Breast Care

Systematic Review

Breast Care
DOI: 10.1159/000546605

Received: February 4, 2025
Accepted: May 23, 2025
Published online: June 11, 2025

Using Virtual Therapy for Lymphedema and Disability Post-Mastectomy: Meta-Analysis with Systematic Review

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Keywords
Lymphedema · Virtual reality · Breast cancer · Disability · Mastectomy · Meta-analysis

Abstract
Introduction: This review and meta-analysis aimed to examine the effects of virtual reality (VR) therapy on lymphedema and disability management in post-mastectomy breast cancer patients, following PRISMA protocol. ***Methods:*** Databases were extensively searched, including Wiley Online Library, ProQuest, MEDLINE, CINAHL, Google Scholar, Science Direct, and SAGE Journals, covering studies from January 2016 to August 2024. This review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. ***Results:*** Nine studies met the inclusion criteria. The findings indicate VR therapy effectively reduces post-mastectomy lymphedema and aids upper limb disability rehabilitation, with sessions lasting 10–50 min. The meta-analysis statistics showed a significant decrease in disability, measured by the disability of the arm, shoulder, and hand (DASH) scale, with an effect size of −0.931 (Z score = −2.713, p = 0.007) and a 95% confidence interval of −1.604 to −0.259. ***Conclusions:*** These results strongly support VR's efficacy in managing lymphedema and disability, recommending its integration into routine care at oncology centers and hospitals. This article explains compelling evidence that VR is effective in helping patients with lymphedema manage their disabilities. Rehabilitation programs using VR after mastectomy should be incorporated into the daily care in oncology centers and hospitals. Further interventional studies are needed to strengthen evidence and refine VRs clinical application.

Introduction

Lymphedema is characterized by an increase in circumference of the upper limb on the same side, resulting from an excess accumulation of fluid and extracellular proteins [1]. This condition is caused by impaired lymphatic valve function and increased outflow resistance. Furthermore, the prevalence of lymphedema increases by approximately 1% annually [2]. Post-mastectomy lymphedema can significantly impair the functional activity of the upper limbs [3]. Without proper treatment, lymphedema may lead to reduced muscle flexibility and restricted joint mobility [4].

Cancer of the breast is the world's most common cancer, affecting around 2.3 million women in 2020 (Arnold et al. [5]). By 2022, it ranked second in cancer incidence with 2.3 million new cases globally [6]. Breast cancer diagnosis, treatment, and symptoms like lymphatic pain greatly affect overall health [7, 8]. Post-surgery, patients often experience adverse changes, including lymphedema, restricted shoulder mobility on the operated side, and postural disorders [9].

Virtual reality (VR) is a non-invasive simulation that creates a three-dimensional, interactive artificial environment using a VR head-mounted display with a control handle [10] (shown in Fig. 1). It serves as an adjunctive intervention for cancer patients undergoing painful procedures, anti-cancer treatments, or hospitalization [10]. VR encourages breast cancer patients to engage in targeted activities to address impairments [11] and is a feasible, accessible, and easy-to-learn tool for postoperative

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rehabilitation [12]. Postoperative upper limb exercises using VR can improve muscle strength and reduce complications like lymphedema [13]. Rehabilitation exercises safely and effectively promote lymphatic reflux for patients at risk of breast cancer-related lymphedema [14]. VR exercise can enhance muscle pump, improve lymphatic fluid flow and increase intra-abdominal pressure to promote chest duct pump blood, which reduces the excess accumulation of fluid in the upper limbs, and it could improve the range of motion (ROM) of the shoulder [12]. Thus, VR-based activities designed to prevent post-mastectomy complications, such as disability, are highly valuable [9]. Disability is defined as physical infirmity, malformation, paralysis, amputation, or lack of coordination [15]. Disability can be effectively managed through VR as a safe and innovative intervention [9].

Objective

The objective of the study was to assess VR therapy's impact on lymphedema and disability in post-mastectomy breast cancer patients.

Methods

The review followed PRISMA guidelines (online suppl. material; for all online suppl. material, see https://doi.org/10.1159/000546605 PRISMA checklist) for systematic reviews and statistical meta-analyses [16]. This systematic review was performed as an independent study and does not have a prior protocol registration.

Search Strategies

A comprehensive literature search was executed across multiple online databases, including PubMed, MEDLINE, Embase, CINAHL, EBSCO, Scopus, ProQuest, Google Scholar, SAGE Journals, Wiley Online Library, and Science Direct, covering the period from January 2016 to August 2024. The search strategy was formulated using a combination of specific keywords: "virtual reality," "virtual therapy," "virtual rehabilitation," "virtual reality head-mounted display," "breast tumor," "Breast Neoplasms," "breast cancer," "breast cancer lymphedema," and "upper limb rehabilitation." These terms were strategically merged using Boolean operators to refine and focus the results (e.g., "Virtual Reality AND Lymphedema," "Virtual Reality AND post-mastectomy," "Lymphedema AND disability post-mastectomy OR disability").

