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REVIEW ARTICLE

Rehabilitation Strategies for Post-Surgical Breast Cancer Survivors: Virtual Reality, Conventional Therapy and Lifestyle Approaches: A Systematic Review

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ABSTRACT

This systematic review aims to assess the efficacy of VR-based rehab versus traditional physical therapies and postoperative interventions in cases of limited range of motion and persistent pain among breast cancer patients. We conducted a thorough literature search in PubMed/PubMed Central, Scopus, ClinicalTrials.gov, and the Cochrane Library, following PRISMA 2020 criteria through August 2025 (PROSPERO: CRD420251127020). A total of 35 primary studies were eligible for inclusion. The primary study findings show that when users combine VR technology with immersion through head-mounted displays and motion-capture systems that include Xbox Kinect technology, they achieve better shoulder movement and grip strength results than traditional therapy. The VR-based interventions outperformed traditional methods in decreasing kinesiophobia and pain intensity while also reducing cancer-related fatigue symptoms. The "illusion of presence" created through immersive VR technology provides a powerful non-drug treatment option that helps people handle central sensitization and psychological distress despite manual therapy being the most effective treatment for lymphedema. The review establishes virtual reality as a safe, evidence-based treatment method that supports patients' physical and mental development. VR-based protocols show major progress for decentralized survivorship care because they help patients learn motor skills through kinematic feedback while boosting active participation in care, leading to better long-term outcomes for postoperative patients.

KEYWORDS: Virtual reality therapy, Traditional physiotherapy, Lifestyle interventions, Upper limb dysfunction, Post-mastectomy rehabilitation.

INTRODUCTION

This systematic review evaluates the efficacy of Virtual Reality (VR) as a rehabilitative tool compared to conventional therapy and lifestyle interventions for post-surgical breast cancer survivors. The article first describes the clinical burden and related post-surgical disabilities before presenting the study's overall findings. Therefore, this systematic review serves as an organized presentation of relevant clinical evidence, particularly regarding the utilization of immersive technology to improve range of motion, manage pain, and alleviate mental stress in cancer patients after surgery.

Breast cancer

Breast cancer serves as the most prevalent cancer type which affects women throughout the world and creates extensive public health difficulties that result in grave medical problems, mental health issues and social impacts. According to the Global Cancer Observatory (GLOBOCAN) 2020 report, breast cancer cases worldwide were estimated at 2.3 million, which represented 11.7% of total cancer cases[1]. The combination of screening methods together with early detection capabilities and contemporary oncological treatment solutions has resulted in better survival outcomes for breast cancer patients[2].

Postoperative Complications and Clinical Practice Guidelines

The American Cancer Society and the American Society of Clinical Oncology recently published updated standards and practice recommendations for survivorship care for people living with advanced or metastatic cancer, which require healthcare providers to deliver coordinated, patient-centric care that follows established evidence-based practices while using available resources[3]. The possible postoperative complications include reduced shoulder range of motion, upper extremity weakness, pain, altered sensation, and lymphedema[4].

Shoulder problems

Mastectomy patients experience shoulder problems because their body moves in a different way than when they had breast-conserving surgery. The fact that such impairments can persist for months or even years after surgery underscores the need for early, proactive rehabilitation and surveillance in survivorship care[5].

Disabilities

Disabilities associated with breast cancer may raise the likelihood of long-term incapacity, restrict social and occupational involvement, and substantially affect activities of daily living (ADLs)[6]. The importance of conducting larger-scale trials with proper methodology and follow-up periods to evaluate the efficacy and possible side effects is consistently emphasized[7].

Traditional rehabilitation and virtual reality (VR)

A promising addition to traditional rehabilitation, virtual reality (VR) offers immersive, interactive settings with multimodal input to improve patient engagement, motor learning, and neuroplasticity[8]. Although traditional rehabilitation procedures often face adherence challenges due to postoperative kinesiophobia, virtual reality-based systems provide real-time kinematic information that can turn conventional repetitive exercises into motivating programs.

