Original Article

From Mobility to Management: A Scoping Review on Exercise in Breast Cancer-Related Lymphedema

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Abstract

This scoping review synthesized 21 studies on exercise interventions for breast cancer-related lymphedema (BCRL). Exercises including resistance, aerobic, aquatic, Pilates, and scapulothoracic stabilization, applied 2 to 5 times weekly for 6 to 12 weeks, effectively reduced edema and improved function and quality of life. Despite safety and efficacy, protocol variability underscores the need for standardized guidelines.

Purpose: Breast cancer-related lymphedema (BCRL) is a prevalent complication that adversely affects survivors' physical function and quality of life. Exercise is increasingly used in BCRL management, yet the diversity in exercise types and lack of standardization present challenges for clinical implementation. This scoping review aimed to systematically map and synthesize the available literature on exercise interventions for BCRL, focusing on the types of exercises used, their frequency and duration, and their effects on clinical and functional outcomes. **Methods:** Studies were included if they were randomized or non-randomized controlled trials involving adult women with BCRL, evaluated at least one lymphedema-related outcome, and were published in English within the last 10 years. A comprehensive search was conducted in PubMed, Scopus, Web of Science, PEDro, and CINAHL databases using MeSH terms. Data were extracted on study design, sample size, exercise type, frequency and duration, and outcome measures. **Results:** Out of 974 records, 21 studies met the inclusion criteria. Exercises examined included resistance, aerobic, aquatic, Pilates, and scapulothoracic stabilization. Most interventions were 6 to 12 weeks in duration and applied 2 to 5 times per week. Exercise was found to be effective in reducing edema volume and severity, improving range of motion, pain, function, and quality of life, both independently and alongside CDT. **Conclusion:** Exercise is a safe and effective intervention for BCRL management. However, variability in exercise protocols highlights the need for standardized recommendations. Future studies should aim to determine optimal parameters to guide clinical decision-making.

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Introduction

Lymphedema is a chronic pathology of the lymphatic system characterized by obstruction or impairment of lymph circulation. Impaired circulation leads to the accumulation of protein-rich fluid in the interstitial space and an aggressive increase in the volume of the involved tissue if left untreated. Lymphedema is characterized by a reduced quality of life, leading to skin changes, loss of sensation, a feeling of fullness, pain and ultimately loss of function.[1,2] Breast cancer-related secondary lymphedema (BCRL) has been identified as one of the most important survival problems often seen after cancer treatment.[3]

Reported incidence of lymphedema varies widely among women undergoing breast cancer surgery and radiation therapy due to variability in diagnosis.[4] Correct diagnosis and treatment and patient education are very effective in the management of lymphedema. However, there is no definitive treatment for lymphedema. However, effective treatment methods are available. Non-surgical lymphedema treatment methods are based on compression therapy with complex decongestive therapy (CDT), which is considered the gold standard, advanced pneumatic

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compression pumps and exercise. These treatments are mainly effective in early stage lymphedema.[5,6]

Different exercise protocols have been described for BCRL. However, there is no standard. Exercise improves both cancer-induced fatigue, decreased muscle strength and flexibility, and optimizes quality of life by improving the deteriorated body image as a result of surgery.[7,8] Considering the physiologically musculoskeletal pumping feature of exercise, it can be thought that venous and lymphatic load is transferred more efficiently for the affected extremity in lymphedema. Various restrictions are, however, imposed to avoid trauma in breast cancer survivors due to the risk of BCRL.[9]

In previous years, due to the limited number of studies directly addressing the relationship between exercise and lymphedema, clinicians restricted patients' movement to prevent adverse events. This has led to frustration and fear in breast cancer survivors due to not knowing the safe level of exercise.[10] The dragon boat racing study, which was one of the first studies in the literature to show that upper body exercises were not related to the onset or exacerbation of BCRL, paved the way for a bolder investigation of exercises with lymphedema.[11] Given the limited breadth of the literature, exercise types and classifications are unclear and there are gaps in knowledge. The aim of this study is to comprehensively review and analyze exercise protocols for breast cancer-related lymphedema over the last 10 years and to provide an updated mapping of evidence-based exercise protocols.

Methods

Design

This study, which was conducted in a scoping review design, examined the findings of studies on the effects of exercises in Cancer-related lymphedema between January 1, 2005 and May 1, 2025. To conduct this review, Arksey and O'Malley's 5-stage process for determining the scope of review studies was used.[12] The literature review was conducted between April 20, 2025 and May 1, 2025. The study protocol and manuscript followed the "Preferred Reporting Items for Systematic Reviews and Metaanalyses-extension for scoping reviews" criteria (PRISMA-ScR).[13]

Study Questions

Five questions were identified for the study:

1. Which type of exercise was used?
2. On which parameters was its effect evaluated?
3. How many days a week, how many sessions and for how long in total?
4. Were the exercises performed together with CDT?

Identifying Related Studies

"PubMed," "Scopus," "Web of Science," "PEDro," and "CINAHL," electronic databases were used for literature search. The literature search was conducted in English. The following terms from the Medical Subject Headings (MeSH) were used to identify keywords: "Breast Cancer Related Lymphedema," "Upper Extremity Lymphedema," "Arm Lymphedema," "Upper Limb Lymphedema," "Post Mastectomy Lymphedema," "Secondary Lymphedema After Breast Cancer," "Arm Lymphedema After Breast Cancer," "exercise," "training" and Boolean operators "AND" and "OR,", the search strategy for each database is shown in Table 1. To enhance search precision, we utilized Medical Subject Headings (MeSH) terms and field-specific filters in PubMed. Boolean operators were systematically applied to combine related terms. The complete search strategies for each database, including MeSH terms, are provided in Table 1.

Study Selection

The inclusion and exclusion criteria were explicitly aligned with the PICOS framework. Studies were included if they focused on Breast Cancer Related Lymphedema (Population), examined any form of exercise intervention (Intervention), had either a control group or a comparison group (Comparison), measured at least one lymphedema-related outcome (Outcome), and followed a randomized controlled, non-randomized controlled, or quasi-experimental design (Study Design). Studies that did not meet these criteria were excluded.

Inclusion criteria: Randomized or non-randomized controlled studies that directly discuss the results of exercise in Breast Cancer Related Lymphedema, and original studies published in the last 10 years with full text available in English written in the style of before and after exercise intervention. Only studies that included participants with Breast Cancer Related Lymphedema were considered for inclusion. Exclusion criteria were case reports, case series, systematic reviews, meta-analyses, and non-English studies for which full text was not available. Both randomized and non-randomized controlled studies were included. Studies without a control group were excluded to minimize heterogeneity in outcome assessment.

