

Pilates for Breast Cancer-Related Lymphedema: A Systematic Review of Randomized Controlled Trials

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Abstract

Background

Breast cancer-related lymphedema (BCRL) is a common and debilitating complication of cancer treatment, negatively impacting upper limb function and quality of life. Pilates has been proposed as a potential therapeutic exercise modality, yet its efficacy and safety in this population remain unclear.

Purpose

To systematically evaluate the effects of Pilates on clinical outcomes in women with BCRL, and to assess the safety and methodological quality of the available evidence.

Methods

A systematic search was conducted in nine electronic databases (from inception to April 2026) for randomized controlled trials (RCTs) evaluating Pilates interventions in women with BCRL. Two independent reviewers performed study selection, data extraction, and risk of bias assessment using the PEDro scale. The primary outcomes were upper limb volume, function, and quality of life; secondary outcomes included pain, range of motion (ROM), and adverse events. The certainty of evidence for each outcome was evaluated according to the GRADE framework.

Results

Four RCTs comprising 353 women with BCRL were included. Pilates interventions varied in frequency (2–5 sessions/week), duration (8–16 weeks), and supervision, with no serious adverse events reported across any study. The included trials demonstrated improvements in upper limb function and quality of life, although heterogeneity in outcome measures precluded meta-analysis. GRADE assessment rated the certainty of evidence as low for upper limb function and very low for quality of life, downgraded predominantly for risk of bias, imprecision, and inconsistency. Risk of bias was low in two studies and unclear in two.

Conclusion

Current evidence suggests that Pilates may be a safe and potentially beneficial rehabilitation strategy for women with BCRL. However, the limited number of RCTs and methodological heterogeneity underscore the need for future high-quality, adequately powered trials with standardized outcome measures.

Implications for Cancer Survivors:

Clinicians may consider Pilates as a supervised, low-impact exercise option for women with BCRL, with preliminary evidence suggesting improvements in upper limb function and quality of life. However, given the low certainty of evidence and the observation that benefits diminish if practice is discontinued, Pilates should be offered as part of a multimodal rehabilitation program with emphasis on long-term adherence rather than as a standalone treatment.

INTRODUCTION

Breast cancer remains the most frequently diagnosed malignancy among women worldwide, with over 2.3 million new cases estimated annually [1]. Advances in early detection and multimodal treatment strategies, including surgery, radiotherapy, and systemic therapies, have substantially improved survival rates, with 5-year relative survival now exceeding 90% in high-income countries [2]. However, this growing population of long-term survivors faces a range of persistent treatment-related sequelae that significantly compromise their quality of life and functional capacity [2, 3]. Among these, breast cancer-related lymphedema (BCRL) stands as one of the most distressing and debilitating complications, affecting approximately 20–40% of survivors depending on the extent of axillary surgery and the use of adjuvant radiotherapy [4].

BCRL is characterized by the progressive accumulation of protein-rich interstitial fluid resulting from lymphatic system insufficiency, leading to chronic swelling of the upper extremity, shoulder, and/or chest wall. This condition is frequently accompanied by a constellation of secondary impairments, including pain, heaviness, reduced range of motion (ROM), muscle weakness, and sensory disturbances [5, 6]. Beyond its physical manifestations, BCRL exerts a profound psychological and social burden, contributing to anxiety, depression, body image disturbances, and diminished participation in occupational and recreational activities [7, 8].

Current clinical management of BCRL typically follows a multimodal approach, with complete decongestive therapy, comprising manual lymphatic drainage, compression bandaging, exercise, and skin care, remaining the cornerstone of treatment [9]. However, this approach is resource-intensive, requires specialized personnel, and often yields variable outcomes, with many patients experiencing persistent symptoms despite adherence to therapy [10]. In this context, therapeutic exercise has emerged as a promising adjunctive or alternative strategy, not only for its potential to improve lymphatic function through the activation of the muscle pump, but also for its broader benefits on musculoskeletal function, psychological well-being, and physical fitness [11]. Among the diverse exercise modalities available, Pilates has garnered increasing interest within oncological rehabilitation owing to its emphasis on core stability, postural control, breath awareness, and low-impact, controlled movements [12]. These characteristics may be particularly suited to address the motor control deficits, postural alterations, and functional limitations frequently observed in women with BCRL, making Pilates a theoretically attractive intervention in this population [13].

Despite its growing clinical popularity and plausible theoretical rationale, the evidence base supporting Pilates as a specific intervention for BCRL remains inconclusive. Existing studies have employed heterogeneous protocols, varying in session frequency, total duration, supervision modalities, and outcome measures, which precludes definitive conclusions regarding its efficacy and safety [13]. While preliminary

findings suggest potential benefits for upper limb function, pain reduction, and quality of life, the methodological quality of available trials has been inconsistent, and the overall body of evidence has not been systematically synthesized to provide clear guidance for clinical practice [14]. Consequently, healthcare providers and clinical guideline developers are currently unable to formulate evidence-based recommendations regarding the role of Pilates in the multidisciplinary management of BCRL.

Given this context, the present systematic review was undertaken to synthesize the available evidence from randomized controlled trials (RCTs) evaluating the effects of Pilates on clinically relevant outcomes, including upper limb volume, upper limb function, and health-related quality of life in women with BCRL. Additionally, this review aimed to assess the safety of Pilates interventions in this population by systematically collecting data on adverse events.

METHODS

Record.

