting how this condition affects their daily life. The results showed that women with symptoms of lower extremity lymphedema had poorer body image (p<0.001) and worse sexual health (p<0.001) compared to women without lymphedema.
Pedrosa et.al. 2019	The evaluation of the impact of unilateral lower extremity lymphedema on functionality and quality of life. Descriptive study	n = 25 patients, mean age 52 years. <ul style="list-style-type: none"> ▪ n = 18 women ▪ n = 7 men 	Circumference measurements	SF-36 Lymph-ICF-LL TUG test	Physical role (25.0 ± 31.4), emotional role (36.0 ± 42.9) and functional ability (45.4 ± 25.9) were most affected according to SF-36. Mobility (6.0 ± 2.6) and mental health (5.6 ± 2.5) were more affected than life domains/social life (3.9 ± 2.4) which were the least affected in Lymph-ICF-LL. The mean TUG time was 9.88 ± 1.98 s, which is considered satisfactory.

Kim et.al. 2015	The evaluation of the effect of lower extremity lymphedema on quality of life in survivors of gynecological cancer. Contemporary study	<p>n = 54 women, aged 28-80 years.</p> <ul style="list-style-type: none"> n = 25 with lymphedema of lower extremities n=28 without lymphedema. 	περομετρία λεμφοσπινθηρο γράφημα MRI CT	Gynecologic Cancer Lymphedema Questionnaire (GCLQ-K) European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30 (EORTC QLQ-C30)	<p>According to the GCLQ-K scale the total symptom score was higher in the lymphedema group than in the control group (mean, 5.32 vs. 1.86, $P < 0.001$). Among the seven scales scores for general edema ($P < 0.001$), limb swelling ($P < 0.001$), and weight ($P = 0.007$) were significantly higher in the lymphedema group, while scores for physical function, infection , pain and numbness did not differ significantly between the two groups.</p> <p>In the EORTC QLQ-C30, the scores of the five functioning scales (physical, role, emotional, cognitive and social functioning), three symptom scales (fatigue, pain and nausea and vomiting) and five symptoms (dyspnea, insomnia, loss of appetite, constipation and diarrhea) were not statistically different between the two groups. However, a significant economic burden was observed in the lymphedema group than in the control group (mean, 16.0 vs. 6.0, $P = 0.035$). In addition, global health status was poorer in the lymphedema group, with borderline statistical significance (mean, 62.7 vs. 71.4, $P = 0.069$).</p>
Rowlands et.al. 2014	Evaluation and comparison of the quality of life of women with self-reported lower limb lymphedema and with women with lower limb swelling compared with women without lymphedema or lower limb swelling after treatment for endometrial cancer 3-5 years after diagnosis. Contemporary study	<p>n = 639 women, mean age 65 years.</p> <ul style="list-style-type: none"> n = 394 without lymphedema or edema n= 177 edema only n = 68 with lymphedema 	Self-reference	SF-12	<p>Women with lymphedema had clinically lower levels of overall physical quality of life ($p < 0.05$) than women without lymphedema, and also scored significantly lower on three of the eight subscales (physical functioning, physical role limitations, and social functioning) than than women without lymphedema or lower extremity edema ($p < 0.05$).</p> <p>Women with lymphedema scored lower on the physical functioning subscale and had significantly lower overall physical and mental quality of life and significantly lower scores on all 8 subscales than women without. Mental quality of life did not differ significantly between groups.</p>
Sponholtz et.al. 2022	The assessment of patient-reported incidence and severity of early lymphedema and its impact on quality of life in women undergoing surgery for early-stage cervical cancer. Cohort study	<p>n = 200 women, mean age 43 years..</p> <ul style="list-style-type: none"> n = 36 with lymphedema n=164without lymphedema 	Self-reference	LYMQOL EORTC QLQC30 and QLQ-CX24	<p>According to LYMQOL women with severe lymphedema had reduced physical functioning ($p = 0.001$) and appearance ($p = 0.007$) The impact of lymphedema on quality of life as assessed by the EORTC QLQ-C30 and QLQ-CX24 questionnaires showed that early lymphedema was associated with significant impairment in body image ($p = 0.002$), global health status ($p = 0.04$), physical functioning ($p = 0.008$), role ($p = 0.04$), cognitive ($p = 0.04$) and social functioning ($p = 0.007$), as well as a higher level of fatigue ($p = 0.01$), pain ($p =$</p>