All stages of study selection were carried out using the Rayyan program as a tool for the organization and management of the studies obtained. Study selection was carried out in 2 stages according to the protocol outlined by Arksey and O'Malley: 1) Titles and abstracts were reviewed and screened for inclusion by 2 reviewers (CSP and HG). 2) Articles selected for full-text review were independently assessed by 2 experienced reviewers (EC and ZS). They met to discuss inconsistencies and reach consensus on articles for inclusion.

Data Extraction, Synthesis and Analysis

Two authors (HG and CSP) prepared the data table before the study. General descriptive information about the studies was provided, including authors, year and country of publication, study design, sample, exercise type, outcomes and findings. Any discrepancies were resolved through discussion or consultation with a third reviewer (EC).To handle heterogeneity across studies, a narrative synthesis approach was employed. Studies were grouped based on the type of exercise (aerobic, resistance, stretching), duration, and frequency (once vs. multiple sessions per week). The results were synthesized by identifying patterns and trends across studies, rather than performing a meta-analysis.

Results

Electronic databases were searched, and 974 studies were available. After eliminating 508 duplicate studies, 436 of the remaining 466 studies were eliminated by title and abstract review. The full

Table 1 Search Strategy For Each Data Base

Data Base	Search Strategy
Pubmed	("Breast Cancer Related Lymphedema" [MeSH] OR "Upper Extremity Lymphedema" [MeSH] OR "Arm Lymphedema" [MeSH] OR "Upper Limb Lymphedema" [MeSH] OR "Post Mastectomy Lymphedema" [MeSH] OR "Secondary Lymphedema After Breast Cancer" [MeSH] OR "Arm Lymphedema After Breast Cancer") AND ("Exercises"[MeSH] OR "Training"[MeSH]) Filters: from January 01, 2005 to May 01, 2025
PEDro	"Breast Cancer Related Lymphedema" AND "Exercise" Clinical trials only, English, 2005-2025
Cinahl	("Breast Cancer Related Lymphedema" OR "Upper Extremity Lymphedema" OR "Arm Lymphedema" OR "Upper Limb Lymphedema" OR "Post Mastectomy Lymphedema" OR "Secondary Lymphedema After Breast Cancer" OR "Arm Lymphedema After Breast Cancer") AND ("Exercises" OR "Training") Limiters Date of publication: January 01, 2004 to May 01, 2024
Web of Science	(("Breast Cancer Related Lymphedema" OR "Upper Extremity Lymphedema" OR "Arm Lymphedema" OR "Upper Limb Lymphedema" OR "Post Mastectomy Lymphedema" OR "Secondary Lymphedema After Breast Cancer" OR "Arm Lymphedema After Breast Cancer") AND ("Exercises" OR "Training")) (All Fields) Timespan: January 01, 2005 to May 01, 2024
Scopus	TITLE-ABS-KEY(("Breast Cancer Related Lymphedema" OR "Upper Extremity Lymphedema" OR "Arm Lymphedema" OR "Upper Limb Lymphedema" OR "Post Mastectomy Lymphedema" OR "Secondary Lymphedema After Breast Cancer" OR "Arm Lymphedema After Breast Cancer") AND ("Exercises" OR "Training")) AND PUBYEAR > 2004 AND PUBYEAR < 2025

texts of thirty- studies were reviewed and 9 of them were excluded because they did not meet the inclusion criteria. Finally, the remaining 21 studies were included in the review (Figure 1).

Outcome Measures and Findings

The studies included in this review mostly investigated the effect of exercise on edema volume, severity and swelling. Only 2 studies did not investigate the effect of exercise on these parameters.[14,15] All studies except 2 of the included studies showed that exercise was effective on edema volume, severity and swelling, while 1 study reported no effect on edema volume[16] and 1 study reported no effect on severity.[17]

Included 8 studies examined the effect of exercise on symptoms.[17-24] Five studies reported that exercise was effective on symptoms,[20-24] while 3 studies reported that exercise had no effect on symptoms.[17-19]

Included 7 studies examined the effect of exercise on range of motion.[15,16,21,23,25-27] The included studies reported that exercise was effective on ROM, while only Kizil et al.[16] reported that exercise had no effect on ROM.

Included 7 studies examined the effect of exercise on pain.[15,17,18,23,25,26,28] Five of the studies reported that exercise had an effect on pain,[15,23,25,26,28] while 2 studies reported that exercise had no effect on pain.[17,18]

Included 7 studies examined the effect of exercise on function.[16,21,23,26,28-30] All studies have reported that exercise has an effect on function.

Included 4 studies examined the effect of exercise on quality of life (QoL).[16,26,29,30] All studies have reported that exercise has an effect on QoL.

Included 4 studies examined the effect of exercise on physical characteristics (such as BMI, body composition).[20,21,29,31] All studies have reported that exercise has an effect on physical characteristics.

Included 3 studies examined the effect of exercise on hand grip strength.[26,27,30] Two studies reported an effect of exercise on grip strength[26,30] while 1 study reported no effect of exercise on grip strength.[27]

The included studies examined the effect of exercise on balance,[32] well-being,[21] bioimpedance,[33] endurance,[29] muscle thickness[14] and inflammatory markers.[18] Studies have reported that exercise has an effect on these parameters, while exercise has no effect on inflammatory markers.[18]

Exercise Type, Duration

10 of the studies examined the effects of resistance exercises,[14,15,17,18,23,26,29-31,34] 4 of aerobic exercises,[17,20,24,29] 4 of water exercises[21,25,27,33] and 2 of remedial exercises in patients with BCRL.[19,28]

Studies examining the effects of scapulothoracic stabilization exercises,[32] pilates,[27] continues passive motion,[16] X-Box based exercise[26] ve PULE-MRT exercise[22] on BCRL are also included.