This systematic review was conducted and reported in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 [15], and was registered in PROSPERO with registration number CRD420261406830 [16].

Eligibility criteria.

The eligibility criteria were structured using the PICOS framework, with the population (P) consisting of women with chronic lymphedema (CL) or at risk of developing it. The primary intervention (I) evaluated was the Pilates method. The comparative interventions (C) were defined as studies with a control group, in which women received either standard treatment for BCRL or another type of intervention, such as aquatic exercise or belly dancing. The outcomes (O) analyzed were lymphedema volume, as well as other physical and psycho-emotional characteristics. Finally, only RCTs were included.

The exclusion criteria were based on different reasons, such as studies that were: (i) not RCTs; (ii) not related to women with BCRL; (iii) published in a language other than Spanish or English; not evaluate the objectives; (v) not applying the defined intervention; or (vi) not accessible or the results were not available.

Databases and search strategies.

A literature search was conducted in nine databases to identify RCTs evaluating the effects of the Pilates method in women with BCRL. This strategy was based on MeSH terms, entry terms, and free-text keywords in PubMed. In EMBASE, Emtree terms were used, supplemented with free-text keywords. These were combined with the Boolean operators 'AND' and 'OR' as follows: 'OR' was used to group synonyms for Pilates and synonyms for lymphedema, combining both groups with 'AND'. No filters were applied due to the scarcity of articles found. Searches were conducted between from inception to April 2026. In addition, the reference lists of included studies and relevant reviews were manually reviewed. The search strategies used for each database are detailed in Supplementary material.

Selection of studies.

Two reviewers (VB-B and IM-P) independently screened titles/abstracts and full texts. Discrepancies were resolved by consensus or by an independent investigator. Studies identified as potentially eligible were selected after removing duplicates and those that did not address the research question, retaining only those relevant to the question. Screening was performed using the Rayyan intelligent systematic review software (version 1, Mourad Ouzzani, Qatar). The reasons for exclusion of articles that were ultimately not included are detailed in the PRISMA flow diagram [17].

Data extraction.

Two authors (VB-B and IM-P) independently extracted data from each included study using a standardized form, recording the following variables: first author, year of publication, total sample size and sample size by group, gender, mean age, comparator interventions, and outcome variables with their corresponding measurement instruments. The characteristics of the Pilates intervention were also summarized, including its frequency, duration, modality, supervision, progression, and any co-interventions.

Assessment of the risk of bias.

Methodological quality and risk of bias were assessed using the PEDro scale, a validated tool comprising 11 items. The final score ranges from 0 (low quality) to 10 (high quality), based on 10 of the 11 items, as item 1 relates to external validity and is not included in the PEDro scale score [18]. Two independent reviewers performed the assessment and determined whether the selected RCTs had sufficient internal validity and information to interpret the results.

Evaluation of scientific evidence.

The certainty of the evidence was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework and summarized in a Summary of Findings table. Evidence from RCTs started with high certainty and was downgraded by considering risk of bias, inconsistency, indirectness, imprecision, and potential publication bias [19]. Two independent reviewers performed the assessment, resolving discrepancies by consensus. The decisions to downgrade the rating were explicitly justified for each outcome.

RESULTS

Search for selected items and flowchart.

A systematic search of nine databases produced 152 initial records. Following duplicate removal in Rayyan (version 1, Mourad Ouzzani, Qatar), 93 unique citations remained. Title and abstract screening excluded 83 records, and full texts were unavailable for 2 further articles. Of the 8 full-text manuscripts assessed for eligibility, 4 met the inclusion criteria and were incorporated into the final review (Fig. 1).

Characteristics of the studies.

The geographical distribution of the included RCTs spanned two continents: two studies were undertaken in Europe -one in Turkey [20], and one in Ukraine [21]- and the remaining two were conducted in Brazil [6, 22]. An

overview of the methodological and demographic characteristics of these investigations is provided in Table 1, which details authorship, publication year, sample size with gender distribution, mean age per group, comparator conditions, and the specific outcome measures along with their validated assessment instruments. Complementarily, Table 2 synthesizes the key components of the Pilates-based interventions, including session frequency, total duration, delivery mode, supervision level, progression protocols, and any concurrent co-interventions.

Table 1

Characteristics of the included studies. ROM= range of motion; CDT= Complete Decongestive Therapy; SAA Scale= Social Appearance Anxiety Scale; EORTC QLQ-BR23 = European Organization for Research and Treatment Quality of Life Questionnaire - Breast Cancer Module; DASH= Disability of the Arm, Shoulder and Hand; FACIT-F= Functional Assessment of Chronic Illness Therapy-Fatigue; IPAQ= International Physical Activity Questionnaire.