The search included filters to limit results to English-language articles of clinical trials involving participants aged 18 years and older. We used EndNote to manage and remove duplicate records, ensuring a streamlined process. Two independent reviewers conducted title and abstract

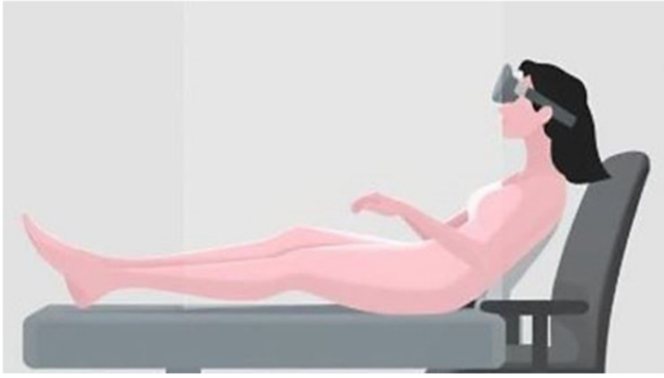

Fig. 1. AI generated image of VR for the management of the lymphedema.

screening, followed by a full-text evaluation to ensure inclusion based on predefined criteria. This rigorous search strategy aimed to yield precise, relevant data concerning the intersection of VR applications and breast cancer rehabilitation and management.

Eligibility Criteria and Selection of Studies

Inclusion criteria for this review were (1) studies on post-mastectomy breast cancer patients; (2) VR interventions alone or combined with other therapies for lymphedema or disability management; (3) English-language clinical trials; (4) participants aged 18 or older; and (5) evaluations of VR use for lymphedema management. Exclusions included protocols, conference papers, abstracts, posters, letters, and editorials.

The electronic search was carried out by M.A. and I.B.M. Two authors independently removed duplicates, screened titles and abstracts, and evaluated full-text studies for inclusion. The PICOS criteria (Table 1) were applied to assess the eligibility of studies for inclusion in the review.

Data Extraction

Data were extracted using the Joanna Briggs Institute's standardized form [17]. Data included author, year, country, session length, sample details, tools, and outcomes (Table 3). The research team collaboratively discussed the included articles to categorize them appropriately. Then, the data were analyzed to pinpoint key intervention components in the studies.

Quality Assessment

Assessment of Risks and Bias

The PEDro scale was used to evaluate the risk of bias in the included studies [25, 26]. The PEDro scale includes 11 items assessing validity and reporting, scored 0–10; scores: 0–3 (poor), 4–5 (acceptable), 6–8 (good), 9–10 (excellent) [25]. The authors assessed independently the quality of the included studies. Two independent reviewers (M.A. and I.B.M.) evaluated the studies' methodological rigor and assigned

Table 1. PICOS criteria for inclusion in the systematic review

P	Population	Women with lymphedema in the upper limb
I	Intervention	VR intervention
C	Comparison	traditional interventions with either no intervention or another intervention
O	Outcomes	Lymphedema, disability
S	Study	Clinical trials

PEDro scores independently to ensure objectivity. The reviewers worked independently to reduce potential bias during assessment. Discrepancies in evaluations were resolved through discussion and consensus between the reviewers.

The risk of bias in the selected studies was assessed using the PEDro scale, which evaluates methodological quality across 11 items. The quality ratings for the included studies varied.

- One study was rated as having excellent methodology.
- Five studies were rated as having good methodology.
- Three studies had acceptable methodology quality. The lowest scores were observed in patient blinding (0%) and therapist blinding (11%). 77% of the studies met random and intervention allocation criteria.

Results of Individual Studies

For each study, summary statistics and effect estimates were extracted. The results are presented in structured tables (not shown here). For example, one study reported a significant reduction in disability with a difference in mean of −0.931 (95% confidence interval (CI): −1.604 to −0.259) on the disability of the arm, shoulder, and hand (DASH) scale, indicating a moderate to large effect size.

Reporting Biases

Risk assessment showed no significant reporting bias concerns. All relevant outcomes were reported, and the studies adhered to their predefined protocols.

Certainty of Evidence

Outcome certainty was assessed using the GRADE approach. The overall confidence in the body of evidence was rated as moderate due to the diversity in study designs and the risk of bias in some studies. However, the consistent findings across multiple studies demonstrate the effectiveness of VR interventions in reducing disability among breast cancer patients.

Data Analysis and Statistical Methods

Meta-analysis was conducted for three studies that compare the efficacy of two different programs of VR or study the effect of VR against traditional intervention. The 95% CI and p value were calculated by comparing the change in the outcomes between the intervention and the control groups using the random-effect model of analysis. Heterogeneity in treatment effect was examined by calculating the I2 index. The significance level was at a p value of up to 0.05. Furthermore, the comprehensive meta-analysis, version 2.2.064 software package (Biostat, Englewood, New Jersey, USA), was used to carry out the meta-analyses.

Table 2. Assessment of the articles using PEDro scale

	Items											
	1*	2	3	4	5	6	7	8	9	10	11	Total
Aguirre-Carvajal [18]	1	0	0	1	0	0	0	1	0	1	1	4
Atef [11]	1	1	0	1	0	0	0	1	1	1	1	6
Basha [19]	1	1	1	1	0	1	1	1	1	1	1	9
Feyzioğlu [20]	1	1	1	1	0	0	0	1	1	1	1	7
Harfoush [21]	1	1	0	1	0	0	0	1	1	1	1	6
House [22]	1	0	0	1	0	0	0	1	1	0	1	4
Piejko [23]	1	1	0	1	0	0	0	1	1	1	1	6
Yassa [24]	1	1	0	1	0	0	0	1	1	1	1	6
Zhou [12]	1	1	0	1	0	0	0	1	0	0	1	4

*Item 1 influences external validity but not internal validity. This item is not used to calculate the PEDro score. Item 1: eligibility criteria; item 2: random allocation; item 3: concealed allocation; item 4: group homogeneity; item 5: patient blinding; item 6; therapist blinding; item 7: rater blinding; item 8: key outcome collection; item 9: intervention allocation; item 10: between-group statistical comparisons; item 11: key outcome measures report.