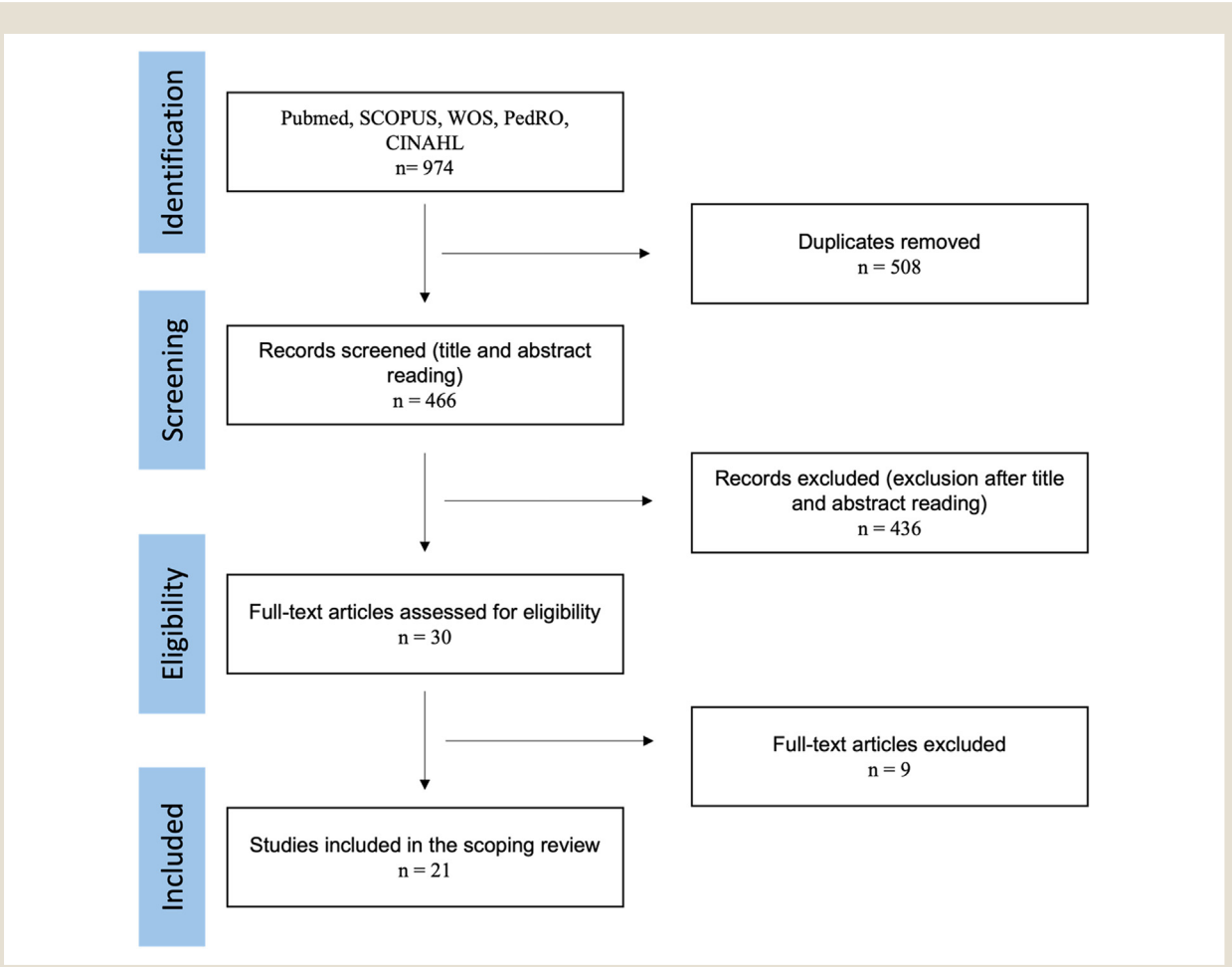
The included studies applied exercise methods for different durations. The most preferred duration among the included studies was 12 weeks.[17,20,22,27,29,32] Another preferred duration of exercise is 8 weeks.[14,23,25,26] Two studies preferred a 6-week exercise duration.[15,28] There were studies that applied exercise for 10 weeks, 13 weeks and 24 weeks.[21,24,31]

The most preferred exercise frequency was 3 days a week.[15,23,25,27,30,32] Three studies preferred an exercise frequency of 5 days a week.[17,20,28] One study used an exercise frequency of 2 days per week.[14] The 6 studies included in the study were performed with exercise and CDT together.[14,16,26,28,30,32]. The contents of the included articles are presented in Table 2.

Discussion

This scoping review study aimed to evaluate the effects of different exercise approaches applied to patients with breast cancer-related lymphedema on multidimensional health outcomes such as edema volume, severity, symptoms, range of motion, and quality of life. Our findings showed that exercise interventions applied to patients who developed lymphedema after breast cancer were most frequently evaluated in terms of edema volume, severity, symptom control, range of motion, pain, and exercise capacity. The studies included in this study show that exercise is not only limited to symptom control in the management of lymphedema, but also contributes positively to functional and psychosocial well-being.

Figure 1 Flowchart of studies included in the scoping review (Preferred reporting items for systematic reviews and meta analyses - extension for scoping reviews)



Lymphedema is a chronic, progressive condition that often occurs after cancer treatments. In the clinical picture, an increase in limb volume is the primary problem, while symptoms such as limitation of joint movement, numbness, tingling and a feeling of heaviness may accompany at different stages of the disease.[35] There is a belief among patients that exercise can lead to an increase in limb volume. However, scientific evidence suggests that exercise has a positive effect on the functioning of the lymphatic vessels and helps to reduce limb volume.[32] Although exercise is one of the components of CDT, these exercises refer to remedial exercises, which are exercises for upper limb function. There is no consensus on the effects of different exercises such as aerobic, resistance, aquatic and Pilates exercises in patients with BCRL.[36] In the included studies, it is noteworthy that most of the studies were on different exercise applications such as resistance exercises, aerobic exercises, aquatic exercises, scapulothoracic exercises. The most common effects of these exercises on edema volume, severity and swelling were investigated. In most of the studies, it has been shown that different exercise applications in patients with BCRL have a decreasing effect on limb volume and have positive effects on other parameters evaluated without increasing limb volume.