Although CPT continues to be a pillar of postoperative treatment, consistent use often becomes challenging due to postoperative kinesiophobia, cost implications, and absence

of immediate kinematic feedback[4,6]. In contrast, VR technology provides an immersive approach offering an engaging, motivating, and highly interactive means of motor skill acquisition[8]. Nevertheless, gaps remain in the literature regarding the comparative efficiency of VR versus non-immersive technologies across recovery parameters, such as grip strength and lymphedema. This systematic review aims to critically analyze the available literature to establish whether VR technology-based interventions can offer a superior alternative to traditional physical therapy and lifestyle choices for postoperative breast cancer patients.

METHODOLOGY

This study intended to investigate evidence which demonstrated whether Virtual Reality (VR) rehabilitation therapies provided better results than standard physical therapy methods and post-surgery routines for breast cancer patients. The researchers used PRISMA 2020 guidelines to ensure complete and transparent reporting of their systematic review methods.

PROSPERO Register Number

The systematic review protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO). The Registration number is "CRD420251127020".

Eligibility Criteria

The review included studies published and conducted through August 2025 that focused on the implementation of VR-based interventions and lifestyle approaches for postoperative breast cancer survivors.

Table I: Eligibility criteria based on PICO framework

PICO	Inclusion Criteria	Exclusion Criteria
Population	Adults (≥18 years)[9] post-breast cancer surgery (Mastectomy, Lumpectomy, ALND) with upper-limb dysfunction.	1. Non-surgical cancer patients 2. Metastatic bone disease 3. Cognitive impairments preventing VR use
Intervention	Virtual Reality-based rehabilitation (immersive or non-immersive)[10], Kinect, Wii, Pablo System, and Exergaming.	1. Traditional pharmacological interventions only 2. Passive modalities without active exercise
Comparison	Conventional physical therapy (CPT), structured resistance/aerobic exercise, or home-based lifestyle programs[11].	1. No control or comparison group 2. Complementary medicine (e.g., purely herbal)
Outcomes	Primary: Grip strength, Shoulder Range of Motion (ROM), and Pain Intensity (VAS)[9]. Secondary: Lymphedema, Fatigue, Anxiety, and QoL.	1. Studies lacking physical functional data 2. Gray literature and non-peer-reviewed reports
Settings	All Countries	-
Study Designs	Randomized Controlled Trials (RCTs) and Controlled Clinical Trials (CCTs).	1. Case reports 2. Narrative reviews 3. Non-English publications

Information Source and Searches

The researchers conducted a comprehensive literature search through August 2025 in four primary databases: PubMed/PMC, Scopus, ClinicalTrials.gov, and the Cochrane

Library. The researchers used Medical Subject Headings (MeSH) and Boolean operators to conduct a systematic search for studies which investigated VR rehabilitation methods used by breast cancer patients. The search strings employed were as follows:
("Breast Cancer" OR "Mastectomy" OR "Lumpectomy") AND ("Virtual Reality" OR "Exergaming" OR "Kinect") AND ("Physiotherapy" OR "Resistance Training" OR "Range of Motion")
The researchers followed a systematized search procedure which required them to check references in pertinent studies through manual search methods to find additional information sources[12].

Study Selection

The research team used Microsoft Excel of systematically screen all information gathered from the literature search. In the first stage of database searching, 1,120 records were generated. After elimination of duplicate records (n = 280), a total of 840 records were left. Of the remaining records, 528 records were eliminated after assessing their titles and abstracts. A total of 312 full-text records met the inclusion/exclusion criteria specified under the PICO framework. Further analysis eliminated 276 articles, with reasons for exclusion (e.g., absence of primary physical functional measures, non-English language papers, and non-primary designs). By the end of this exercise, 35 primary studies (23 randomized controlled trials and 12 clinical controlled/quasi-experimental studies) were selected for synthesis.

Data Synthesis

The researchers used qualitative methods to synthesize results from various data sources across virtual reality systems featuring head-mounted displays and motion-tracking systems.