					0.04), dyspnea (p = 0.03) and symptom experience (p = 0.007) between women with lymphedema and those without. 18% of women developed early lymphoedema, negatively affecting several aspects of their quality of life physically, psychosocially and sexually.
Watson et.al. 2019	Primary objective was to estimate the incidence of lower extremity lymphedema after endometrial cancer surgery and secondary objectives were to analyze postoperative quality of life and lower extremity function. Longitudinal pilot study	n =97 women, mean age 62 years	Circumference measurements	LEFS FACT-G,	LEFS scores significantly decreased by an average of 9.1 points from baseline to the 4–6 week measurement period (95% CI: 5.6–12.7). This trend was not maintained at later measurement periods and no significant differences in quality of life were observed at any of the measurement periods. The presence of lymphedema was significantly associated with worse lower extremity function at 4–6 weeks and 6–9 months, with a mean reduction of 27% at 4–6 weeks and 13% reduction at 6–9 weeks months, compared with the median LEFS score 4% and 0% in patients without lymphedema at these measurement periods. This change caused difficulty in performing activities of daily living and deterioration of general mobility. This difference did not persist at 12-18 months. No correlation was found between lymphedema and global quality of life

All studies were conducted in pa ents over 18 years of age with the mean age of par cipants ranging from 52 to 65 years. The sample size ranged from 13 to 1067 and the majority were female.

No study reported randomiza on of par cipants except for one in which lack of randomiza on was cited as a study limita on⁽³⁸⁾.

Convenience sampling was used in three studies, in which pa ents were voluntarily referred to par cipate^(30,32,36).

The es ma on of the sample size refers to four studies^(25,30,32,40).

Lymphedema was defined in different ways between studies. In thirteen, lymphedema was iden fied by peripheral measurements^(22,24-26,28,30-32,35,37,40,43-44). In three by pa ent self-report^(33,39,41). In one the water displacement method was used and in the other the bioelectric impedance device method^(23,38). In two studies lymphedema was iden fied by

bioimpedance spectroscopy (L-Dex)^(29,40). One study used MRI and one MRI, CT, perometry, and lymphoscintigraphy together (27,34). In two studies no method is mentioned^(36,42).

A total of 4530 patients were evaluated, 1242 had a diagnosis of upper limb lymphedema and 512 had a diagnosis of lower limb lymphedema.

Five studies assessed upper extremity grip strength with dynamometer^(22,30-31,36,40). Three assessed body composition changes in the limb with lymphedema with Dual Energy X-ray Absorptiometry (DEX), Lunar DPX-NT model (Lunar/GE Corp, Madison, Wisconsin), so were 4.7 and MRI^(27,29,31). Two studies assessed shoulder range of motion with a goniometer^(23,40). Two evaluated sensibility with Semmes–Weinstein (SWM) monofilament filaments^(24,40).

Nine studies evaluated the quality of life of patients with upper limb lymphedema^(26,30,32,33,35,37-38,42,44). Six studies evaluated the quality of life of patients with lower limb lymphedema^(25,28,34,39,41,43).

Strength

There are conflicting results regarding the impact of lymphedema on strength. One study showed that healthy upper limbs were stronger than those with lymphedema ($p < 0.01$)⁽²²⁾. One study reported significant decreases in both grip strength and precision grip strength in women with lymphedema compared to healthy women ($p < 0.05$)⁽³⁶⁾. Also, Smoot et.al. 2010 showed that for the lymphedema group, the affected side had less elbow and wrist flexion strength of the upper extremity compared to the unaffected side ($p < 0.05$)⁽⁴⁰⁾. In contrast, one study showed that the grip strength of limbs with and without lymphedema was similar for all three stages of lymphedema⁽³⁰⁾. Similarly, in the study by Gomes et.al. 2014 grip strength remained unchanged regardless of the presence or absence of lymphedema⁽³¹⁾.

The Range of Motion

Range of motion was assessed in two studies^(23,40). The results of the study by Baran et.al. 2021 showed that the patients' affected shoulder had lower active range of motion values than the unaffected shoulder for all measures ($p < 0.05$) of flexion, abduction, external and internal rotation, and the severe lymphedema group had significantly less active range of motion of the shoulder joint ($p = 0.007$) in abduction than the group with no or moderate lymphedema ($p = 0.005$)⁽²³⁾. Smoot et al. 2010 reported overall less range of motion ($p < 0.05$) on the affected side compared to the unaffected side, significantly less range of motion was in shoulder flexion, abduction and external rotation, wrist flexion, index finger and

proximal interphalangeal joint of the affected limb, the greatest differences were observed in shoulder abduction⁽⁴⁰⁾.

The change in body composition

The change in body composition was investigated in three studies^(27, 29, 31). One study showed that trunk muscle mass was reduced in the lymphedema group compared to the control group ($p=0.04$), and although changes in body composition were observed in the upper limbs and trunk, the relationship could not be clarified of body composition changes in the presence of lymphedema⁽³¹⁾. Another study showed that total fascial volume (fluid and fat) was significantly different ($p<0.0005$) between affected and unaffected limbs, with greater volume in the affected arms and fat being the predominant component of edema, muscle volume was not significantly different between the two arms⁽²⁷⁾. The study by Crescenzi et.al. 2022 indicates an increased ratio of adipose tissue to muscle tissue in the limb with lymphedema. The results showed that the fat-to-muscle fraction in participants with lymphedema was asymmetric ($p = 0.007$) and significantly increased on the affected side (fraction= 0.732 ± 0.184) versus the unaffected side (fraction= 0.639 ± 0.167), while in healthy participants the fraction of fat volume to muscle was symmetrical on the right and left sides ($p = 0.51$)⁽²⁹⁾.