Although lymphedema is characterized by swelling of the extremities, it may also have negative effects on different parameters such as joint movement, quality of life, body composition, and hand grip strength. In the treatment process of BCRL, treatments such as surgery, radiotherapy and chemotherapy may cause fibtoticization of the affected area and development of tissue stiffness.[37] The literature studies in our study have shown that different exercise applications have an improving effect on parameters such as range of motion, pain, functional capacity, balance, muscle thickness in patients with BCRL. Regular and controlled exercise practices may have positive effects on range of motion and pain by increasing tissue flexibility, controlling edema and increasing pain threshold. This can increase the comfort level of patients and enable them to take an active role in life. Lymphedema not only causes physical discomfort, but can also negatively affect patients' lives psychologically and socially. With different exercise practices, impaired body perception can be regulated and patients' impaired self-confidence can be rebuilt. This

Table 2 Characteristics of the Included Studies

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Park et al.[30] Korea	Progressive resistance exercise (PREG) Fifty minutes, 3 times a week, for 6 wk. Complex decongestive physical therapy Self-home resistance exercise (SHREG) Fifty minutes, 3 times a week, for 6 wk. Complex decongestive physical therapy	Randomized Trial	Twenty patients with breast cancer-related lymphedema PREG ($n = 10$) SHREG ($n = 10$)	Edema volume arm circumference measurement Hand-grip strength Digital dynamometer Upper extremity function K-DASH Quality of life (QoL) European Organization for Research and Treatment of Cancer (EORTC) QLQ C30	Changes in edema volume between groups showed no significance, but both groups within the groups showed significant differences ($P < .05$). Changes in hand-grip strength showed significant between and within-group variations ($P < .05$). PREG showed a greater increase ($P < .05$). Changes in upper extremity function showed significant between and within-group variations ($P < .05$). PREG showed a greater increase ($P < .05$). QoL changes showed a significant difference between groups in the global health status/QoL and role function ($P < .05$). global health status/QoL, physical, role, cognitive, and dyspnea function within the group, the PREG showed significant differences ($P < .05$), while there was no significant difference in the SHREG ($P > .05$).
Sahbaz Pirincci et al.[32] Türkiye	Complex decongestive physiotherapy (CDP) Manuel lymphatic drainage, skin care, compression bandage, and remedial exercises Five days a week for 3 wk CDP+Scapulothoracic stabilization Exercises (SSE) SSE was applied in 3 phases as static (2 wk), dynamic (3 wk), and functional phase (3 wk) Three days a week for 8 wk in addition to the treatment applied in the CDP group.	Randomized Control Trial	Twenty-five patients were randomly divided into 2 groups as Complex decongestive physiotherapy (CDP) (n: 12) CDP+SSE (n: 13)	Lymphedema severity Circumferential measurements Scapular function Strength of the trapezius muscle Scapular isometric compression test Lateral scapular slide test Posture The New York Posture scale The thoracic kyphosis angle Balance The Mini-BESTest	The volume difference between the extremities decreased similarly in both groups after the treatment phase (TP) ($P = .903$) and the maintenance phase (MP) ($P = .457$) Improvements in the lower trapezius muscle strength were found in both groups after the TP ($P < .05$). In addition, the middle trapezius muscle strength and general posture improved more in the CDP+SSE group than in the CDP group after the TP ($P < .05$). In the MP, scapulothoracic muscle strength, scapular endurance, and general posture improved more in CDP +SSE group compared to the CDP group ($P < .05$).

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Odynets et al.[27] Ukraine	Water exercise group The scheme of water individualized physical intervention included a variety of breathing exercises and physical exercises. It was proposed to apply resistance exercises and exercises with a rubber expander to increase muscle strength. Pilates group The Pilates exercises consisted of roll-downs, hundreds, 1-leg stretch, Chester stretch, dumb waiter, swan dive, resistive and stretch exercises for the upper extremity. In addition, the program included resistance exercises with an elastic band to increase upper limb strength, as well as a set of breathing exercises to activate the lymph system. Water exercise group and the Pilates group was conducted during 12 wk, 3 times a week.	A randomized trial	Sixty-eight patients after BCRL were randomly enrolled for water individualized physical intervention (water exercise group, $n = 34$) and Pilates physical intervention (Pilates group, $n = 34$)	Upper limb force Dynamometry Upper limb lymphedema Circumference Active range of motion Goniometry	After 12-wk physical rehabilitation, the average values of active range of flexion and abduction were statistically Significantly higher in the water exercise group compared with the Pilates group by 8.73 degrees ($P < .01$) and 6.87 degrees ($P < .01$), respectively. The size of lymphedema in the area of forearm and hand was significantly lower in the water exercise group compared with the Pilates group by 0.46 cm ($P < .05$) and 0.44 cm ($P < .05$), respectively. There were no statistically significant differences in upper limb force between the studied groups at the end of the 12-wk intervention.
Khadra et al.[25] Egypt	Study Group Sixty minutes of aqua therapy exercise comprising of warm-up for 10 min, 40 min of strengthening exercises, and 10 min of cooling down, 3 times a week for 8 wk. Control group Sixty minutes of land-based exercise 3 times a week for 8 wk.	A Prospective Randomized Controlled Trial	Fifty eligible breast cancer survivors with lymphedema were assigned randomly to study group ($n = 25$) or control group ($n = 25$)	Limb volume Arm circumference Shoulder joint ROM Shoulder flexion, and abduction range of motion (ROM) Pain visual analog scale (VAS)	There was a statistically significant difference in limb volume, shoulder flexion and abduction ROM, and VAS scores in favor of the study group ($P < .001$) after 8 wk of intervention. The mean ± standard deviation for limb volume, shoulder flexion, abduction, and pain score were 2,108.71 ± 200.97 mL, 169.68° ± 4.54°, 150.44° ± 3.92°, and 3.16 ± 1.1 in the study group and 2,256.41 ± 186.94 mL, 147.36° ± 5.32°, 131.32° ± 4.38°, and 5.68 ± 0.94 in the control group, respectively.