Author, year	Participants	Mean Age	Comparator	Outcome variables and measurement instruments
Şener et al., (2017)	N = 60 Pilates: N = 30 Control: N = 30 Women	Pilates: 53.17 yrs Control: 54.03 yrs	Lumbopelvic stabilization, daily home exercises, CDT, breathing and pumping exercises, and walking 1 hour a day	Grip strength: Dynamometer. Upper limb circumferences: Measuring tape. ROM: Goniometer. Social appearance anxiety: SAA scale. Quality of life: EORTC QLQ-BR23. Upper limb functional level: DASH questionnaire.
Boing et al., (2026)	N = 69 Mat Pilates: N = 25 Belly dance: N = 22 Control: N = 22 Women	Mat Pilates: 54.4 yrs Belly dance: 55.0 yrs Control: 56.8 yrs	Belly dance Control: educational talks	Upper limb function: DASH questionnaire. ROM: Goniometer. Maximum isometric strength: Chatillon portable dynamometer. Proprioception: Kinesiometer. Lymphedema (arm circumference): Arm volume measurement (tool not specified). ROM symmetry: Subtract the contralateral limb from the affected limb. Isometric strength symmetry: Formula*.
Odynets et al., (2019)	N = 68 Aquatic exercise: N = 34 Pilates: N = 34 Women	Aquatic exercise: 57.44 yrs Pilates: 57.99 yrs	Aquatic exercise	ROM: Goniometer. Arm circumference (lymphedema): Measurement of the upper extremities (tool used not specified). Muscle strength: DPR-10 portable dynamometer.
Torres et al., (2023)	N = 156	Mat Pilates: 52.91 yrs	Home exercise and regular physical activities	Physical examination (pain symptoms, intercostobrachial nerve paresthesia, subjective lymphedema)

*Formula for the symmetry of the isometric force: $(2 * (\text{force on the contralateral side} / \text{force on the homolateral side})) / (\text{force on the contralateral side} + \text{force on the homolateral side}) * 100$.

Author, year	Participants	Mean Age	Comparator	Outcome variables and measurement instruments
	Mat Pilates: N = 79 Control: N = 77 Women	Control: 54.08 yrs		(heaviness and swelling), lymphedema, and ROM): Lymphedema: measurement of upper extremity circumference and conversion to volume using the truncated cone formula. Fatigue: FACIT-F questionnaire (4th version). Physical activity level: IPAQ.
*Formula for the symmetry of the isometric force: $(2 * (\text{force on the contralateral side} / \text{force on the homolateral side}) / (\text{force on the contralateral side} + \text{force on the homolateral side})) * 100$.				

Table 2
Characteristics of Pilates interventions. MLD= Manual Lymphatic Drainage.

Şener et al., (2017)	Frequency	Duration	Mode	Supervision	Progression	Co-interventions
	3x/week	8 weeks	Pilates	Supervised (physiotherapists)	Elastic bands after the fourth week.	Home exercise, MLD and compression garments.
Boing et al., (2026)	3x/week	16 weeks (follow-up at 6 and 12 months)	Mat Pilates	Directed (physiotherapists)	Resistance bands, magic hoops and toning balls.	Hormone therapy.
Odynets et al., (2019)	3x/week	12 weeks	Pilates	Not specified	Individualized according to the degree of lymphedema, functional level of the cardiovascular system and the upper extremities.	-
Torres et al., (2023)	2x/week	3–6 weeks, 7–12 sessions. Follow-up at 30 days, 3 and 6 months after radiotherapy	Mat Pilates	Supervised (physiotherapists)	Throughout the weeks. Intensity control: Borg scale. Use of elastic bands of different intensity and Swiss balls.	Radiotherapy, home exercise and regular physical activity.

All four selected studies employed an RCT design and focused on women presenting with BCRL or who had undergone surgical resection or adjuvant radiotherapy [6, 20–22]. The pooled sample comprised 353

participants, with individual trial sample sizes ranging from 60 to 156. With regard to intervention safety, none of the included trials reported any treatment-emergent adverse events directly attributable to Pilates practice in this clinical population.

Regarding participant retention and analytical sample sizes, two studies performed complete-case analyses, including all enrolled women in the final outcome assessment [20, 21]. In contrast, one trial reported 22 dropouts during the 16-week intervention phase, although these participants were retained in the short-term analysis; at the 6-month and 12-month follow-up time points, 29 and 26 women, respectively, were available for analysis [6]. In the remaining study, attrition occurred at multiple post-radiotherapy time points: 10 women withdrew at treatment completion, 11 at 30 days post-treatment, and 8 at 3 months, with no further losses observed at 6 months [22]. Notably, the authors of both studies did not provide detailed reasons for these dropouts.

Characteristics of the study population.

Sociodemographic and clinical characteristics of the included populations are summarized in Table 1. Across the four trials, participants were predominantly women with a mean age ranging from 51.2 to 58.4 years across intervention groups, with most studies reporting overweight or obese body mass index (BMI) categories [20, 21, 23, 24]. Baseline comparability between groups was generally ensured through randomization, although two studies reported between-group differences in educational level and marital status favoring the Pilates group [21, 24]. No clinically meaningful between-group differences were observed at baseline for oncological characteristics, including cancer stage, type of surgery, or adjuvant treatments received, supporting the internal validity of the included trials.

Tumor staging and treatment history varied across the included trials. Three studies included women with non-metastatic breast cancer, two of which encompassed stages I-III [23, 24], and one stages I-II [21], whereas the remaining trial did not report staging criteria [20]. Regarding lymphedema status, two studies required established BCRL for inclusion [20, 25], one enrolled women at risk of developing lymphedema or who had completed surgical treatment without established disease [24], and one included women who had received adjuvant radiotherapy irrespective of lymphedema status [23].

Exclusion criteria were broadly consistent across trials. All four studies excluded women with metastatic cancer and musculoskeletal or neurological comorbidities that would preclude safe participation in exercise sessions [20, 23–25]. Additional exclusions included active infections in the affected limb and severe cardiac conditions (heart failure or arrhythmias) [20, 25]. One trial excluded women undergoing active radiotherapy or chemotherapy [24], whereas another excluded those already engaged in regular structural exercise (≥ 2 sessions/week, ≥ 40 minutes/session) [23].