Sensibility

Sensory perception of the affected upper limb is impaired in women with lymphedema. In one study sensory evaluations showed that affected sides had significantly higher values for SWM ($p<0.001$), static ($p = 0.002$) and moving ($p = 0.011$), two-point discrimination, PPT pain ($p = 0.001$) and touch localization ($p < 0.001$)⁽²⁴⁾. In the study by Smoot et.al. 2010 there was less sensitivity in the Semmes-Weinstein test on the medial side of the arm, forearm and index in the lymphedema group⁽⁴⁰⁾.

Quality of life

Five of the nine studies that assessed the quality of life of patients with upper extremity lymphedema focused on comparing quality of life between patients with lymphedema and those without lymphedema^(32-33,35,37-38). Two assessed quality of life among patients at different stages of lymphedema^(30,42). Although there is disagreement in the results of the studies, the majority report that patients with lymphedema had significantly worse quality of life, reduced physical function, as well as psychological and social well-being, compared to those without lymphedema^(32-33,38).

One study showed that women with lymphedema had a poorer quality of life compared to those without and scored significantly lower on all measures⁽³⁸⁾.

Another study showed that lymphedema is associated with long-term impairment of quality of life, especially in the physical and psychosocial domains, with the General Health Percep on Scale being worse even among those who reported at least one symptom of lymphedema (P value < 0.0001)⁽³²⁾.

In Togawa's study, women who reported lymphedema with or without symptoms had worse scores on the SF-36 and the domains of func oning, physical role, pain, general health, and social func oning (all P-values ≤ 0.01), were more affected than women without lymphedema (all P-values < 0.05)⁽³³⁾.

While in the study of Popović-Petrović et.al.2018 there was no sta s cally significant difference between the groups in the overall quality of life score ($t = 0.469$, $p > 0.05$) and only the percep on of illness ($\beta = -0.603$, $t = -5.958$, $p < 0.001$) and depression ($\beta = -0.411$, $t = -4.101$, $p < 0.001$) contribute to the variance of quality of life⁽³⁷⁾. The same in the study by Lee et.al. 2012 there were no sta s cally significant differences in all scales of the SF-36⁽³⁵⁾.

Anbari et al. 2021 showed that lymphedema had a significantly nega ve impact on physical func oning, daily life, sociability as well as the psychology of pa ents with feelings of frustra on and depression⁽⁴⁴⁾.

In another study there was a sta s cally significant ($p < 0.05$) higher quality of life score in mental health (47.0 ± 12.2) than physical health (42.2 ± 7.5). The highest SF-36 values were found in the domains of mental health (67.7 ± 22.9) and social func oning (70.1 ± 23.1), while lower values were recorded in the domains of role (46.9 ± 39.1), physical and general health (49.3 ± 20.1)⁽²⁶⁾.

In two studies the assessment of quality of life was made between pa ents at different stages of lymphedema^(30,42). In the study by Giray et.al.2019 pa ents with stage III lymphedema showed greater disability and worse quality of life compared to pa ents in the other two stages of lymphedema. In the EORTC QLO-30 ques onnaire the func onality scale had sta s cally significantly lower scores in stage III pa ents (36.88 ± 32.07) than stage I and II lymphedema pa ents (66.91 ± 22.01 / 66.46 ± 15.85) respec vely⁽³⁰⁾.

In the study by Tamam et.al. 2021 found sta s cally significant differences between the three stages of lymphedema ($P < 0.05$), with stage III pa ents having lower quality of life scores on all scales compared to pa ents in the other two stages of lymphedema. Pa ents with lymphedema III showed lower values in the scales of func onal and physical status, role-related, emo onal, cogni ve and social func oning (57.3 ± 8.5 , 59.6 ± 8.7 , 65.2 ± 9.4 ,

61.6 ± 8.3 and 58.5 ± 7.9), on the symptom and global health quality of life scales (32.4 ± 5.6) compared to patients with stage I lymphedema (64.2 ± 9.4 , 66.3 ± 10.2, 71.6 ± 11.4, 68.5 ± 10.8 /65.4 ± 9.8) (38.7 ± 7.4), and II(61.4 ± 9.1, 63.5 ± 9.8, 69.6 ± 10.5, 65.2 ± 9.4 /62.3 ± 8.7) (36.1 ± 6.8) respectively⁽⁴²⁾.