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Linquist et al.[21] Sweden	Water exercise The water training was a standard program with the aim of increasing aerobic capacity, strength, and mobility. The 50 min program included the following components: warm-up exercises for 10 min, mobility and stretch exercises for 10 min, movements to increase the pulse for 10 min, strength training for 10 min, and slow-down mobility exercises for 10 min. Ten weeks once a week Land exercise The program included the same components as the water exercise. The only difference was that the leader adjusted the training to the women who could not jump, so that they could instead perform exercises near the floor Standart care group included 24 subjects receiving standard care, i.e., self-care as skin-care, mobility exercises for the arm or leg, placing the swollen limb above heart level, own massage of the arm and leg, compression sleeves/hosiery and occasional manual lymph drainage in health care.	Controlled clinical intervention	Sixty-nine female cancer survivors with secondary lymphedema Land Exercise ($n = 19$) Water exercise ($n = 30$) Standart care ($n = 20$)	Limb volume Water displacement or circumference with tape measurement Body mass index (BMI) Range of motion Joint movement with goniometry (Active hip and knee flexion in the lower extremity, and active elevation-abduction, and lateral rotation in the shoulder joint) Daily physical function Disability of arm, shoulder and hand questionnaires (DASH) Hip Osteoarthritis outcome score questionnaire (HOOS) Development of the study-specific lymphedema questionnaire Well-being and body-image	There was a higher proportion of women who participated in water exercises who reduced their secondary arm limb volume ($P = .029$), and there were also significant differences for BMI ($P = .047$) and self-reported frequency of swelling ($P = .031$) in the water exercise group after intervention. Women with arm lymphedema in the land exercise group improved DASH scores ($P = .047$) and outer rotation in the shoulder ($P = .001$). After intervention with land exercise subjects improved their external rotation in the shoulder ($P = .012$). Elevation in the shoulder was significantly decreased but this was not clinically significant. There were no other improvements in range of motion in or between the groups.
Zhang et al.[31] USA	Weight-lifting group received a 12-mo gym membership and participated in supervised exercise sessions twice a week for 90 min during the first 13 wk in groups of 2-6, followed by 39 wk of unsupervised training. The program included stretching, warm-up, core strengthening, and upper and lower body weight-lifting exercises, performed as 3 sets of 10 repetitions, with weight gradually increased if tolerated. The control group was instructed to maintain their usual physical activity level and was offered the same gym access and supervised training after the study ended.	Randomized Trial	Breast cancer survivors with lymphedema ($n = 141$) weight-lifting group ($n = 71$) control group ($n = 70$)	Arm volume Water displacement volumetry Fat Bone mineral density Bone mineral content	After 12 mo of weight-lifting, composition of the affected arm was improved: lean mass (71.2 g; $P = .01$) and BMD (14.0 mg/cm2; $P = .02$) increased, arm fat percentage decreased (−1.5%; $P = .003$). Composition of the unaffected arm was only improved in lean mass (65.2 g; $P = .04$).

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Kizil et al.[16] Türkiye	Complete decongestive therapy (CDT) Self-manual lymphatic drainage, multilayer short stretch compression bandage, instructions in self-care, therapeutic exercise (supervised, ROM, and strengthening program were given by researcher), and meticulous education on skin and nail care 15 sessions CDT+continuous passive motion (CPM) CDT+third-level speed plus flexion-directed exercise up to approximately 90% of the shoulder jointROM for 20 min in the first 5 sessions and for 30 min in the next ten sessions All treatments for 15 sessions, 60 min of CDT and 30 min of CPM per session on consecutive days	A randomized controlled trial	Fourteen patients were treated with CDT and CPM in the intervention group, and 16 patients were treated with CDT alone (control group) for 15 sessions	The shoulder range of motion (ROM) Goniometer Limb volume (volumetric differences) The water immersion method Function The disabilities of the arm shoulder and hand (DASH) QoL Functional assessment of cancer Therapy for breast cancer (FACT-B4)	Significant improvement was found in ROM, volumetric differences, DASH, and FACT-B4 scores in both groups. No significant differences were observed in the volumetric differences, ROM, and the DASH, and FACT-B4 scores between the groups, except for the FACT-B4 physical well-being subscores, which were better in intervention group.
Harvie et al.[20] UK	The standard care (control) group This group was encouraged to maintain optimal self-management and received written guidance on weight control, the Mediterranean diet, and 150 min of moderate-intensity physical activity per week. The supervised weight control and upper body/arm exercise group: Participants were guided to follow a Mediterranean diet with a 25% calorie reduction below their energy requirements. They participated in moderate-intensity cardiovascular exercise for 30 min, 5 days a week (at 50%-80% of maximum heart rate), along with a 12-week progressive upper body/arm exercise program. The home-based weight control and upper body/arm exercise group Participants followed a 12-week home-based weight control (diet and cardiovascular exercise) and upper body/arm exercise program. Initially, individualized diet and exercise recommendations were provided. The arm exercises were demonstrated by the physiotherapist and were to be performed at least 3 times per week. Home-based upper-body arm exercise program This group received the same instruction on the 12-week progressive arm exercise program as the other home-based group and had fortnightly follow-up phone calls.	Randomized Trial	Fifty-seven BCRL patient were randomized to a 12-week supervised ($n = 12$) or homebased combined weight loss and upper body/arm exercise programme ($n = 16$), a home-based upper-body arm exercise only programme ($n = 17$) or standard care ($n = 12$).	Edema volume Perometer L-Dex Self-reported symptoms Functional Assessment of Cancer Therapy-Breast + 4 (FACTB+ 4) Self-reported dietary intake of energy, total fat, saturated fat, protein, carbohydrate Wisp version Body Weight Body composition Tanita	Reductions in weight occurred in the supervised and home-based weight control and exercise programmes; Mean (95% CI) change compared to standard care − 1.68 (− 4.36 to − 1.00), − 2.47(− 4.99 to − 0.04) Kg. Reductions in perometer assessed RAVI were seen in the supervised and home-based combined weight control and arm exercise groups and the weight stable home-based arm exercise only group: mean (95% CI) change compared to standard care − 2.4 (− 5.0 to + 0.4),−1.8 (− 4.3 to + 0.7), − 2.5(−4.9 to −0.05)%.