Effect Measures

For assessing the effectiveness of virtual therapy interventions for the primary outcome measures, the mean and standard deviation of the difference were calculated to compare baseline and post-intervention scores on measures including anxiety, pain management, and QoL outcomes. Furthermore, for the synthesis and presentation of secondary outcome measures, such as proportions of improvement or adherence rates, risk ratios along with their corresponding CIs were used. These effect measures were chosen to ensure clarity in evaluating the intervention's impact and to facilitate robust comparisons across the studies in the review.

Results

Study Characteristics

Nine studies evaluating VR interventions for breast cancer-related lymphedema and disability (shown in Fig. 2) were included in this systematic review. A three-stage screening process yielded nine studies for inclusion

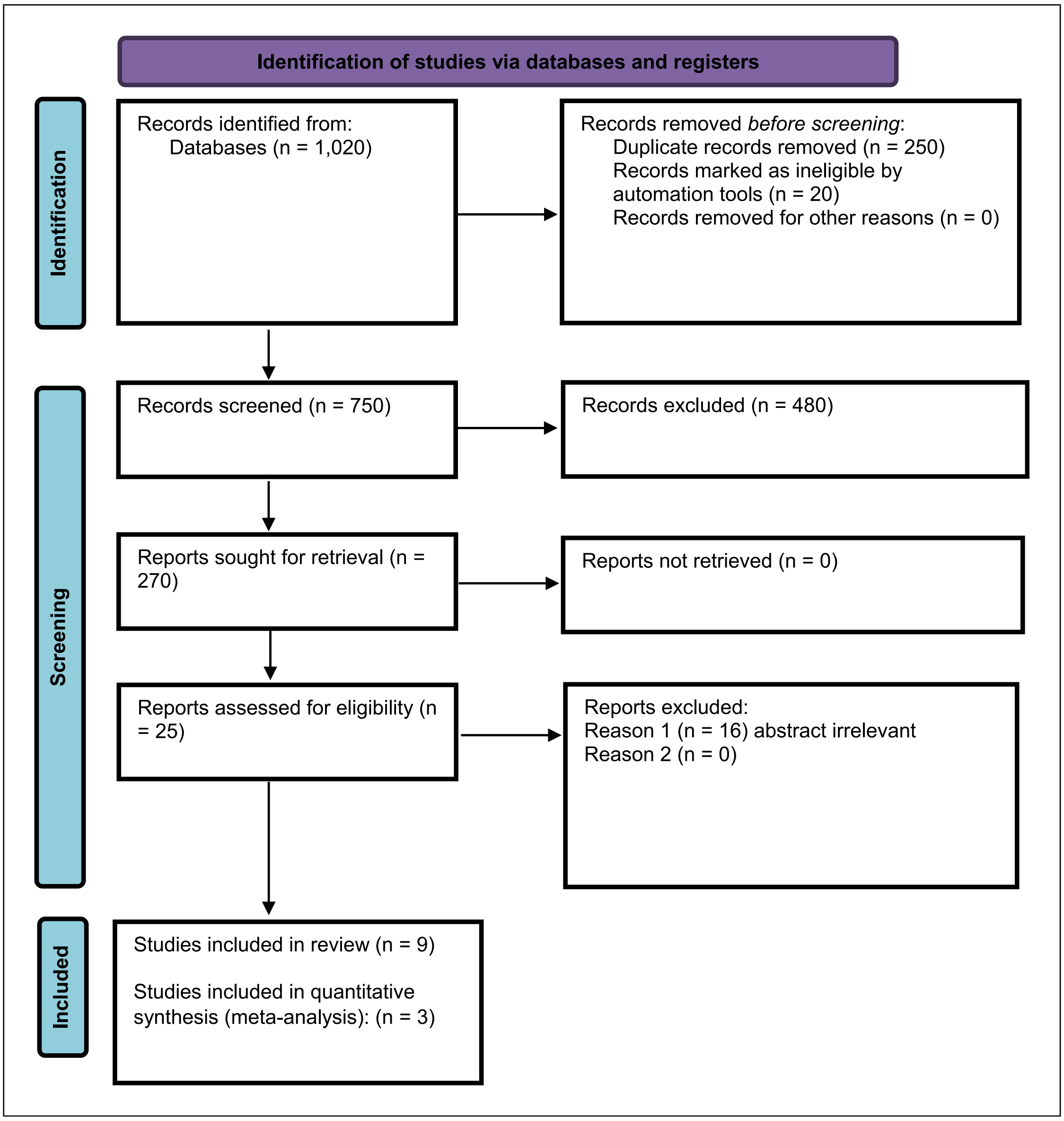

Fig. 2. PRISMA flow diagram of literature search.

[11, 18–22]. Results from individual studies were tabulated in a structured format (e.g., Table 3). The studies varied in design, sample size, intervention type, and outcome measures. Mastectomized patients treated with VR were assessed across several outcome domains: psychological, functional, ROM, and disability (using the DASH scale).

The quality ratings differed across this selection of studies (Table 2). One study has excellent methodology [19]. Five studies have good methodology [11, 20, 21, 23, 24]. While three studies had acceptable methodology quality [12, 18, 22]. Item 5 (patient blinding) had the lowest score (0%). Items 6 (therapist blinding) and seven (rater blinding) had 11%. Furthermore, 77% of the studies met random allocation, intervention allocation, and between-group statistical comparison criteria. All of the studies met the following criteria: item 1 (eligibility criteria), 4 (group homogeneity), 8 (key outcome collection), and 11 (key outcome measures report) each had the highest score (100%).