The study by Kim et.al. 2015 showed that patients with lower extremity lymphedema had more symptoms than patients without on the GCLQ-K total score (mean, 5.32 vs. 1.86, $p < 0.001$). On the EORTC QLQ-C30 questionnaire global health status was poorer in the lymphedema group (mean, 62.7) versus those without (mean, 71.4), ($P = 0.069$), while five functioning scales (physical, role, emotional, cognitive and social), three symptom scales (fatigue, pain and nausea and vomiting) and five symptoms (dyspnea, insomnia, loss of appetite, constipation and diarrhea) were not statistically different between the two groups⁽³⁴⁾. In addition, a greater economic burden was observed in the lymphedema group than in the control group (mean, 16.0 vs. 6.0; $P = 0.035$)⁽³⁴⁾.

Another study reported that the group of women with lower extremity lymphedema had lower levels of overall physical quality of life ($M = 41.8$, $SE = 1.4$), lower scores on three of the eight subscales (physical functioning, physical role, and social functioning,) of the SF-12 compared to women without lymphedema or edema ($M = 45.1$, $SE = 0.8$, $p = .07$), while mental quality of life was within the normative range ($M = 49.6$; $SE = 1.1$ $p = 1.0$)⁽³⁹⁾.

In the study by Sponholtz et.al. 2022, early lymphedema was associated with significant impairment in body image ($p = 0.002$), global health status ($p = 0.04$), physical condition ($p = 0.008$), physical role ($p = 0.04$), cognitive ($p = 0.04$) and social functioning ($p = 0.007$), as well as a higher level of fatigue ($p = 0.01$), pain ($p = 0.04$), dyspnea ($p = 0.03$) and symptom experience ($p = 0.007$)⁽⁴¹⁾.

In the study by Watson et.al. 2019 the presence of lymphedema was significantly associated with worse lower extremity function at 4–6 weeks and 6–9 months, however global quality of life, as measured by the FACT-G, was not significantly affected by the postoperative presence of lymphedema at either the measurement periods⁽⁴³⁾.

In the study by Pedrosa et.al. 2019 according to the results physical role (25.0 ± 31.4), emotional role (36.0 ± 42.9) and functional ability (45.4 ± 25.9) were the most affected domains of SF-36, while in the Lymph-ICF-LL the areas of mobility (6.0 ± 2.6) and mental function (5.6 ± 2.5) were more affected, while the areas of life and social life (3.9 ± 2, 4) were less affected⁽²⁵⁾.

DISCUSSION

In this systematic review, the effect of lymphedema on the morphometric and biokinematic characteristics of the limb with lymphedema and the quality of life of patients with lymphedema after cancer treatment was evaluated. In the results of the studies, it was found that lymphedema has a negative effect both on the morphometric and biokinematic characteristics of the limb, as well as on the patients' quality of life. However, no study correlates the morphological and biokinematic changes of the limb with the quality of life of these patients.

The results of our study showed that there were decreases in grip strength and precision grip strength in women with lymphedema. Also, patients with severe lymphedema had reduced range of motion of the shoulder joint, mainly in abduction, reduced sensory perception of the affected upper limb, and in addition, changes in body composition were observed in the upper limbs and trunk with adipose tissue being increased compared to the muscle in limbs with lymphedema versus healthy limbs. The majority of studies reported reduced quality of life in patients with lymphedema, and the areas most affected were body image, role, mental health, and sociality.

In the study it has been shown that lymphedema is a serious complication of patients after cancer treatment and is responsible for the most symptoms, motor limitations and the worst quality of life of these patients.

In the studies evaluating morphometric and biokinematic changes of the limb with lymphedema the sample size was not large enough and was cited as a limitation in all studies.

Also, a limitation is the fact that healthy limbs of the same patients and healthy subjects were used as a control group. Studies have shown that the unaffected limb may also exhibit different joint movement patterns after mastectomy, which may be due to either muscle dysfunction or side effects of breast cancer treatments⁽⁴⁵⁻⁴⁶⁾.

Also, in the study of Smoot et.al. 2010 there was reduced strength and limited range of motion on the operated side even in patients without lymphedema, but the reductions were less than those with lymphedema. There are no range of motion and strength results in the same patients before surgery for more accurate conclusions⁽⁴⁰⁾. Comparisons are made with healthy populations, which is a limitation of the studies and does not leave clear conclusions that the presence of lymphedema was the absolute cause of these reductions. The reduction in strength may not be due to lymphedema but to reduced use of the affected limbs either due to pain or disorders following surgery. Also, the

effect of the potential reduction of muscle mass versus adipose mass on muscle weakness of the affected limb has not been evaluated.

There was variation across studies in terms of the use of different quality of life measurement tools, which contain data for different domains. Questionnaires for specific diseases and conditions do not always measure the same domains, and general health scales may not adequately capture symptoms of lymphedema. Most studies used instruments that assess general health across diseases, and only three used a lymphedema-specific questionnaire (LYMQOL), which captures lymphedema-specific symptoms^(25,32,41).