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Cormie et al.[18] Australia	Low load; A series of assessments were conducted immediately prior to and 24 h after each of the experimental conditions Moderate load; The low-load trial involved sets of 15 to 20 RM (ie, load corresponding to the maximum weight that could be lifted 15-20 times). The moderate-load trial involved sets of 10 to 12 RM. High load The high load trial involved sets of 6 to 8 RM. Series of assessments were conducted immediately prior to and 24 h after each of the experimental conditions.	A randomized, cross-over design	Twenty-one women completed low-load (15-20 repetition maximum [RM]), moderate-load (10-12 RM), and high-load (6-8 RM) exercise sessions consisting of 3 sets of 6 upper-body resistance exercises	Inflammatory markers CK, CRP, IL-6, and TNF-α Lymphedema status associated symptoms Bioimpedance spectroscopy (BIS) L DEX Arm circumferences The severity of lymphedema symptoms was assessed using visual analogue scales (VAS) for pain, heaviness, and tightness.	There was no significant interaction effect between time and trial for CK, CRP, IL-6, and TNF-α. No significant increases were observed in BIS or interlimb circumference difference at any time point during the 3 exercise conditions. BIS scores and interlimb circumference differences generally tended to decrease at 24 h after exercise in all 3 conditions. Circumference difference decreased significantly 24 h after low-load resistance exercise ($P = .02$). There was no worsening of symptom severity of the affected arm at any time throughout the study. Tightness ratings of the affected arm decreased significantly 24 h after the high-load trial ($P = .015$).
Buragadda et al.[28] Saudi Arabia	Conventional treatment group manual lymphatic drainage, Low elastic compression garment Glenohumeral mobilization Deep breathing 5 times per week for 6 wk Complete decongestive therapy group Manual lymphatic drainage Low elastic compression garment Remedial exercise home program 5 times per week for 6 wk	Paralel group	Sixty patients with post mastectomy lymphedema Conventional treatment group ($n = 30$) Complete decongestive therapy group ($n = 30$)	Pain VAS Upper extremity function The Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire Arm circumference measurements	The within and between groups comparison revealed there were significant improvement in the circumferences. The circumference of the proximal part of the arm at post-test was significantly reduced compared to its value at pre-test. The Complete decongestive therapy group showed significant improvements in pain, DASH scores and arm volume ($P \leq .05$).
Omar et al.[23] Egypt	Rex group Women in both groups performed resistance and active stretching exercises targeting the shoulder muscles 3 times per week for 8 wk. Each session began with warm-up and cool-down periods, including 15 min of stretching, and each stretching exercise was maintained actively for 5 min. Compression garment (Rex-Com-group The participants in the Rex-Comp group were instructed to wear their compression garment during the supervised exercises sessions.	Single-blinded randomized controlled trial	Sixty women with unilateral BCRL were randomly assigned to low-intensity resistance exercises (Rex group, $n = 30$) or exercises and compression garment (Rex-Com-group, $n = 30$).	Lymphedema volume circumference measurements (percentage reduction of excess limb volume-) Self-reported lymphedema Symptoms Pain severity, feeling of tightness, and heaviness using a 10-cm horizontal line of the visual analogue scale (VAS) Shoulder mobility and function Shoulder range of motion (ROM) Disabilities of the arm, shoulder, and hand (DASH)	A significant reduction in percentage of ELV ($P < .01$), pain severity ($P < .05$), a sensation of heaviness ($P < .05$) and tightness ($P < .001$), and improvement in shoulder range of motion ($P < .05$) and function on DASH scores ($P < .05$) were observed at W8 and W12 in both groups. However, no between-group differences were observed over time.

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Park.[15] Korea	Complex exercise group The protocol consists of three 20-min sections: morning arm ergometer (2 wk at 20 RPM, 4 wk at 30 RPM), noon various arm-shoulder exercises and range of motion (2 wk at 1 kg, 4 wk at 1.5 kg), and afternoon treadmill (2 wk at 1 km/h, 4 wk at 2 km/h) exercises Conventional decongestive therapy group Pneumatic compression (30 min), manual lymph drainage, skin care and low stretch bandages (30 min a week for 4 wk)	A single-blind, randomized controlled trial	Sixty-nine women participated in this study and then they were randomly allocated to complex exercise group ($n = 35$) or the conventional decongestive therapy group ($n = 34$).	Shoulder range of motion Goniometer Pain Visual analog scale (VAS)	There was group X time interaction for shoulder flexion ($P = .003$;g2 = 0.137), shoulder extension ($P = .000$; g2 = 0.701),shoulder abduction ($P = .000$; g2 = 0.302), shoulder adduction ($P = .002$; g2 = 0.148), shoulder external rotation ($P = .000$; g2 = 0.283), and shoulder internal rotation ($P = .000$; g2 = 0.208), indicating significant difference between both groups in shoulder range of motion. There was a significant group 9-time interaction for VAS ($P = .000$; g2 = 0.220), indicating significant difference between both groups in shoulder range of motion.
Deacon et al.[33] Australia	Conventional aquatic exercise (CAE) 50 min conventional aquatic intervention Low speed aquatic exercise (LSAE) 50 min modified Ai Chi Participants received 2 intervention sessions (randomized order) with 1 week apart	A cross-over randomized controlled trial	Eighteen women with a history of breast cancer related lymphoedema were recruited. Participants received 2 intervention sessions (randomized order) with 1 week apart	Arm volumetry Volumetry tank Bioempedans L-Dex	Comparison between interventions showed larger decreased arm volume of 140 mL (95% CI, 17-263) immediately after intervention in favor of the Ai Chi intervention, however it was not sustained at 1 h follow-up. A post hoc analysis showed 72% of participants had a decrease in arm volume immediately after Ai Chi compared to 28% immediately after conventional aquatic therapy; with a number needed to treat of 3 (95% CI, 1.4-6.6). There were no differences between interventions for bio-impedance.

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Buchan et al.[29] Australia	Participants in both groups were instructed to undertake 150 min of supervised and unsupervised exercise (resistance- or aerobic-based) each week at a MET level of 3 to 3.5 (weeks 1-6), increasing to 5 in weeks 7-12. The resistance-based exercise group Full-body strength training program, including: chest fly, Triceps kick-back, squat, curl-ups, bent-over row, bridging, wall push-up, bicep curls, Calf raises, shoulder press, external rotation and forward lunge The Aerobic group Aerobic exercise was progressed throughout the 12-week intervention to maintain the same intensity and MET-level as undertaken by the resistance-based exercise group	Randomized Trial	Forty-one patients with breast cancer-related lymphedema Resistance ($n = 21$) or aerobic-based ($n = 20$) exercise group (12-week intervention)	Lymphedema status Bioimpedance spectroscopy (BIS) and circumference measurements, and via self-report (Norman lymphedema survey) Lower-body muscular endurance Squat test Upper body muscular strength a 4-6 repetition maximum (RM) bench press Two isometric tests using a shoulder and arm dynamometer A handgrip dynamometer Aerobic Fitness Six Minute Walk Test Body Composition Dual-energy X-ray absorptiometry Body Functioning The Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire QoL The Functional Assessment of Cancer Therapy-Breast+4 (FACT-$B + 4$)	There was no significant difference between groups in lymphedema status and symptoms. However, the aerobic exercise group showed a clinically meaningful reduction in the number of symptoms, and both groups showed a trend toward decreased symptom severity. Upper-body strength improved in both groups, with greater gains in the resistance group. Both groups showed clinically meaningful but not statistically significant improvements in lower-body endurance and aerobic capacity. Clinically meaningful improvements in quality of life (FACT-$B + 4$) were observed at 12 and 24 wk in the resistance and aerobic exercise groups.