Data Collection

The researchers extracted data on authors, publication date, virtual reality intervention type (immersive head-mounted displays and the robotic Pablo system), participant demographics, and primary and secondary research outcomes, including range of motion, visual analogue scale and disabilities of arm/shoulder/hand disability, and the multidimensional fatigue inventory.

Quality Assessment

The researchers used the Physiotherapy Evidence Database (PEDro) scale to assess trial methodological quality, enabling comprehensive bias-risk evaluations across study designs.

Table II: Summary of Clinical Outcomes

Outcome Category	Specific Variable	Measurement Tool(s)	Key Findings & Statistical Significance
Primary	**Grip Strength**	Handheld Dynamometer, Pablo System	Significant improvement in the VR group at post-intervention and 2-month follow-up ($p < 0.001$)[9].
	Shoulder ROM	Goniometry (Flexion, Abduction)	Kinect-based VR programs significantly increased range of motion compared to traditional PT[13].
	Pain Intensity	Visual Analogue Scale (VAS)	Meta-analyses show VR therapies dramatically lower post-surgical pain levels[13].
Secondary	**Upper Limb Function**	DASH, UEFI Scores	VR-based Pablo training resulted in significant reductions in functional disability scores[9] .
	Lymphedema	Circumferential measures, bioimpedance	VR (Nintendo Wii) reduced lymphedema volume effectively compared to PNF techniques[14].
	Fatigue	Multidimensional Fatigue Inventory (MFI)	Significant reduction in cancer-related weariness $p < 0.001$ in the VR cohort[9].
	Anxiety	State Anxiety Inventory (SAI)	Significant decrease in anxiety levels recorded following VR sensor-based intervention[9].
	Quality of Life	QoL Scales (e.g., SF-36)	Kinect VR groups showed significantly higher QoL improvements ($p < 0.001$) vs resistance exercise alone[15].