Table 3 presents the characteristics of the nine studies, with five featuring control and intervention groups [11, 18–21]. One study used a single group pre-posttest design [22]. Most were RCTs focusing on lymphedema, ROM, and disability, with all interventions involving VR-based exercises. The eight studies included 661 participants aged 18 and older, with VR sessions lasting 10–50 min. The time frame for the rehabilitation was carried out for the patients who had lymphedema with at least 6 months postsurgical duration.

Results of Syntheses

The meta-analysis conducted revealed a substantial decrease in disability across the studies. The overall effect size was −0.931 (Z score = −2.713, p = 0.007), with a 95%

Table 3. Main characteristics of reviewed studies

First author	Title	Location	Study design duration	Sample size, *N*, (mean age±SD)	Intervention	Instrument	Outcome
Aguirre-Carvajal [18]	Psychological and functional effects in mastectomized patients treated with virtual reality	South America	Descriptive clinical trial It was 10 sessions of 32 min: three serial of 10 min of effective exercise and two serial of 1 min to rest, 3 days per week, between 7th day and 30th day post-surgery	*N* = 77 (26–83 years) (58.76±SD 1.46) IG = 41 (57.66±SD 1.65) CG = 36 (60.03±SD 2.51)	The measures with the described tools were made before the surgery (pre-operatory, day 0) and post-surgery at the 7th day and the 30th day. The physical rehabilitation protocol with VR exercises (Nintendo Wii™ console) was applied in the IG	Quick DASH HADS	VR sessions increase upper limb ipsilateral function, especially MRM group, and decreases the risk of depression and anxiety unlike control group who maintains the risk **Quick DASH**, *mean±SD* IG = 17.86±6.30 CG = 20.13±5.79 **HADS**, *mean±SD* IG = 5.25±1.79 CG = 4.29±1.92
Atef [11]	A quasi-randomized clinical trial: virtual reality vs. proprioceptive neuromuscular facilitation for post-mastectomy lymphedema	Egypt	Quasi-randomized clinical trial The duration of the VR-based therapy sessions included 30 min of training over a period of 4 weeks, with 2 sessions every week	*N* = 30, (40–65 years) VR group = 15 (54.07±8.28) PNF group = 15 (53.07±7.24)	Nintendo Wii game Tennis, triceps extension, and rhythmic boxing	QuickDASH-9 EAV	VR is beneficial in reducing post-mastectomy lymphedema ($p < 0.05$) and can be used as an exercise based technique in those who have undergone modified radical mastectomy **Quick DASH**, *median (IQR)* VR group = 38.5 (27.5) PNF group = 38.5 (19.25) **EAV**, *median (IQR)* VR group = 6,854.23 (9,459.49) PNF group = 5,718.9 (6,834.54)

Table 3 (continued)

First author	Title	Location	Study design duration	Sample size, *N*, (mean age±SD)	Intervention	Instrument	Outcome
Basha [19]	Effect of exercise mode on physical function and quality of life in breast cancer-related lymphedema: a randomized trial	Egypt	A single blinded randomized trial Five sessions per week for 8 weeks	*N* = 60 Group 1 = 30 Group 2 = 30 women older than 30 years	Group 1: VR Kinect-based games Group 2: resistance exercise group received resistance training Complex decongestive physiotherapy was received by both groups include manual lymphatic drainage, compression bandages, skin care and exercises	SF-36 DASH ROM VAS ELV	The VR training was superior to resistance exercises training. There were statistically significant differences in shoulder flexion strength ($p = 0.002$), external rotation strength ($p = 0.004$), and abduction strength and handgrip strength ($p < 0.001$). ELV ($p = 0.15$) **ELV**, *mean±SD* Group 1 = 431.5±25.82 Group 2 = 442.6±33.27 **DASH**, *mean±SD* Group 1 = 22.9±3.07 Group 2 = 27.1±5.22
Feyzioğlu [20]	Is Xbox 360 Kinect-based virtual reality training as effective as standard physiotherapy in patients undergoing breast cancer surgery?	Turkey	RCT A total of 6 weeks of exercising with the Kinect (duration of 35 min/day for 2 days per week)	*N* = 40 (50.84±8.53) IG = 19 50.84 (8.53) CG = 17 51.00 (7.06)	Non-Immersive Xbox 360 Kinect-based VR training: using Kinect Sports I (darts, bowling, boxing, beach volley ball, table tennis) and Fruit Ninja	VAS, ROM, arm strength, DASH questionnaire, TKS	Significant changes in the management of upper limb dysfunction, ROM, muscle strength, grip strength, functionality, and TKS scores after the treatment ($p < 0.05$) **DASH** IG = 16.49 (SD = 6.47) CG = 16.49 (SD = 6.47) **TKS** IG = 29.47 (SD = 5.31) CG = 37.35 (SD = 4.51)

DOI: 10.1159/000546605

Table 3 (continued)