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Singh et al.[17] Australia	Aerobic-based only or Resistance-based only A 12-week home-based exercise program involved aerobic or resistance exercises. The first 4 wk included supervised and unsupervised 50-min sessions, followed by 1 supervised and at least 100 min of unsupervised sessions. Intensity was adjusted using RPE. The aerobic group chose exercises based on MET values (light-moderate intensity for the first 6 wk, then brisk walking). The resistance group performed 12 different bodyweight exercises after a warm-up (6 exercises initially, then increased); repetitions and sets varied weekly, with intensity determined by RPE. Rest days were included between resistance sessions. Twelve -week home-based exercise program In weeks 1-4, women participated in two 50-min exercise sessions and one 50-min unsupervised exercise session. In weeks 5-12, participants completed 1 supervised (50 min) session and at least 100 min of unsupervised exercise	Randomized Trial	Forty-one patients were randomly divided into aerobic-based only ($n = 21$) or resistance-based only ($n = 20$) exercise	Lymphedema status L-Dex Circumference measurements Self-report of lymphedema symptoms and other characteristics Participants were asked to rate their current levels of pain, swelling, heaviness, tightness, aching, tenderness, stiffness, weakness, numbness, tingling and reduced arm or shoulder range of motion as mild, moderate or severe through a participant-administered survey.	No significant interaction effect between time and compression use for lymphedema was observed. There was no difference between groups over time in the number or severity of lymphedema symptoms. Irrespective of compression use, there were trends for reductions in the proportion of women reporting severe symptoms, but lymphedema status did not change.
Bok et al.[14] Korea	The PRE group Conventional therapy (manual lymphatic drainage, non-elastic bandage compression therapy, and skin care) together with PRE (1 weeks 5 times 2 set twice a day, 2 wk 10 times 2 set twice a day, 3 wk 15 times 2 set twice a day, 4 wk 20 times 2 set twice a week, 5-8 wk 20 times 2 set twice a week. (The exercise group performed a series of exercises using a 0.5-kg dumbbell. The prescribed exercises included (1) dumbbell fly, (2) triceps extension, (3) 1-arm bent-over row, (4) biceps curl, (5) dumbbell side raise, and (6) lifting the arms forward The exercise was performed, and the progress was recorded over a total of 8 wk The non-PRE group Conventional therapy (manual lymphatic drainage, non-elastic bandage compression therapy, and skin care	Randomized Trial	Thirty-two patients with diagnosed BCRL were randomly divided into 2 groups the PRE group and the non-PRE group	Muscle thickness In both affected and unaffected upper extremities, circumference, subcutaneous thickness, and muscle thickness were measured at 2 points (proximal part, distal part)	Upper limb circumference in the PRE group did not significantly change after 4 wk of exercises ($P > .05$); however, both distal and proximal circumferences showed a significant reduction after 8 wk ($P < .05$). These parameters did not significantly change in the non-PRE group ($P > .05$). The PRE group showed that the muscle thickness of distal part significantly increased at 4 wk and 8 wk, and the proximal part significantly increased at 8 wk ($P < .05$). The thickness of subcutaneous tissue in the affected upper limb showed a significant decrease after 8 wk in the PRE group ($P < .05$). No significant differences were found in this parameter in the non-PRE group ($P > .05$).

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Schmitz et al.[24] Pennsylvania	Home-based exercise intervention Walking goals per week were: 90 min for weeks 1 through 3, 120 min for week 4, 150 min for weeks 5 and 6, and 180 min there after Dumbbells weighing 0.45 to 9.45 kg Weight loss intervention Twenty-four weekly sessions led by a registered dietitian Combined exercise and weight Loss intervention group intervention group started with 6 wk of exercise instruction, at week 7, the weight loss intervention in addition to the exercise intervention	Randomized trial	Three hundred fifty-one women were randomized to the control Group ($n = 90$), exercise intervention group ($n = 87$), weight loss intervention group ($n = 87$), and combined exercise and weight loss intervention group ($n = 87$).	Percentage of interlimb volume perometry Clinical characteristis the Clinical Lymphedema Evaluation of the Upper Extremity (CLUE) Self-report survey score Norman lymphedema survey	In comparison with the control group, the percentage of change from baseline was 0.66% (95% CI, −0.88% to 2.20%) in the combined group, 0.53% (95% CI, −1.04% to 2.10%) in the weight loss group, and 0.04% (95% CI, −1.57% to 1.65%) in the exercise group. Mean (SD) total upper extremity score changes from the objective clinical evaluation were −1.40 (11.10) in the control group, −2.54 (13.20) in the exercise group, −3.54 (12.88) in the weight loss group, and −3.84 (10.09) in the combined group. Mean (SD) overall Norman Lymphedema survey score changes from the self-report survey were −0.39 (2.33) in the control group, −0.12 (2.14) in the exercise group, −0.57 (2.47) in the weight loss group, and −0.62 (2.38) in the combined group. Weight loss from baseline was −0.55% (95% CI, −2.22%to 1.11%) in the control group, −8.06% (95% CI, −9.82%to 6.29%) in the combined group, −7.37%(95% CI, −8.90% to −5.84%) in the weight loss group, and −0.44% (95% CI, −1.81% to 0.93%) in the exercise group.
Basha et al.[26] Saudi Arabia	Xbox Kinect group "Macarena" dance typically consisting of upper extremity activities were given as warm-up (5 min) to reduce joint stiffness. Other Xbox Kinect games (darts, bowling, boxing, table tennis, fruit ninja, and beach volleyball) were chosen as per the participant's performance level Resistance exercise group The participants performed stretching exercises then RE using dumbbells in the form of seated rows, pulling down of latissimus dorsi, 1 arm bent over row, biceps brachii curl, bench press, and extension of triceps. These exercises were conducted at 50% to 60% of their estimated 1 repetition-maximum, 2 sets of 10 to 12 repetitions for each one Both groups received complex decongestive physiotherapy (manual lymphatic drainage, compression bandages, skin care, and exercises) 5 sessions per week for 8 wk	Randomized trial	Xbox Kinect group ($n = 30$) RE group ($n = 30$)	Edema volume circumference measurements (ELV-Excessive limb volume) Pain visual analogue scale (VAS) Upper extremity function Disability of the Arm, Shoulder, and Hand (DASH) questionnaire, Shoulder range of motion (ROM), Shoulder muscles strength, Hand grip strength **QoL** Short-Form (SF-36)	Post intervention univariate ANOVAs demonstrate statistically significant change for ELV, $F(1,58) = 1.44$, p0.24, $= \eta 2 = 0.02$; for percentage of ELV, $F(1,58) = 0.12$, $P = .73$, $\eta 2 = 0.002$. Statistical significant differences were recorded in VAS (pain intensity), DASH, shoulder ROM ($P < .001$), bodily pain ($P = .002$), general health ($P < .001$), and vitality ($P = .006$) in favor of the Xbox Kinect group. There were statistically significant differences in shoulder flexion strength ($P = .002$), external rotation strength ($P = .004$), and abduction strength and handgrip strength ($P < .001$) in favor of the resistance exercise group.