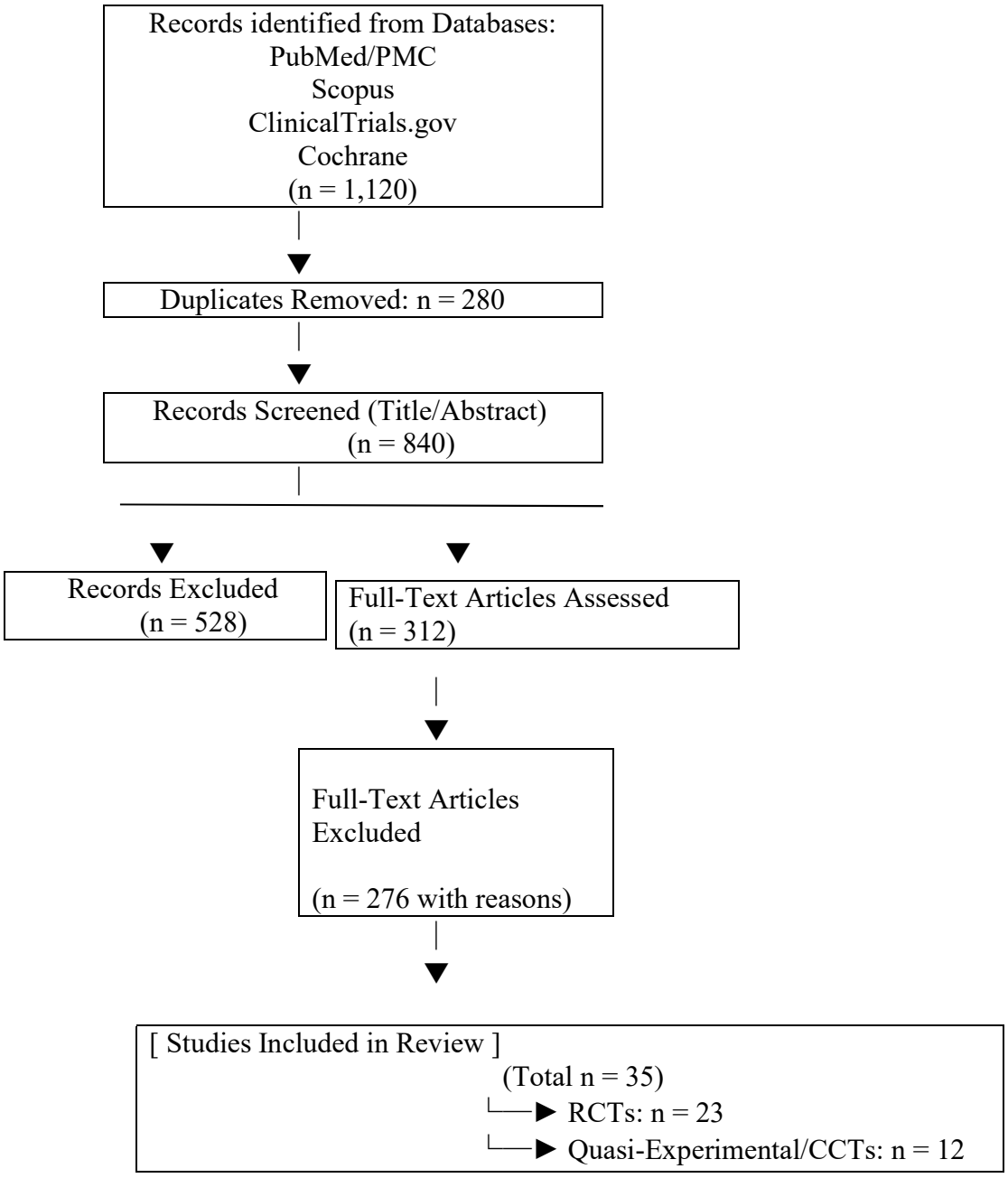

Figure 1: PRISMA Flow Diagram detailing the screening, inclusion, and study selection process for the systematic review.

RESULTS

The systematic review and selection process has led to the identification of 35 primary studies that met all criteria and are depicted in the PRISMA flow diagram shown in **Figure 1**. Of the 35 included studies, 23 are RCTs, and 12 are controlled clinical trials or quasi-experiments. Integrated rehabilitation approaches can serve as therapeutic interventions when coping with problems after surgery. Immersive VR using head-mounted displays decreases kinesiophobia and pain levels according to the VAS scale. The utilization of VR technologies improves both function and psychology, but manual techniques remain the standard treatment for lymphedema and reduce bodywide fatigue through lifestyle changes[16]. The Xbox Kinect and Nintendo Wii, along with Bright Arm Duo VR systems, show potential for increasing shoulder flexion and abduction range and movement speed, with muscle-pump stimulation reducing lymphedema volume. The Oculus Quest does more than support physical mobility by offering an opportunity to address "chemobrain" and anxiety through training and relaxation distraction.

Research shows a shift toward decentralized healthcare, as home-based telerehabilitation and mobile VR research demonstrate high usability and patient-safety benefits that enhance self-efficacy for rural survivors. The treatments help to manage immediate post-surgical symptoms. At the same time, they enable patients to achieve long-term functional improvement through their ability to decrease cancer-related fatigue and psychological distress, which allows patients to maintain physical activity for twelve months after treatment.