There were differences in the study sample regarding the disease, although all patients included in the studies had lymphedema after cancer treatment, however there were differences in the type, stage, therapeutic recovery of the disease (radiotherapy, chemotherapy, total or partial mastectomy, number of lymph nodes removed), as well as differences in time from surgery to quality of life assessment.

Studies showed difference in the time point at which quality of life was assessed. It is possible that for patients with early lymphedema the reduced quality of life is not due to the lymphedema but to the diagnosis of cancer, while for patients with chronic lymphedema there is no reduction in the mental health scale because of the time that passed from the diagnosis to the evaluation helps the patients to they familiarize themselves with the new situation, learn to live and function with lymphedema.

Also, the country in which the research is conducted plays an important role, as in developed countries patients are put under frequent follow-up after surgery, receive psychological support and are referred early for lymphedema treatment. These tactics have a significant impact on stabilizing the mental health of these patients. Also, the different cultures of the countries contribute to the different perception of the disease, there are strong families from where the patients are psychologically supported.

Only one study evaluated the costs. As lymphedema is a chronic disease, which can develop many years after cancer surgery, the issue of financial burden is crucial and should be further evaluated. Patients with lymphedema either have difficulties to return to work or because of the swelling their productivity is reduced, they also bear the cost of the treatments as in most countries they are not covered by the state and private insurance companies.

CONCLUSION

Based on this systematic review, it is concluded that lymphedema has a high incidence among people who have undergone cancer treatment, and has a significant impact on patients' mobility and functionality, and this in turn affects the quality of life of these patients. These findings are important for health care providers and lymphedema therapists to enroll these patients in frequent follow-up programs, referrals to specialized therapists, and lymphedema-specific treatments that will reduce the risk of symptoms and improve quality of life.

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KNOWLEDGE AND PERCEPTIONS OF GREEK PHYSIOTHERAPISTS REGARDING THE FUNCTIONAL TESTS USED IN PATIENTS WITH POST-COVID-19 SYMPTOMATOLOGY

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[https://doi.org/ 10.55742/DVAY2009](https://doi.org/10.55742/DVAY2009)

SUMMARY

Aim: To investigate the knowledge and attitudes of Greek physiotherapists regarding functional assessment tests used in the rehabilitation of post-COVID-19 patients.

Methods: Based on the literature, a specific 27-question questionnaire was designed and divided into 3 sections: a) sources of information about the management of patients with post-COVID-19 symptomatology, b) functional assessment tests most commonly used in clinical practice, c) willingness for further knowledge on performing functional tests. Inclusion criteria for completing the questionnaire were: a) physiotherapy profession, b) involvement with post-COVID-19 patients' treatment in the last year. The completion of the questionnaire was anonymous. It was shared in Google Forms format, via personal email invitations and public sharing on social media by all researchers, with republishing ability by each user. Sharing was conducted over two periods, lasting 16 and 13 days, respectively.

Results: The study included 82 physiotherapists (28 men and 54 women), 56.1% of whom were less than 39 years old and 50% had more than 10 years of professional experience. The main sources of information on rehabilitation in post-COVID-19 patients were journal publications (69.6%). Among the most well-known and frequently used tests were the six-minute walk test (85.4%), the one-minute sit-to-stand test (86.6%), and the timed up-and-go test (76.9%). A large percentage of physiotherapists used functional assessment tests before initiation (80.5%) and at the end (70.8%) of the treatment program. The 91.5% expressed the willingness for further education on practicing functional tests.

Conclusions: Greek physiotherapists get information from the recent literature and use well-known functional tests for assessing functional capacity in post-COVID-19 patients.

Keywords: functional assessment, 6-minute walk test, 1-minute sit-to-stand test, post-COVID-19, physiotherapy, knowledge, rehabilitation

INTRODUCTION

In Europe, approximately 270 million people were infected with SARS-Cov-2 virus, and about 2% of them died after infection (Conor, 2023). The elderly and

people with comorbidities are considered most vulnerable (Guan et al., 2020). The rate of hospitalization due to COVID-19 in people younger than 40 years of age, the rate is 0.4%, while for people older than 60 years of age the hospitalization rate is about 9.2% (Menachemi et al., 2021). In addition, severe disease, age, and the presence of comorbidities are also factors for incomplete recovery. Hospitalized patients recover at a slower rate than those who did not require hospitalization (Evans et al., 2021).

Of all patients infected with the virus, a percentage of 10-20% may experience persistent symptomatology after the initial infection, regardless of whether or not they were hospitalized (WHO, 2023). When this symptomatology lasts from 4 to 12 weeks, the syndrome is classified as post-COVID-19. When this symptomatology persists for more than 12 weeks or new symptoms appear, this syndrome is classified as Long-COVID-19 (Boutou et al., 2021). There are also cases where even in mild disease (without hospitalization) some patients have persistent symptoms that last for a long time, affecting their quality of life, their muscle strength, and their functionality in daily activities (Montes-Ibarra et al., 2022). The main symptoms reported by patients to remain 12 weeks after the disease are dyspnea and fatigue, at 60-71% and 60-87% respectively (WHO, 2023). These symptoms affect the physical function and quality of life of patients, who avoid carrying out daily activities due to fatigue (McFann et al., 2021).