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Gülören et al.[19] Türkiye	Remedial exercises with and without compression: Performed 3 sets within 24 h. Exercises included deep breathing, joint mobilization, distal pumping, PNF (D1-D2) patterns, and stretching. Exercises were administered with and without multilayer compression bandaging.	Randomized cross-over design	Thirty-four women with breast-cancer-related lymphedema	Severity of lymphedema: Circumferential measurements, Bioimpedance spectroscopy (L-Dex score) Lymphedema symptoms: Visual Analog Scale (VAS) (swelling, heaviness, tightness)	The change in the affected total arm volume and the difference between the affected and unaffected side volume (cm3) and relative arm volume (%) decreased significantly compared with the baseline and after the remedial exercise with compression bandage ($P < .001$). No significant changes were found from before exercise to 24 h post remedial exercise without compression in the symptoms of swelling, heaviness, and tightness according to the VAS mean scores ($P > .05$).
Godoy et al.[34] Brazil	While sitting in an upright position, the participants were submitted to a 1h session of active exercises. This session consisted of four 12-min stints with intervals of 3 min to rest.	Pre-post study	Thirty patients with arm Lymphedema resulting from the surgical, chemotherapeutic, and radiotherapeutic treatment of breast cancer	Change in lymphedema Water volumetry	The mean arm volume before starting the exercises was 2070.4 mL and after 1 h of exercising using the apparatus the mean arm volume was 2012.0 mL, thus giving a statistically significant loss of 58.43 mL (P-value $< .004$).

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Table 2 (*continued*)

Author and Country	Exercise Type	Study Design	Sample	Outcome Measures	Findings
Baydogan et al.[22] Türkiye	This study involved a 3 mo rehabilitation program Phase I: preoperative period Control group: 20 patients who met the inclusion criteria completed the introductory information form. Intervention group: Twenty patients who met the inclusion criteria completed the introductory information form and were provided with a lymphedema self-care and exercise handbook, along with information about the rehabilitation program. Phase II: postoperative period Control group: Patients received standard nursing care; arm circumference measurements and symptom warning model forms were used. Intervention group: Patients underwent the PULE-MRT program starting 24 h after surgery and continuing until discharge; arm circumference measurements and symptom warning model assessments were performed. Phase III: post-discharge period Control group: patients were instructed on how to measure their arm circumference and were asked to perform home measurements during the first 3 mo. Monthly phone follow-ups were conducted, and the lymphedema self-care scale was administered at the end of the third month. Intervention group: Patients were taught how to measure arm circumference and asked to continue home measurements for 3 mo. The 15-d PULE-MRT exercise program was repeated throughout the 3-mo period. Monthly phone follow-ups were conducted, and the lymphedema self-care scale was administered at the end of the third month.	Randomized Trial	Forty female patients who underwent breast cancer surgery, İntervention group ($n = 20$) control group ($n = 20$)	The symptom warning model for lymphedema tracking form the upper extremity circumference Measurement tracking form The self-care scale for breast Cancer- related lymphedema	In the study, no lymphedema developed in the intervention group, while 2 individuals in the control group developed lymphedema ($P > .05$). The average symptom count based on the lymphedema symptom warning model in the intervention group was statistically significantly lower than that of the control group in the second- and third-months post-surgery ($P < .05$). Furthermore, the intervention group's average score on the breast cancer-related lymphedema self-care scale was statistically significantly higher than the control group ($P < .05$). In the study, no significant difference was found between the affected arm measurement values of the intervention and control groups at 3 mo post-surgery compared to pre-surgery ($P > .05$).

may lead to significant improvements in different sub-dimensions of quality of life such as emotional well-being and psychological health.[2,38] In the literature included in our study, it has been determined that different exercise applications have positive effects on quality of life.

Symptoms of lymphedema such as increased limb volume, limitation in joint mobility, and fatigue may cause a decrease in the functional capacity of patients by preventing the active use of the upper extremity in daily life tasks. Exercise interventions have been shown to be effective on cardiovascular endurance in different patient groups.[39] In the included studies, the effects of different exercise practices on cardiovascular endurance were examined and it was found that this exercise improved cardiovascular endurance positively. This positive effect may have been achieved by increasing functional movement ability by increasing range of motion, increasing muscle strength, increasing skill and endurance by increasing hand-eye coordination and fine skills.

In the studies included in this study, it is noteworthy that some of them were applied together with CDT, while some of them were applied only exercise interventions independently. This has led to some uncertainty as to whether the effects of exercise occur independently or whether it provides a supportive contribution to CDT. In studies focusing only on exercise, it is noteworthy that exercise without compression also produces positive effects.[39] However, it can be said that treatments supported by CDT also provide a more reliable area for edema control.[40] In addition to edema control, improvements in different dimensions such as functionality, quality of life, grip strength and muscle thickness can be achieved with multimodal treatment approaches.

It is noteworthy that there are also differences in the duration of exercise interventions among the studies. Acute effects of exercise have been investigated with medium and short-term exercises as well as long-term exercise applications. It is seen that there is a heterogeneous distribution in terms of duration. These studies are generally aimed at evaluating the safety or acute effects of exercise, although short-term interventions are not expected to produce a significant change in edema reduction, functional capacity increase or quality of life. Therefore, it is of great importance to consider the duration of application carefully in studies evaluating the effects of exercise and to interpret the results in this context.

Conclusion

As a result, it was concluded that different exercise applications have positive effects on different parameters such as joint range of motion, pain, quality of life, balance, especially edema control, and can be applied together with CDT or independently in patients with breast cancer-related lymphedema. However, it is noteworthy that there is no standard for the duration, intensity and type of exercise. It is recommended that these uncertainties should be taken into consideration in future studies.

Data Availability

No datasets were generated or analyzed during the current study.

Disclosure

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Cansu Sahbaz Pirincci: Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Hasan Gercek:** Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Emine Cihan:** Investigation, Writing – original draft. **Elif Dilara Durmaz:** Methodology, Writing – original draft. **Zübeyir Sari:** Writing – original draft, Writing – review & editing.

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