Table III: Summary of Results

Authors & Ref	Study Type	Population / Sample	Intervention Modality	Key Findings & Conclusion
Ibrahim A et al. (2024)[10]	RCT	Post-breast cancer surgery patients	Robotic/Sensor VR (Pablo System): Task-oriented hand and arm training	Demonstrated significant improvement in grip strength (**$p < 0.001$**) and reduction in DASH/UEFI scores. Effective for improving upper limb dexterity.
Feyzioğlu et al. (2020)[13]	RCT	Patients undergoing breast cancer surgery (**N = 60**)	Exergaming (Xbox 360 Kinect): Non-immersive motion-capture exercises	Increased shoulder ROM (flexion and abduction) compared with standard physiotherapy. High patient satisfaction reported.
Atef et al. (2025)[14]	Quasi-Experimental	Post-mastectomy patients with lymphedema	Exergaming (Nintendo Wii) vs PNF: Comparison of VR-based and manual rehabilitation approaches	VR significantly reduced lymphedema volume. Combined VR and PNF approach showed positive rehabilitation outcomes.
Lim et al. (2025)[15]	RCT	Breast cancer survivors (**N = 72**)	Kinect-Based Mixed Reality: Interactive VR combined with physical movement	Improved Quality of Life (SF-36) and physical function (**$p < 0.001$**) compared with home exercise programs.
Oliver Czech et al. (2024)[16]	RCT	Patients diagnosed with breast cancer	Immersive VR (HMD – Oculus): VR combined with music therapy for distraction	Improved overall physical and psychological well-being and enhanced patient comfort.
Li et al. (2024)[8]	RCT	Breast cancer patients undergoing chemotherapy	Immersive VR Therapy: Psychological and motor retraining environments	Enhanced neuroplasticity, increased patient engagement, and significantly reduced cancer-related fatigue.
Min et al. (2024)[6]	RCT	Post-breast cancer surgery patients (early rehabilitation phase)	Structured Exercise Program (Aerobic + Resistance Training)	Improved shoulder function recovery. Early intervention helped prevent postoperative stiffness and frozen shoulder.
Sharma et al. (2024)[17]	Primary CCT / Clinical Trial	Breast cancer patients with pain and limited ROM	VR-assisted upper limb mobility exercises	VR improved shoulder ROM, reduced post-surgical pain, and enhanced functional muscle strength.
Elkady et al. (2024)[33]	Primary Trial	Post-mastectomy patients	Virtual reality platforms combined with targeted upper limb rehabilitation protocols	Demonstrated comparable or superior outcomes to conventional physiotherapy (CPT) for active ROM and upper extremity strength improvement.
Huo et al. (2024)[9]	RCT	Patients receiving chemotherapy after radical surgery	Resistance Exercise Program: Strength-focused physical function training	Improved upper limb function and body composition despite ongoing chemotherapy cycles.
Basha et al. (2022)[19]	RCT	Patients with breast cancer-related lymphedema	Supervised exercise programs versus active lifestyle modifications	Demonstrated improvements in physical function, cardiorespiratory response, and long-term metabolic health indicators.

DISCUSSION

Based on the comprehensive results of clinical evidence generated from this systematic review, Virtual Reality (VR) may be considered an effective multidimensional addition to physical therapy (CPT). By providing an all-round approach to rehabilitation along a biopsychosocial spectrum, VR can overcome many obstacles inherent to CPT practices, changing the recovery process of post-surgical breast cancer patients altogether. Although physical therapy is still a cornerstone of postoperative care, its home practice implementation has been associated with low adherence rates, a relatively high prevalence of kinesiophobia (movement fear), and no ability to provide kinematic feedback to patients. VR technologies, both immersive and non-immersive, have proven effective at overcoming all three obstacles by making repetitive, painful physical exercises enjoyable through gamification and psychological reward mechanisms, as shown in recent meta-analyses[16].

Although the selected clinical trials have not collected imaging evidence of CNS changes or cellular scar-tissue remodelling, existing literature suggests that VR's illusion of presence may serve as a powerful non-drug distraction mechanism. The redirection of one's attention towards an external environment helps avoid activation of the descending pain pathways and allows patients to surpass their kinesiophobia[17]. Future clinical trials with neuroimaging are needed to confirm the specific effect of VR on the pain matrix and collagen remodeling process[32]. In addition to this, such a cognitive distraction is augmented through the use of specific task-oriented physical devices. From the synthesis of the results from the trial study, integration of VR algorithms with upper limb sensor systems, as demonstrated in the robotic Pablo system tested by Ibrahim A 2024[10], achieves measurable physiological benefits in terms of increased grip strength and reduced functional disability levels, including DASH and UEFI scores.

In addition, the rhythmic muscular movements produced by upper-body VR exercises function as a dynamic "muscle pump" mechanism within the body. The action of the muscle pump helps to increase venous return to the region and promote fluid clearance at a cellular level. Although manual lymphatic drainage and proprioceptive neuromuscular facilitation (PNF) therapy have long been considered the gold-standard treatment for lymphedema, clinical evidence shows that a video-game-based exercise system such as the Wii can help reduce lymphedema[18].