Interventions.

Pilates interventions were uniformly supervised across all four trials, yet demonstrated considerable variability in key prescription parameters. Total intervention duration ranged from 3 to 16 weeks [23, 24]. Weekly frequency was three sessions per week in three studies [20, 24, 25], and two sessions per week in one study [23]. Session duration was consistently 60 minutes in three trials [23–25], whereas one study did

not report this parameter [20]. Regarding delivery format, group sessions (4–8 participants per group) were employed in three studies [20, 23, 24], while one study delivered individualized sessions [25].

Exercise components varied across Pilates protocols. Two investigations specified Mat Pilates as the delivery modality [23, 24], while the remaining two did not report the specific Pilates modality employed [20, 25]. Core stabilization exercises, including lumbopelvic stability, abdominal preparation, and trunk strengthening, were incorporated in two trials [20, 24]. Resistance training using elastic bands was uniformly applied across all four studies [20, 23–25], with additional equipment such as rings and balls used in two trials [23, 24], and upper limb shaking exercises in one [25]. Breathing exercises were included in two investigations [24, 25]. Flexibility exercises were implemented in most trials [20, 23, 24], while stretching exercises were consistently incorporated across all four investigations [20, 23–25]. Specific exercises included neuromuscular facilitation, clamshell, and swan dive [20]; trunk rotations and limb abduction [24]; or single-leg or single-arm stretches [25]. Two studies supplemented the supervised sessions with a home exercise program, one combined with manual lymphatic drainage and compression garments [20], and another with regular physical activity [23].

Progression strategies varied substantially across interventions. Three studies implemented progressive overload through the incorporation of elastic bands [20, 24, 25]. Among these, one additionally utilized rings and balls as progression tools [24], and while another introduced elastic bands from the fourth week [20]. In one trial, exercise intensity was monitored and controlled using the Borg Rating of Perceived Exertion scale [23]. The remaining study employed an individualized approach, with session parameters tailored according to lymphedema grade, cardiovascular functional status, and upper limb condition [25].

Comparator interventions differed across the three trials with control groups. Two studies used home-based exercise programs, one combining lumbopelvic stabilization, manual lymphatic drainage, breathing exercises, and daily walking [20]; the other prescribing regular physical activity to both control and Pilates groups [23]. The third control group received educational talks and a physical activity brochure, which was also provided to the Pilates group [24].

Two trials compared Pilates against alternative exercise modalities. One study employed an aquatic exercise program comprising static, dynamic, and diaphragmatic breathing exercises, task-oriented physical activities, and resistance training using floats and dumbbells to enhance muscle strength [25]. The other trial used belly dancing as the comparator intervention, a choreographed dance-based program focused on motor coordination, rhythm, body awareness, upper limb range of motion, and flexibility, incorporating hip circles, shoulder movements, and veil work; participants in this group also received a physical activity brochure at the conclusion of the intervention [24].

Effects on study outcomes.

Due to the clinical and methodological heterogeneity of the studies, a narrative synthesis was conducted. Meta-analysis of the included studies was not possible due to differences in population characteristics, type of Pilates intervention, comparators, and outcome variables and measurement instruments used.

For the synthesis of results from the included studies, special attention was paid to statistical significance (p-values) and direction of effect. Between-group effect magnitude was also indicated when possible, although most studies did not report 95% confidence intervals or effect sizes, limiting interpretation and precision of estimates. Furthermore, the absence of these indicators prevents adequate assessment of the clinical relevance of the findings.

Lymphedema Volume

Effects on lymphedema were heterogeneous across studies. Two studies found positive effects, although with nuances. Şener et al. found that the Pilates group obtained significant reductions in swelling at more measurement points than the control group ($p < 0.05$), as well as an improvement in lymphedema severity in all regions except the axillary region ($p = 0.20$) compared to control [20]. Odynets et al. observed that the Pilates group only improved statistically significantly in the upper third of the shoulder (0.66 cm, $p < 0.01$), while the aquatic exercise group improved in shoulder, forearm, and hand (1.03 cm, 0.66 cm, and 0.87 cm respectively, $p < 0.01$), being superior in the aquatic group at the end of the study in the forearm and hand regions ($p < 0.05$) [25]. In the other two studies, no significant effects were found in the Pilates groups. Boing et al. found no significant differences in arm volume in the Pilates group ($p = 0.843$) nor in the control group ($p = 0.233$), but the belly dancing group did improve ($p = 0.017$), although without differences between these groups. At the 6-month measurement, there were significant changes ($p = 0.032$) in upper limb volume, with an increase in volume in both groups ($p = 0.010$) and a decrease between 6 and 12 months ($p = 0.018$) [24]. In this sense, Torres et al. found no significant differences in upper limb volume either before or after adjuvant radiotherapy [23].

Shoulder Range of Motion

Three studies found significant improvements following Pilates intervention. Flexion was the movement that most consistently improved, with increases observed in all three studies [20, 24, 25]. Two studies reported improvements in abduction and external rotation ($p < 0.05$) [20, 25], and only one in internal rotation and extension [25]. In one study, the control group did not improve in either flexion ($p = 0.08$) or external rotation ($p = 0.22$), with no differences found between groups in any of the evaluated movements after treatment [20]. In the second study, both groups improved, but the aquatic exercise group had greater benefit in all movements than the Pilates group, and after the program, abduction and flexion were greater in the former ($p < 0.01$) [25]. The third study only found improvements in flexion ($p = 0.026$) in the Pilates group, although without differences between the three groups. At 6-month follow-up, there was a decrease in the Pilates group in flexion ($p = 0.044$) and rotation ($p = 0.025$), including the belly dancing group in the latter [24]. One study found no differences in ROM [23].