Globally, scientific societies have published clinical guidelines on the rehabilitation of patients in each of the stages of the disease (Singh et al., 2020; Spruit et al., 2020). Physical therapists use various functional tests focusing on functional capacity, muscle strength, balance and activities of daily living to assess post-COVID-19 and Long-COVID-19 patients (Postigo-Martin et al., 2021). In a recent systematic review by Simonelli and colleagues (2021), appears that the most well-known functional assessment tests used in patients with COVID-19 disease are the 6-minute walk test (6MWT), the 1-minute sit-to-stand test (1-MSTS) and the Short Physical Performance Battery (SPPB). In parallel, to assess the physical performance on daily activities, physiotherapists use the Barthel Index and the Functional Independence Measure (FIM) scale (Pizarro-Pennarolli et al., 2021). These two scales are used to assess post-COVID-19 patients after discharge, at the beginning and at the end of a rehabilitation program.

To the best of our knowledge, there is no information whether Greek physiotherapists use functional assessment tests in the rehabilitation of post-COVID-19 and Long-COVID-19 patients. This study aimed to investigate whether Greek physiotherapists are familiar with the use of functional assessment tests in the rehabilitation of post-COVID-19 and Long-COVID-19 patients.

METHODS

Participants

A total of 89 participants agreed to participate in this observational study, of whom 82 met the inclusion criteria: a) possession of a bachelor's degree in physiotherapy and b) experience in treating post-COVID-19 patients. To participate, they were asked to sign an informed consent form, after being informed about the aims of the study, the confidentiality of their data, and the conditions of data processing. This observational study was conducted over two time periods with a total duration of one month. The first period was from 10/12/2021 to 26/12/2021 and the second from 2/1/2022 to 15/1/2022.

Study Design

For the purpose of the research, a special questionnaire was designed with a total of 27 questions. At first, two physiotherapists (M.K. and A.M.) with clinical experience in managing patients with post-COVID-19 symptomatology, composed a 32-question questionnaire, for which the entire writing team agreed. The questionnaire was divided into 3 sections: a) sources of information and amount of involvement with post-COVID-19 patients, b) use of functional assessment tests for post-COVID-19 patients and, c) willingness for further education on practicing functional tests. Then, it was distributed to a convenience sample of 20 physical therapists to verify the questions' clarity and completeness. Questions with similar meanings were removed, minor editorial corrections were made, and ultimately, 27 questions remained for the final version of the questionnaire. The final questionnaire was shared digitally using Google Forms (digital questionnaire), through social media invitations and personal email invitations, ensuring both anonymity of responses and

automatic delivery to the researcher. To maximize the number of participants, multiple invitations were made on the same media.

Measurements

Participants had access to the questionnaire by clicking on the available link. In order to continue to the content, they had to have previously not answered the questionnaire (e.g., the second completion period or a second time in the same completion period). When participants completed the questionnaire, they clicked submit to send the responses anonymously, which were automatically received by the research team.

Specific Questionnaire

To create the specific questionnaire, an extensive review of the literature on the use of functional assessment tests in post-COVID-19 patients was conducted, as well as a search of all published clinical guidelines from scientific societies and institutions (up to October 2021). An initial 32-items questionnaire was developed by the research team and it was distributed to 20 physiotherapists with clinical (n=12) and private practice (n=8) experience with different study levels [bachelor (n=14), postgraduate degree (n=4) and PhD (n=2)] aiming to identify the clarity and relevance of each question to the aims of the study. In detail, each participant was asked verbally to judge whether each question was relevant to the aim of the study by answering yes or no (Stone et al., 1993). Thus, questions with similar meaning were removed and minor corrections were made for the final version of the questionnaire. The final version was divided into 3 main sections and an initial demographic section. The initial section (8 questions) addressed the demographic characteristics, educational level and work experience of the participants. The 1st section (8 questions) was related to their involvement with post-COVID-19 patients (number of patients per day) and sources of information (ways to find out about newer research data). The 2nd section (8 questions) was related to the most widely used functional tests used by Greek physiotherapists in clinical practice as a means of assessing post-COVID-19 patients. The 3rd section (3 questions) related to their willingness to participate in further training in the application of functional tests. The format of the answers was multiple choice, single choice, short answers. For those responses that

required scoring, the 5-point Likert scale (1-5) or 10-point (0-10) preference scale was used.

Data collection was done automatically by the Google Forms administration software. In the second questionnaire completion period, the software was set to automatically exclude those who went to complete the questionnaire a second time.

DATA ANALYSIS

All the data received were processed using the Microsoft Excel and SPSS version 22 programs. The responses were categorized and divided based on the subsections of the questionnaire. The results were presented in quantitative and percentage (%).