First author	Title	Location	Study design duration	Sample size, *N*, (mean age±SD)	Intervention	Instrument	Outcome
Harfoush [21]	Effect of virtual reality-based rehabilitation program vs. booklet-based education on self-care practices and prevention of complications among women after mastectomy	Egypt	A quasi-experimental (case-control) research design Instructed the patients to repeat these exercises 5 or 10 times a day for at least 20-min period of time and continue during the first 6 weeks after surgery	*N* = 100 women 58.8±3.45 VR group = 50 (58.25±3.736) Booklet group = 50 (59.5±2.179)	Wand exercise, wall climbing, winging it, snow angels, posture, and side bends Six individual sessions with the patients. Three sessions were conducted in inpatient department at female surgical ward and three sessions were conducted in the outpatient clinic after discharge	Health Profile Structured Interview questionnaire Self-care practices of modified radical mastectomy structured interview schedule Early post-modified radical mastectomy complications checklist	Lymphedema occurred in only 6.0% of the VR group compared to 26.0% in the booklet group (p = 0.006) **Management of lymphedema** VR group = 42.75±2.845 Booklet group = 34.75±4.68 **Arm exercises** VR group = 27.70±1.220 Booklet group = 21.78±5.91
House [22]	A feasibility study to determine the benefits of upper extremity virtual rehabilitation therapy for coping with chronic pain post-cancer surgery	USA	Pre-posttest 20–50 min per session, twice a week for 8 weeks	*N* = 12 22–78 years (57.8±20.4)	The Bright Arm Duo Rehabilitation System	FMA CAHAI-9 ADL	There are significant improvements in strength, function, and ROM metrics increased (p < 0.01) **The ability to perform ADL** pre-training = 41.8 (SD = 15.9) post-training = 50.3 (SD = 12.9)
Piejko [23]	Medical resort treatment extended with modern feedback exercises using virtual reality improve postural control in breast cancer survivors (preliminary study)	Poland	A clinical, pilot, non-controlled study Three times a week, 20 min each	*N* = 46 over 18 years (51.67±6.62)	Physical exercises using feedback based on VR were introduced. Postural control tests performed on the Sabilometric platform were used to assess the progress of therapy	Feedback based on VR The Stabilometric platform	In the assessment of dynamic postural control, the length of the center of foot pressure (COP) movement path was statistically significant (p = 0.0083). Medical treatment with physical exercises using feedback based on VR can improve the dynamic postural control

Table 3 (continued)

First author	Title	Location	Study design duration	Sample size, *N*, (mean age±SD)	Intervention	Instrument	Outcome
Yassa [24]	Pilates exercise vs. virtual reality on upper limb dysfunction post-mastectomy	Egypt	RCT Three sessions per week for 8 weeks, time of the session was 40 min	*N* = 60 35–55 years Non-VR group = (46.97±4.12) VR group = (45.87±3.78)	Group (A) received pilates exercise, mobilization exercises, ROM exercises, and routine medical treatment. Group (B) received VR, mobilization exercises, ROM exercises, and routine medical treatment	ASES ROM	There were significant improvements in ASES, upper limb dysfunction, and ROM in non-VR group compared to VR group **ASES** Non-VR group = 45.66±10.87 VR group = 37.85±10.56 **ROM** Non-VR group = 128.57±12.14 VR group = 113.87±9.62
Zhou [12]	Upper limb rehabilitation system based on virtual reality for breast cancer patients: development and usability study	China	Experimental design 15 min	*N* = 15 54.73±7.78	The participants covered making a fist, screw lifting of the wrist, elbow flexion and around the shoulders, touching the ear, climbing a wall, back-handing, and outreach, comprising 10 rehabilitation actions VR, human-computer interaction technology, and an upper limb function rehabilitation system were used in this study. This upper limb rehabilitation system hardware consisted of head-mounted display, a control handle and notebook computers	System usability scale, the simulator sickness questionnaire subjective measurement scale, and the presence questionnaire scale	VR system is feasible and easy to learn for breast cancer patients. No adverse events were reported **The System Usability Scale score** = 90.50±5.69

ASES, Arabic version of American Shoulder and Elbow Surgeons Evaluation; RCT, randomized controlled trial; *N*, total sample size; IG, intervention group; CG, control group; VR, virtual reality; VAS, visual analog scale; ROM, range of motion; DASH, disability of the arm, shoulder, and hand; TKS, Tampa Scale of Kinesiophobia; FMA, Fulg-Meyer Assessment; SUS, System Usability Scale; PQ, Presence Questionnaire; SSQ, Simulator Sickness Questionnaire; SF-36, Study Short-Form; EAV, excess arm volume; ELV, excessive limb volume; PNF, proprioceptive neuromuscular facilitation; CAHAI-9, the Chedokee Arm and Hand Activity Inventory-9.

confidence interval of −1.604 to −0.259. The analysis indicated moderate statistical heterogeneity among the studies, as assessed by I^2 statistics. Subgroup analyses were performed based on intervention types and participant characteristics, which helped identify potential sources of heterogeneity.

Virtual Realty Effect

Lymphedema

In this review, VR was beneficial in reducing post-mastectomy lymphedema [21]. According to Harfoush et al. [21], lymphedema was reported in 6.0% of the VR group versus 26.0% in the booklet group ($p = 0.006$).

Excessive limb volume (ELV) was used for lymphedema diagnosis by measuring extremity circumference with an inelastic tape, starting distal to the metacarpophalangeal joints and extending in 4-cm stretches up to the axilla base [19]. After 8 weeks, pairwise comparisons showed a significant difference within each group ($p < 0.001$). However, no significant difference was found between groups in ELV (mL) ($p = 0.15$), with the Xbox Kinect and resistance exercise groups showing ELV values of 431.5 ± 25.82 and 442.6 ± 33.27, respectively [19]. Excess arm volume significantly decreased in both the VR group ($p = 0.001$) and proprioceptive neuromuscular facilitation group ($p = 0.005$), with no significant difference between the groups ($p = 0.902$), indicating neither method was superior [11].