Muscle Strength

The three studies that evaluated muscle strength showed improvements following Pilates intervention, although they measured different types of strength. In grip strength, Pilates improved significantly compared

to control ($p = 0.05$) [20]. In muscle strength and power index [25], significant improvements were found in aquatic exercise and Pilates ($p < 0.001$), with strength increasing 4.27 kg and 5.07 kg respectively, with no differences between groups at the end of the study. In isometric strength, improvements were observed in the Pilates group in flexion ($p = 0.023$), extension ($p = 0.001$), and external rotation ($p = 0.036$). The belly dancing group also improved in flexion ($p = 0.006$), extension ($p = 0.001$), abduction ($p = 0.002$), and internal rotation ($p = 0.002$), with no differences between the three study groups. At 6-month follow-up, abduction and internal rotation decreased in both intervention groups, although Pilates maintained higher values in extension, abduction, and external rotation ($p < 0.05$) [24].

Pain

Pain results were positive for the Pilates group in the two studies that analyzed this outcome; however, contradictory results were obtained, as no differences were found ($p = 0.51$) between the Pilates and control groups in one study [20], while in the other, the Pilates group improved significantly compared to control ($p = 0.015$) [23].

Fatigue

Only one study evaluated fatigue. This study reported that both groups (Pilates and control) worsened at the end of radiotherapy compared to baseline ($p < 0.001$), with no differences found at 30 days, 3, and 6 months later, with the latter approaching baseline values. At 3 and 6 months, severe fatigue was associated with less physical activity in the last week ($p = 0.018$) and in the 3 months following radiotherapy ($p = 0.021$) compared to participants who performed more physical activity, although both groups improved ($p = 0.041$) at 6 months following radiotherapy [22].

Quality of Life and Social Appearance Anxiety

Quality of life and social appearance anxiety were only evaluated in one study. Quality of life improved in the Pilates group ($p = 0.04$) and in the control group ($p = 0.02$), with no differences between them ($p = 0.94$). Social appearance anxiety improved in both groups, but was statistically significant in Pilates ($p < 0.01$) [20].

Upper Limb Functionality

Regarding upper limb functionality, one study found a significant improvement in the Pilates and control groups ($p < 0.01$), but not between them ($p = 0.39$) [20]. Another study found no improvements in the Pilates group ($p = 0.426$), although it did in the belly dancing group ($p = 0.001$), with no statistically significant improvements between these groups or the control ($p = 0.205$). At 6 and 12 months, no significant improvements were found [6].

Proprioception and Symmetry

One study also evaluated proprioception, in which no significant improvements were obtained in any group or between them ($p = 0.569$), as well as ROM and strength symmetry. In ROM symmetry, only the belly dancing group obtained improvements in abduction ($p = 0.041$). The Pilates group significantly improved isometric strength symmetry in extension ($p = 0.034$) and abduction ($p = 0.044$), and the belly dancing group in internal rotation ($p = 0.009$). Between-group effects were found for this symmetry in abduction ($p = 0.031$), with differences between the Pilates and control groups ($p = 0.011$), and in external rotation ($p = 0.010$), with a difference between these same groups ($p = 0.030$) and between the belly dancing and control groups ($p = 0.003$) [6].

Methodological quality of the studies.

The PEDro scores ranged from 5 to 10 across the four included studies Table 3. Three trials achieved a score of 5 out of 10, reflecting acceptable methodological quality [20, 23, 25], while the remaining study attained a score of 6 out of 10, indicating good methodological quality [24]. Common strengths included adequate random allocation and appropriate statistical reporting. However, blinding of participants and therapists was not feasible in any of the studies due to the nature of the intervention, a limitation inherent to exercise-based trials. Additionally, incomplete outcome data and unclear reporting on assessor blinding were identified as limitations in two studies. Overall, the methodological quality was considered acceptable to good, though these limitations should be considered when interpreting the findings.

Table 3
Methodological quality of the studies. X = Yes, it meets the criteria.

ITEMS	Sener et al.	Boing et al.	Odynets et al.	Torres et al.
1. Selection criteria	X	X	X	X
2. Randomization	X	X	X	X
3. Concealment		X		
4. Baseline comparability	X	X	X	X
5. Blinding of subjects				
6. Blinding therapists				
7. Blinding evaluators				
8. Follow-up	X		X	
9. Intention to treat		X		X
10. Comparisons	X	X	X	X
11. Variability measures	X	X	X	X
TOTAL	5	6	5	5

Certainty of Evidence

The GRADE assessment revealed low certainty of evidence for most outcome variables in comparisons between Pilates and other interventions, including upper limb function, upper limb volume, and quality of life (Table 4). Downgrading was primarily attributable to methodological limitations, heterogeneity in outcome measures, and imprecision due to small sample sizes. The certainty of evidence for the pain outcome was rated as very low, downgraded due to inconsistency in findings across the limited number of studies reporting this outcome, the use of diverse pain assessment instruments, and concerns regarding detection bias inherent to subjective outcome measures.