RESULTS

Participants' characteristics

Of the total 89 participants, seven did not meet the inclusion criteria and they were excluded from the study. Thus, 82 physiotherapists, 28 males (34.2%) and 54 females (65.8%), made up the sample. The characteristics of the participants are presented in Table 1.

The 80.5% (n=66) of the participants had more than 2 years of professional experience, while half of them (n=41) had more than 10 years. They mainly used scientific articles, recent publications in scientific journals and the internet for their continuous information and updating (Table 2). Participants' sources of information are presented in Table 3.

Table 1. Participants' characteristics regarding gender, age, job position, and educational level (n=82).

Characteristics	Number (n)	% percentage
Men/Women	28/54	34.2/65.8
Age (years)		
<30	27	32.9
30-39	19	23.2
40-49	20	24.4
>50	16	19.5
Position at work		
Intensive care unit	19	23.1
Public Hospital	32	39.1
Private physiotherapy clinic	8	9.8
Rehabilitation centre	17	20.7
Home visits / Freelance	4	4.9
Doctoral candidate	2	2.4
Educational level		
Bachelor's degree	46	56.1
Postgraduate degree	32	39
Doctoral degree	4	4.9
Additional education		
Yes/No	61/21	74.4/25.6
Seminars/Conferences per year (number)		
Up to 2	54	65.8
Up to 4	18	22
> 5	10	12.2

Values are presented as number of participants (n) and % percentage.

Table 2. Professional experience and sources of information (before and after the COVID-19 pandemic) for all participants (n=82).

Characteristics	Population (n)	percentage %
Professional experience (years)		
<2	16	19.5
2-5	18	22
5-10	7	8.5
>10	41	50
Sources of information (before the pandemic)*		
Scientific articles	54	65.9
Internet	49	59.8
Scientific journals	33	40.3
Books	30	36.5
Sources of information (post-pandemic)*		
Recent publications in scientific journals	57	69.6
Scientific meetings via internet	34	41.4
Books	18	22

Values are presented as number of participants (n) and % percentage.

Table 3. Usual informing before and after the COVID-19 pandemic for all participants (n=82).

You used to be informed from...	None	Few	Partially	Mostly	Completely
Before COVID-19					
Scientific articles	9 (10.9%)	14 (17.1%)	24 (29.3%)	21 (25.6%)	14 (17.1%)
Internet	6 (7.3%)	12 (14.6%)	14 (17.1%)	30 (36.6%)	20 (24.4%)
Books	10 (12.2%)	23 (28%)	18 (22%)	23 (28%)	8 (9.8%)
After COVID-19					
Scientific articles	2 (2.4%)	11 (13.4%)	10 (12.2%)	30 (36.6%)	29 (35.4%)
Scientific meetings via internet	9 (10.9%)	15 (18.4%)	23 (28%)	17 (20.7%)	18 (22%)
Books	24 (29.3%)	20 (24.4%)	19 (23.1%)	11 (13.4%)	8 (9.8%)

Values are presented as the number of answers (n) and % percentage of all participants.

Patient involvement and functional assessment of post-Covid-19 patients

The majority of participants treated 3 to 5 post-COVID-19 patients per day. A high percentage of physiotherapists (84.7%) took complete history before starting the treatment program. The 59.8% (n=49) believed that patients needed more attention compared to other patient categories. Table 4 presents the engagement of the sample with the COVID-19 participants.

Table 4. Information on engagement with post-COVID-19 and long-COVID-19 patients (n=82).

Characteristics	Number (n)	Percentage (%)
Working period (months)		
Up to 3	33	40.2
3-5	18	22
>6	31	37.8
Post-COVID-19 patients per day (number)		
<5	57	69.5
5-9	13	15.9
>10	12	14.6
Long-COVID-19 patients per day (number)		
<5	67	81.7
5-9	8	9.8
>10	7	8.5

Values are presented as number of participants (n) and % percentage.

The most well-known functional tests were the 6MWT, the 1-MSTS, and the TUG (Table 5). The 6-minute walk test was most commonly used. A total of 80.5% of participants used the functional tests at baseline assessment, and 70.8% at reassessment. Twelve physiotherapists (14.6%) reported that they did not use functional tests at all in the assessment of their patients. The 73 (89%) of the participants reported that functional testing did not consume time at the expense of treatment while improving the quality of the treatment program [mean (SD) 8.67 (1.54)]. The majority of physiotherapists (91.5%) reported that they would like to be trained to use functional testing correctly in clinical practice.

Table 5. Functional assessment tests of patients with post-COVID-19 used by the physiotherapists (n = 82).