Upper Limb Function

Four studies supported that VR exercises can increase upper limbs function and ROM [18–20, 22]. Using VR for rehabilitation exercises in the ipsilateral upper limbs post-mastectomy improved limb function [18]. A single-blinded randomized trial of 60 patients found VR training superior to resistance exercise, with significant differences in shoulder flexion ($p = 0.002$), external rotation ($p = 0.004$), abduction strength, and handgrip strength ($p < 0.001$) [19]. Outcomes also showed improvements in shoulder ROM, strength, and function [22]. Although significant differences were found in ROM, muscle strength, grip strength, functionality, and Tampa Scale of Kinesiophobia (TKS) scores post-treatment ($p < 0.01$), no differences between groups were observed in ROM, muscle strength, or grip strength ($p > 0.05$) [20].

Advantages and Disadvantages of VR Devices

There are several devices and applications that were used to deliver VR therapy in the treatment sessions. The pros of VR devices include ease of use, safety, immersion, producing advanced sensory experiences, and interactions [11, 20, 21, 23, 24]. However, the cons were cybersickness symptoms such as vomiting, headache, and dizziness [22]. Other studies did not determine the disadvantages of VR devices (Table 4).

Meta-Analysis

A meta-analysis using a random-effects model was conducted to account for variations between studies based on participant characteristics, interventions, or study designs. Subgroup analyses were conducted based on intervention types, participant characteristics, or study regions to identify sources of heterogeneity. Three studies in this review have used DASH scale to assess disability. The meta-analysis results are shown graphically in the forest plot (shown in Fig. 3). The diamond-shaped plot illustrates the effect magnitude, which is −0.931 (Z score = −2.713, $p = 0.007$) and has a 95% confidence interval of −1.604 to −0.259. The Cohen's d effect magnitude of the individual studies for the observed outcomes is illustrated in the plot. IBM SPSS Statistics version 29.0 was used to conduct the meta-analysis, calculate effect sizes, and generate the forest plot [27]. Sensitivity analyses included excluding studies with high bias risk, reanalyzing the data to assess result robustness, and comparing outcomes after adjusting for sample sizes and study quality.

Discussion

This review was performed to summarize and evaluate the methodological quality of primary studies on the use of VR for managing lymphedema and disability. It distinguishes itself through a focused exploration of VR intervention methodologies, analyzing interrelated factors to provide comprehensive insights into strategies for addressing lymphedema and disability in post-mastectomy patients.

The included studies feature diverse designs, sample characteristics, countries, timeframes, procedures, instruments, and outcomes. Key findings are organized into three categories: (1) issues related to lymphedema and breast cancer, (2) lymphedema management using VR technology, and (3) VR-assisted disability rehabilitation.

The meta-analysis showed a significant reduction in disability, which is measured by the DASH scale, across all three studies examined. This is clearly illustrated in the forest plot, which shows an overall effect size of −0.931, indicating a moderate to large impact on disability reduction (Z score = −2.713, $p = 0.007$). The consistency of this finding is supported by the 95% confidence interval, ranging from −1.604 to −0.259. The Cohen's d effect sizes from individual studies align with the overall effect, further validating the intervention's effectiveness in reducing disability. These findings underscore the effectiveness of VR-based interventions to improve disability outcomes, offering valuable insights for clinical practice.

The meta-analysis results are consistent with research that has shown the efficacy of interventions aimed at reducing disability when compared to other studies. For example, Basha et al. [19] conducted a study that reported a comparable reduction in disability using the DASH scale.

Table 4. Pros and cons of VR therapy devices

Study	VR application	Advantages	Disadvantages
Aguirre-Carvajal [18]	VR head set using Nintendo Wii™	Ease of use, low price, and safe device	Unknown
Atef [11]	VR head set using Nintendo Wii™	It motivates the patients to perform repetitive and quick arm movements	Unknown
Basha [19]	VR head set using Xbox Kinect	Simple to use, multiple interactive options, entertaining, competitive environment, and no need of an attached device or a controller	Unknown
Feyzioğlu [20]	VR head set using Xbox 360 Kinect	Easy and advanced user technology Ability to interpret voice, image, and depth data flow Transfer the information through a microphone array and three dimensional depth sensors mounted on it No need for game controller	No complications
Harfoush [21]	VR head set using Wand exercise application	It produces advance sensory experiences (such as visual, aural, tactile, and olfactory inputs)	Unknown
House [22]	VR head set using BrightArm Duo application	It tracked the number, length and intensity of the games played each session by the subjects	No cyber sickness symptoms such as vomiting or dizziness
Piejko [23]	Stabilometric platforms using VR-based feedback stimulates	Collecting data on the type of tasks ordered to patients and the accuracy of their performance by patients	Unknown
Yassa [24]	Oculus VR head set with 2 controllers. Basketball and volleyball applications	Easy to use and available	Headache and dizziness
Zhou [12]	VR head-mounted display with a control handle	Simulate various senses, interactive, and immersive feeling	Dizziness and vomiting