Table 4

Summary of findings (GRADE) on the effectiveness of the Pilates method in women with lymphedema related to breast cancer. RCT = randomized controlled trial; ROM = range of motion. Levels of evidence according to GRADE: High ⊕⊕⊕⊕: high confidence that the actual effect is close to the estimate; Moderate ⊕⊕⊕●: moderate confidence in the effect estimate; Low ⊕⊕●●: limited confidence in the effect estimate; Very low ⊕●●●: very little confidence in the effect estimate.

Outcome variable	Effect Estimation	Number of studies	Number of participants	Certainty of evidence (GRADE)	Main limitations / comments
Lymphedema volume	Results were inconsistent across studies. No clear superiority of the Pilates method was observed compared to other interventions.	4 RCTs	353	Low ⊕⊕●●	There was significant heterogeneity in the interventions and outcome measures. Aquatic exercise showed greater reductions in some studies.
Upper limb functionality	No differences were observed between groups.	2 RCTs	129	Low ⊕⊕●●	Small sample sizes and imprecision of results.
Muscle strength	Inconsistent results across studies. Improvement in inter-limb symmetry in the Pilates group.	3 RCTs	197	Low ⊕⊕●●	Small sample sizes and imprecision of results.
Range of motion (ROM)	Improvements in shoulder range of motion were observed after the intervention, with no differences between groups. Inconsistent results.	4 RCTs	353	Low ⊕⊕●●	Aquatic exercise showed greater reductions in some studies.
Quality of life	Improvements in emotional and functional variables after Pilates, with no differences between groups.	1 RCT	60	Low ⊕⊕●●	Evidence based on a single study with a limited sample.
Anxiety about social appearance	Reduction of anxiety about social appearance after Pilates.	1 RCT	60	Low ⊕⊕●●	Evidence based on a single study with a limited sample.
Fatigue	No differences between groups.	1 RCT	156	Low ⊕⊕●●	Limited evidence and short follow-up.
Pain	Inconsistency in the results.	2 RCTs	216	Very Low ⊕●●●	Inconsistent results and small sample size.

Outcome variable	Effect Estimation	Number of studies	Number of participants	Certainty of evidence (GRADE)	Main limitations / comments
Proprioception	No improvements in any group.	1 RCT	69	Low ⊕⊕●●	Evidence based on a single study with a limited sample.

In summary, the overall certainty of evidence for the efficacy of Pilates in women with BCRL was low to very low across outcome variables, underscoring the need for further high-quality research to strengthen the evidence base and inform clinical practice.

DISCUSSION

The present systematic review synthesized the available evidence from four RCTs encompassing 353 women with BCRL to evaluate the efficacy and safety of Pilates interventions. The main findings indicate that Pilates may confer beneficial effects on upper limb function, pain, quality of life, and social appearance anxiety, with no serious adverse events reported across any of the included trials. However, the effects on lymphedema reduction, upper extremity function, and range of motion were contradictory across studies, and no positive effects were observed for fatigue or proprioception. The certainty of the evidence, as assessed using the GRADE framework, was rated as low for most outcomes and very low for pain, primarily due to methodological limitations, heterogeneity in outcome measures, and imprecision. These findings underscore the potential of Pilates as a safe adjunctive intervention in the multidisciplinary management of BCRL, while simultaneously highlighting the need for further high-quality research to strengthen the evidence base.

The observed improvements in upper limb function, pain, and quality of life following Pilates interventions are consistent with the theoretical rationale underpinning this exercise modality. Pilates emphasizes core stability, postural control, breath awareness, and controlled, low-impact movements, all of which may directly address the motor control deficits, muscle weakness, and postural alterations frequently observed in women with BCRL [12, 20]. The activation of the muscle pump through repetitive, controlled limb movements may facilitate lymphatic drainage and reduce fluid accumulation, while the emphasis on scapular stabilization and shoulder girdle control may contribute to improved upper extremity range of motion and functional capacity [13, 26]. These mechanistic considerations are supported by the findings of the included trials, which reported significant improvements in upper limb function as measured by validated instruments such as the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and the Upper Extremity Functional Index (UEFI).

The improvements in health-related quality of life observed across the included studies are particularly noteworthy, given the profound psychological and social burden associated with BCRL [7, 8]. Women with BCRL frequently report anxiety, depression, body image disturbances, and diminished participation in occupational and recreational activities, all of which contribute to reduced quality of life [27, 28]. The holistic nature of Pilates, which integrates physical exercise with breath control and mind-body awareness, may exert beneficial effects beyond the physical domain, addressing the psychological and emotional dimensions of

living with a chronic condition such as BCRL [29]. The group-based delivery of Pilates in some studies may have also contributed to improved quality of life through enhanced social support and peer interaction, factors that are well-recognized as important determinants of psychological well-being in cancer survivorship [30].

The findings of this review are generally consistent with previous systematic reviews examining exercise interventions for BCRL. A comprehensive meta-analysis by Schmitz et al. demonstrated that supervised exercise programs, including resistance and aerobic training, are safe and effective in improving upper limb volume, function, and quality of life in breast cancer survivors with lymphedema [31]. In another review, they have also demonstrated that exercise is safe for women with BCRL and does not increase the risk of developing or worsening lymphedema [32]. Similarly, a systematic review by Al Onazi et al. concluded that upper body exercise interventions may improve pain and function in patients with BCRL, although heterogeneity precluded pooling of data and the quality of evidence was limited by small sample sizes and unclear risk of bias [33]. However, none of these reviews specifically focused on Pilates in women with lymphedema. Our findings partially align with the general exercise oncology literature, showing improvements in muscle strength and quality of life, while the contradictory results on lymphedema reduction highlight the need for further investigation.