Functional Test	Population (n)	% percentage
<i>Commonly used functional tests*</i>		
1-MSTS	71	86.6
6MWT	70	85.4
TUG	63	76.9
2MST	45	54.9
Barthel Index	39	47.6
SPPB	20	24.4
<i>Frequency of use of functional tests*</i>		
6MWT	42	51.2
1-MSTS	40	48.8
TUG	33	40.3
Barthel Index	18	22
2MST	17	20.7
SPPB	9	11

Values are presented as number of participants (n) and % percentage? 1-MSTS: 1-minute Sit-to-Stand test; 6MWT: 6-minute Walk Test; TUG: Timed Up and Go test; 2MST: 2-Minute Step Test; SPPB: Short Physical Performance Battery.

DISCUSSION

This study was the first attempt to investigate the knowledge of functional tests that used by Greek physiotherapists for the evaluation of patients with post-COVID-19 symptoms. According to the responses, among the most well-known and applicable functional tests were the 1-MSTS, the 6MWT, and the TUG. The less applicable functional test by Greek physiotherapists was the SPPB.

According to a mapping review by Simonelli et al. (2021), the most well-known and widely-used assessment tools in post-COVID-19 patients are the Barthel

Index, the 6MWT, the SPPB, and the 1-MSTS. These tools are used either at hospital discharge or as part of a rehabilitation program for assessing COVID-19 patients' functional status. These tests simulate everyday activities, are inexpensive, and do not require specialized equipment to be performed. In the present study, the majority of the participants (69.5% and 81.7%) (Table 4) treated up to 5 post/long COVID-19 patients per day using MWT, 1-MSTS for the assessment of the functional capacity of those patients who proceeded at the special COVID-19 clinics or at private physiotherapy units. In addition, Greek physiotherapists seem to frequently use the TUG (Table 5), an easy and quick assessment test, which combines gait, leaning, and speed and provides information relevant to the limitations of patients after COVID-19 disease, even 3 months after discharge (Kowal et al., 2023).

Almost 80% of the total number of participants reported that they used functional tests as part of the assessment prior to entering a rehabilitation program. Postigo-Martin et al. proposed a model for early detection of post-COVID-19 sequelae to adopt therapeutic strategies by physiotherapists. This management model assesses cardiopulmonary, neurological, and musculoskeletal deficits. Therefore, taking the medical history and general assessment of the physical status (vital signs, symptoms, body composition, physical activity, etc.) are the key components for the subsequent physiotherapeutic assessment (Kortianou et al. 2022).

Sixty-six of those physiotherapists who took part in this study reported that they used functional tests at the initial assessment of a rehabilitation program, and 59 of them also used the test at the reassessment. According to Torres-Castro et al., functional capacity assessment is essential for assessing the effectiveness of a rehabilitation program, it should be performed at the beginning (between 8 and 12 weeks after hospital discharge) and at the end of the program. (Torres-Castro et al., 2023).

Interestingly, the vast majority of the participants express their willingness to further be trained in the implementation and the interpretation of the results of the functional tests they use. The lack of adequate knowledge and skills in performing functional tests has been reported by previous similar studies. In detail, an observational study by Spiegl et al (2022) demonstrated that 41.8% and 33% of the physiotherapists in South Austria reported a lack of experience and knowledge, respectively in the rehabilitation of post-COVID-19 patients. Similarly, in another study among

professional physiotherapists and final-year physiotherapy students, it was reported that only 11.2% of the participants (n=255) felt adequately trained in the rehabilitation of post-COVID-19 patients. The authors pointed out that there is an urgent need for further training of physiotherapists in the components of assessment and treatment of this patient population (Scheiber et al., 2021).

Research limitations

The study has several limitations. Firstly, the study sample was small (n=82) and was not randomly selected, e.g., from lists of physiotherapists in the Panhellenic Association of Physiotherapists, indicating that it was not representative of the Greek physiotherapy community. Furthermore, the completion of the questionnaire by those physiotherapists who used to treat post-COVID-19 patients, possibly attracted only those who already knew and used the functional tests in their everyday clinical practice, while those who were not aware may probably avoided completing the questionnaire. The aforementioned limitations may bias the results and therefore, we cannot generalize the results to the general Greek physiotherapy professionals.

Finally, the questionnaire was created by the research team after reviewing the literature. It was not the product of a methodological procedure usually followed to strengthen the construct validity of a questionnaire (Jenn, 2006). However, the final questionnaire is the product of a study of the relevant literature and it was completed after previously being pilot-distributed to physiotherapists to investigate questions' clarity and validity (Stone et al., 1993)

This attempt was the first to investigate the knowledge and use of functional testing by Greek physiotherapists and, provides a rough picture immediately after the COVID-19 pandemic of how physiotherapists assessed this patient population prior to their inclusion in any therapeutic program.

CONCLUSIONS

In conclusion, the evaluation of post-COVID-19 patients by Greek physiotherapists included the 1-MSTS, the 6MWT, and the TUG functional tests. The functional tests are mainly used either during the initial assessment or during reassessment. The majority of the participants express willingness to further improve their skills and knowledge on performing and interpreting the results of functional tests.



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