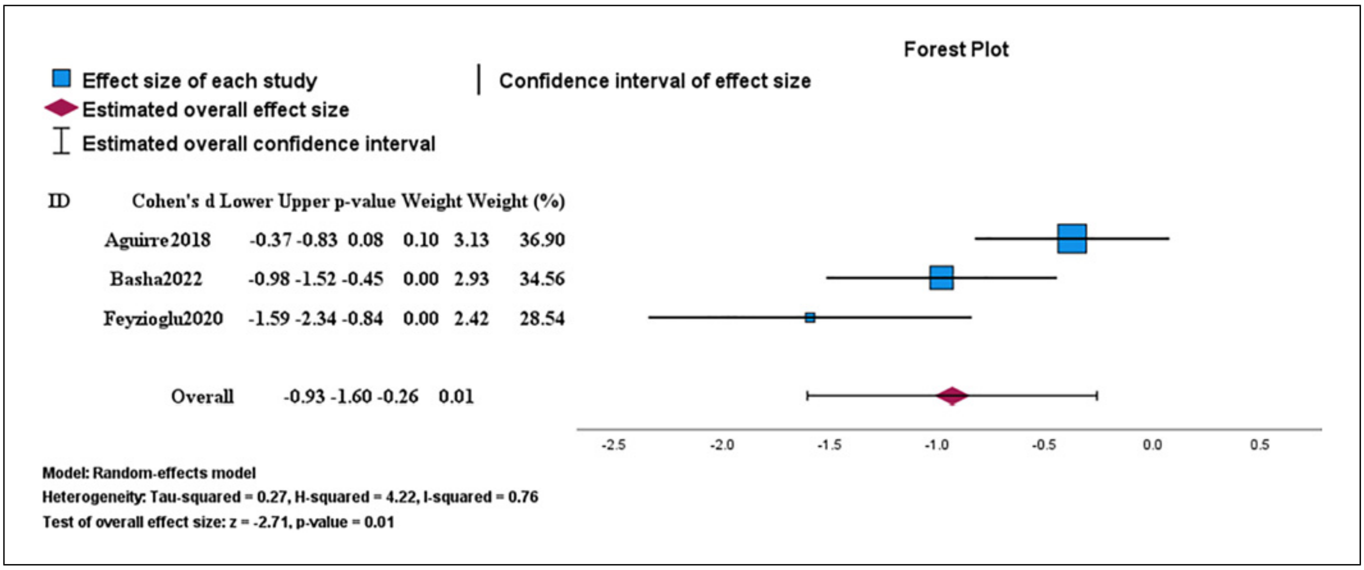

Fig. 3. Meta-analysis with forest plot for the studies that used DASH scale to assess disability.

The study's effect size was 0.40, which suggests a moderate impact, and the *p* value was 0.01, which supports the intervention's efficacy. Nevertheless, the confidence interval in the Basha and Aboelnour [19] study was slightly narrower, spanning from −6.41 to −1.99, indicating that the effect magnitude was more variable across the sample.

According to the extent of the area involved, lymphedema rates can range from 50% for melanoma patients to 75% for patients with breast cancer after axillary node removal to between 14.5% and 41.4% after chest and breast radiation therapy. Genitourinary cancers have a 16% incidence rate of lymphedema [28]. A chronic, serious complication, lymphedema can result from breast cancer surgery and treatment [29, 30]. After mastectomies with the resection of axillary lymph nodes, lymphedema is defined as an abnormal buildup of fluids and proteins in the intercellular space that results in inflammation and edema [31]. Another factor contributing to lymphedema is radiotherapy, which has a detrimental effect on the upper limbs' functional activity and may make breast cancer patients less able to perform daily activities [3]. Lymphedema was brought on by impaired lymphatic valve and outflow resistance; the prevalence of lymphedema rises by 1% annually [2, 30]. Additionally, women with lymphedema experience pain and have less upper extremity strength than those who do not [32].

Patients with cancer experience numerous severe physical disabilities [33]. Post-mastectomy lymphedema and restricted ROM due to scar tissue formation after surgical and radiation treatment most frequently complain of upper limb functional impairment. Unfortunately, restricted ROM in the upper extremities limits daily activities [34].

VR technology was thought to be crucial in demonstrating a high level of patient training on crucial activities [34]. Exercises using VR were successful at improving arm function and the daily activities of lymphedema patients [11, 22, 35]. There are additional benefits; cancer patients can perform various interventions in a safe environment thanks to VR, including pain management for cancer patients, rehabilitation, and cancer discomfort relief [36].

VR encourages breast cancer patients to train on special activities in order to recover from impairments and motivates patients using visual feedback by removing them from the hospital environment and placing them in the world of entertainment and science [11]. Additionally, VR will provide enjoyment and is independent of doctor's orders [37].

VR rehabilitation can treat lymphedema, enhance the mobility of the upper limbs, improve motor coordination, and assess postural control using the stabilometric platform, which is equipped with software that allows postural control diagnostics and data collection [23]. A quasi-experimental study examines 100 participants using different VR applications such as wand exercise, wall climbing, winging it, snow angels, posture, and side bends. The researcher instructed the patients to repeat these exercises 5 or 10 times a day for at least a 20-min period of time and continue during the first 6 weeks after surgery; six individual sessions with the patients and three sessions were conducted in the inpatient department at the female surgical ward, and three sessions were conducted in the outpatient clinic after discharge [21]. The result suggested that the VR group had a reduction in lymphedema compared to the non-VR group ($p = 0.006$) [21].

Using VR is crucial for reducing disability by increasing upper-limb function [4, 18, 20, 22]. VR can stimulate patients in a variety of ways and increase adherence and training intensity by providing an interactive environment with real-world scenarios, but more randomized controlled studies are required to demonstrate that VR can raise adherence rates [38].

To assess disability, four out of six studies examine the effect of VR on disability level by using the Quick DASH instrument [11, 18–20]. The Quick DASH-9 is a valid tool with high reliability for determining the level of disability. A higher value on the Quick DASH-9's 4-point Likert scale, which has nine items, indicates more disability [39].