When comparing Pilates with other exercise modalities, our findings reveal interesting patterns. When compared with standard home exercises or control groups, Pilates demonstrated statistically significant improvements in grip strength, social appearance anxiety, and lymphedema severity in one study [20], while another study found no improvements in lymphedema and only a reduction in pain [23]. When compared with belly dancing, the latter showed short-term improvements in arm functionality and lymphedema, while both groups benefited in strength-related movements; however, during follow-up, both groups worsened in several parameters due to lack of continued physical activity [24]. When compared with aquatic exercise, both groups showed improvements in range of motion and muscle strength, although the aquatic exercise group obtained statistically significant improvements in lymphedema reduction in the forearm and hand, while the Pilates group showed greater benefits in strength, though not significantly [25]. These findings suggest that while Pilates offers specific benefits, particularly in strength and symmetry, other modalities such as aquatic exercise or belly dancing may be more effective for certain outcomes such as lymphedema volume reduction or range of motion symmetry. The heterogeneity in protocols and outcome measures, however, precludes definitive conclusions regarding the superiority of any single modality. This variability may reflect the diverse nature of the interventions, with aquatic exercise providing buoyancy and hydrostatic pressure effects, and belly dancing emphasizing dynamic, independent upper limb movements that may enhance range of motion symmetry [24].

Regarding the dose of intervention, studies with greater positive effects implemented 60-minute sessions, with a frequency of 2 or 3 times per week, for a minimum of 8 weeks. Progression of intensity through the incorporation of elastic bands, rings, or balls, together with supervision by physiotherapists, appears necessary to maximize benefits and ensure patient safety [20, 23–25]. Importantly, the follow-up results at 6 and 12 months indicate that the benefits of Pilates diminish if not maintained over time, highlighting the critical importance of promoting long-term exercise adherence [24]. This finding has significant clinical

implications, suggesting that Pilates should be considered as an ongoing component of rehabilitation rather than a time-limited intervention.

The absence of any reported adverse events across the four included trials is a clinically important finding, supporting the safety of Pilates as an intervention for women with BCRL. This is particularly relevant given the historical concern that upper extremity exercise might exacerbate lymphedema or trigger its onset [34]. However, contemporary evidence has consistently demonstrated that appropriately prescribed and supervised exercise is not only safe but also beneficial for women with BCRL [32, 35]. The present review extends this evidence base specifically to Pilates, suggesting that this modality can be safely incorporated into the rehabilitation of women with BCRL, provided that appropriate supervision and progression principles are followed. Nevertheless, the absence of adverse event reporting does not equate to absence of risk, and the limited number of studies and participants precludes definitive conclusions regarding rare or long-term adverse events.

The present review contributes to this literature by specifically focusing on Pilates, a modality that has received less attention in the context of BCRL despite its growing popularity in clinical practice. Our findings suggest that Pilates may offer comparable benefits to other exercise modalities, while its unique emphasis on controlled, low-impact movements may render it particularly suitable for women with BCRL who may be apprehensive about more vigorous forms of exercise.

Nevertheless, several important limitations should be considered when interpreting the findings of this review. First, the number of included studies was small ($n = 4$), and the total sample size was relatively modest ($n = 353$), limiting the statistical power and precision of the effect estimates. Second, considerable heterogeneity existed across studies in terms of intervention protocols, including session frequency (2-5 sessions/week), total duration (8-16 weeks), and supervision modalities, which precluded meta-analysis and limited the ability to draw definitive conclusions regarding optimal dosing parameters. Third, the methodological quality of the included studies was variable, with two studies demonstrating unclear risk of bias in key domains such as allocation concealment and blinding of outcome assessors. The inherent lack of blinding of participants and therapists to the Pilates intervention is a well-recognized limitation in exercise-based trials and may have introduced performance and detection bias. Fourth, the outcome measures employed across studies were heterogeneous, with different instruments used to assess upper limb function, quality of life, and pain, which limits the comparability of findings and the ability to perform quantitative synthesis. Fifth, the certainty of the evidence was low to very low for all outcomes, primarily due to risk of bias, inconsistency, and imprecision. Finally, the follow-up periods varied across studies, and the longer-term sustainability of the observed effects remains uncertain, as only one study reported outcomes beyond 6 months.

From a research perspective, the present review highlights several critical gaps that warrant attention in future investigations. First, there is a pressing need for large, methodologically rigorous randomized controlled trials with adequate statistical power, standardized outcome measures, and long-term follow-up to strengthen the evidence base and enable more definitive conclusions regarding the efficacy and safety of Pilates in BCRL. Second, future studies should strive to employ validated, disease-specific outcome measures and to standardize assessment protocols to facilitate comparability across trials and enable

future meta-analyses. Third, the optimal dosing parameters, including frequency, intensity, duration, and progression, remain unclear, and future research should systematically investigate these factors to inform evidence-based prescription guidelines. Fourth, given the subjective nature of pain and quality of life outcomes, future trials should consider incorporating objective outcome measures and employing rigorous blinding of outcome assessors to minimize detection bias. Fifth, the mechanisms underlying the potential benefits of Pilates in BCRL warrant further investigation, including the role of lymphatic function, muscle pump activation, and neuromuscular control. Finally, the feasibility and effectiveness of Pilates interventions in diverse populations, including those with varying stages of BCRL, different cancer treatments, and different sociodemographic backgrounds, should be explored to enhance the generalizability of findings.

In conclusion, the present systematic review suggests that Pilates may be a safe intervention for women with BCRL, with preliminary evidence indicating potential benefits for upper limb function and health-related quality of life. However, the certainty of this evidence is low to very low, reflecting the limited number of studies, methodological limitations, and heterogeneity in intervention protocols and outcome measures. These findings underscore the need for further high-quality, adequately powered randomized controlled trials employing standardized outcome measures and rigorous methodological approaches. Until such evidence becomes available, clinicians should consider Pilates as a complementary intervention within a comprehensive rehabilitation program, with careful attention to individual patient characteristics and preferences, and with appropriate supervision to ensure safety and optimize outcomes.

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

Virginia Berdun-Barba: Conceptualization, Methodology, Resources, Software, Investigation, Data curation, Formal analysis, Writing-Original draft preparation.

Ivan Medina-Porqueres: Conceptualization, Methodology, Investigation, Data curation, Validation, Writing-Original draft preparation, Manuscript submission.

All authors reviewed the manuscript.

Data Availability

This study is a systematic review that uses retrospective data already published and is publicly available.

Ethics approval

Not applicable.

Consent to participate

Not applicable.

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Figures

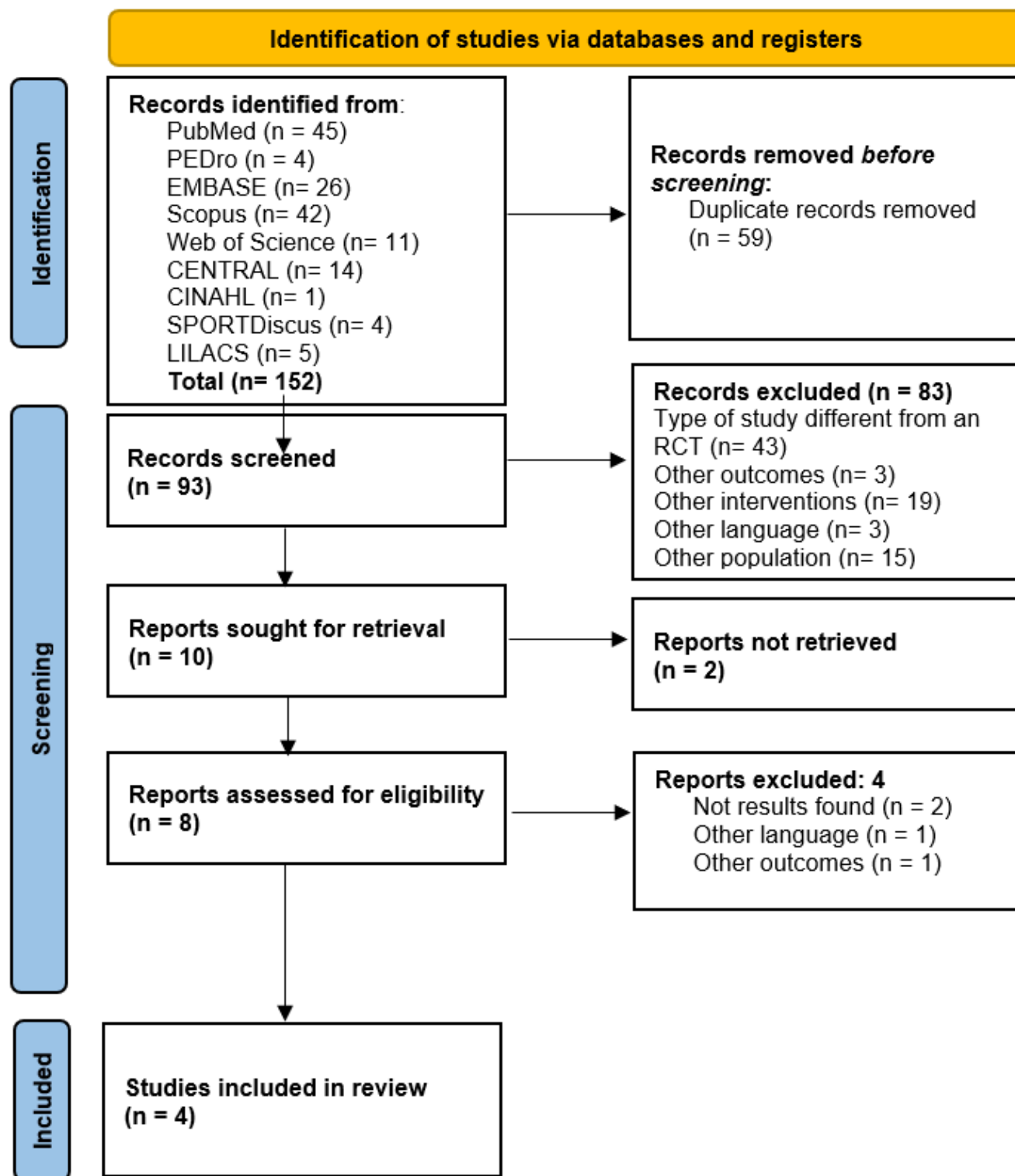


Figure 1

PRISMA flow diagram of study selection.

Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

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