VR technology for postoperative arm rehabilitation in breast cancer significantly improves upper limb dysfunction, ROM, muscle strength, grip strength, and functionality ($p < 0.05$) [20]. Using VR devices with multisensory interactive approaches can increase engagement, as patients focus more on completing VR exercises [22, 40]. An experimental study with 15 participants (mean age 54.73 ± 7.78 years) found the following scores: Presence Questionnaire: 113.40 ± 9.58, Simulator Sickness Questionnaire-disorientation: 0.80 ± 1.27, Simulator Sickness Questionnaire-nausea: 0.93 ± 1.16, System Usability Scale: 90.50 ± 5.69, and Simulator Sickness Questionnaire total: 2.53 ± 3.40. The results suggest that the VR rehabilitation system is available, feasible, and easy to learn for upper limb disability in breast cancer patients [12].

Lymphedema may lead to severe consequences related to patients' functional and psychological aspects of life, reducing quality of life. In this study, there is only one study that determines the effect of exercise mode on quality of life in breast cancer–related lymphedema; the authors demonstrated that quality of life among the VR training group was superior to resistance exercises training in lymphedema management [19]. Moreover, VR can improve physical functioning and quality of life, including personal care functions, work, home, and social relationships [19]. The positive point is that the patients practice VR therapy to favor incorporation into daily activities and to have a better quality of life.

Few studies focused on determining the duration of lymphedema symptom severity. Comparing the impacts of VR training and resistance exercises training on the duration of lymphedema symptom severity, there was no lymphedema exacerbation or adverse effects recorded during the study VR sessions for 8 weeks [19]. There was a statistically significant decrease in the severity of lymphedema [19]. However, the severity of lymphedema was assessed by the difference in the limb volume between the affected and unaffected upper limb [11].

VR has many advantages for breast cancer patients. It is considered an effective distraction intervention for managing pain and anxiety among breast cancer patients [41]. VR intervention for breast cancer patients provides an enjoyable, affordable, and motivating environment with fewer medication side effects. It is easy to use, requires no prior training, and can be administered by any healthcare provider [42]. In a randomized controlled study, women with breast cancer were assigned to either the experimental group (Xbox 360 Kinect-based VR training) or the control group (standardized physical therapy). Significant improvements were observed in upper limb dysfunction, ROM, muscle strength, grip strength, functionality, and TKS scores after treatment ($p < 0.05$) [18]. A randomized controlled study in Egypt found that routine exercise was more effective than VR in improving upper limb dysfunction post-mastectomy [24]. One challenge of VR application is cybersickness, which is caused by exposure to a VR environment and is similar to motion sickness symptoms, such as general discomfort, headache, and nausea; however, only 8.70% of patients experienced mild discomfort, such as cybersickness, after using VR [43]. A randomized controlled trial with 40 participants (mean ± SD = 50.84 ± 8.53) reported significant changes in fear of movement ($p < 0.001$) as measured by the Tampa Kinesiophobia Scale [20]. Other challenges include the cost of VR equipment and the weight of headsets and helmets [44].

This study offers several strengths. VR as a therapeutic option is highly accessible for both patients and healthcare professionals. Additionally, VR therapy is generally associated with minimal adverse effects, making it a safe and viable intervention. However, the interpretation of the study results must consider several limitations. These include the lack of control groups and small sample size in some studies and a lack of blinding, which may introduce bias.

Another limitation was that there was no specific measurement that compared the compliance effect of VR to the other conventional techniques. Furthermore, the assessment techniques for extremity volume, such as the circumference method, have limitations. This technique is unable to differentiate between intracellular and extracellular fluid changes, which may affect the accuracy of lymphedema evaluation. Furthermore, the included studies did not determine whether radiological diagnosis of lymphedema was carried out to confirm the diagnosis or not. They just used clinical diagnoses such as ELV [23]. Future reviews should consider formal registration to enhance credibility, avoid duplication of research efforts, and ensure alignment with best practices for systematic reviews.

Implications

This meta-analysis holds promising implications for clinical practice. VR offers a unique opportunity to do exercises in secure, controlled settings, potentially enhancing the management of disability and lymphedema. However, more evidence is required to establish reliable recommendations regarding the optimal frequency, duration, and content of VR-based interventions.

Recommendations

There is a need to enhance the system's functionality, expand sample sizes, and employ randomized controlled trial (RCT) designs to rigorously assess using VR in enhancing upper limb function and rehabilitation feasibility among breast cancer patients. Further studies incorporating diverse non-invasive assessment modalities are also recommended. It is essential to determine VR exercise compliance and compare it to conventional techniques.

Conclusion

The comparison demonstrates that the current meta-analysis reveals a robust and consistent impact on disability reduction. However, the magnitude of this effect may vary depending on factors such as study design, sample characteristics, and the specific interventions implemented. These variations underscore the importance of considering the broader evidence base when evaluating the efficacy of disability reduction interventions.

Based on the findings of the reviewed studies, the integration of new technology, such as VR, into the management of disability and lymphedema in breast cancer patients appears to be a prudent and promising approach. VR, as a non-invasive intervention, has the potential to transform current practices and enhance patient satisfaction. Furthermore, this review highlights existing knowledge gaps in the use of new technologies for disability management, examines how key variables have been measured in prior studies, and provides both conceptual and empirical foundations for future research. Nevertheless, additional interventional studies focusing on VR are needed to further validate its effectiveness and refine its application in clinical settings.

Statement of Ethics

An ethics statement is not applicable because this study is based exclusively on published literature.

Conflict of Interest Statement

The authors report no conflicts of interest.

Funding Sources

There was no funding for this article.

Author Contributions

I.B.M.: writing – review and editing, writing – original draft, visualization, validation, supervision, software, resources, and project administration. M.A.: methodology, investigation, formal analysis, data curation, and conceptualization.

Data Availability Statement

All data are available in open access domain.

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