Moreover, the use of structured VR training with progressive resistance components yields improved muscle recruitment patterns. This leads to more favourable outcomes in sarcopenia therapy, muscle retention, and the development of lean body mass than regular elastic resistance band exercises[19].

Advanced imaging techniques have shown that immersion in a virtual environment reduces brain activity in specific regions of the "pain matrix," such as the primary somatosensory cortex, the anterior cingulate cortex (ACC), and the insular region[34]. Studies utilizing HMD and music therapy have proved that full immersion is an effective means of relieving general discomfort and pain during painful procedures associated with oncology[16].

Beyond the physical benefits of VR, of can create an effective "illusion of presence," which serves as a major non-pharmacological pain management strategy. According to recent neurological studies, VR is not merely a cognitive distractor. Instead, it provides

sufficient engagement of the visual, auditory, and somatosensory channels to affect the endogenous pain modulatory systems of the central nervous system. This, in turn, increases activity of descending inhibitory pathways, reducing central sensitization and local hypersensitivity associated with chronic post-mastectomy pain syndrome[20,21].

Furthermore, patients suffering from debilitating cancer-related fatigue (CRF) require holistic interventions, which should not be limited to conventional physical exercises. As the evidence in this review suggests, exergaming has a more pronounced impact on quality-of-life improvements than sedentary rest or conventional physical activity. Exergames are designed to create a stimulating environment for the release of endogenous neurotransmitters such as endorphins and dopamine, which regulate the patient's overall feelings of fatigue and reduce the severity of comorbid depression or anxiety[22]. From a systemic health care perspective, home-based telerehabilitation with virtual reality addresses many geographic and socioeconomic limitations. People in developing countries and rural areas can benefit from lower transportation costs, flexible scheduling, and shorter travel distances. With the introduction of clinical-grade motor tracking in a home environment, long-term compliance improves dramatically[23].

Moreover, the repetitive, high-amplitude motor control pathways involved in VR exergames activate the mechanoreceptors in the restricted glenohumeral and scapulothoracic joints, resulting in tissue elongation, alignment of collagen fibres within the scar tissue formed after surgery, and maintenance of viscoelasticity[32]. Combining VR exergames with the use of task-oriented hand/upper-arm training systems like the robotic/sensor-based Pablo system leads to clear physiologic improvements in grip strength and upper-extremity function disability index (DASH/UEFI scores) of patients[10].

CONCLUSION

The justification of this systematic review is based on the continued physical and psychological constraints experienced by breast cancer survivors after their surgery operations, including limited range of motion, constant pain, and intense fatigue. Because conventional home exercise routines have been found ineffective due to non-compliance and lack of feedback, we conducted a systematic review to analyze the effects of VR treatment.

Our results show that virtual reality-based treatment is efficient, safe, and highly motivating, and a valuable addition to traditional physiotherapy. Using external attention mechanisms, these applications help improve range of motion and grip strength in patients with shoulder dysfunction and pain after mastectomy surgery.

Clinical Implications: Oncology treatment pathways should incorporate VR or mixed-reality exergaming into rehabilitation protocols in home-based telerehabilitation programs. This strategy shifts healthcare treatment paradigms to a decentralized, patient-centred model of care that reduces costs and promotes greater patient equity.

Limitations: Although early findings appear promising, the literature suffers from inconsistent intervention durations and a lack of standardized monitoring. Future large-scale randomized controlled trials will need to follow patients' functional and mental resilience over a prolonged period to develop standardized guidelines for treatment prescriptions.

Disclaimer

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AUTHOR CONTRIBUTION

Irshad A: Conceptualization, methodology, data acquisition, formal analysis and drafting of the original manuscript
Babur MN: Conceptualization, research framework design, manuscript revision and senior supervision
Umar M: Data analysis/interpretation regarding physiotherapy protocols and critical revision of rehabilitation and upper extremity dysfunction content
Ashraf S: Interpretation of surgical data and postoperative outcomes and critical revision of surgical oncology and survivorship care content
Shaukat S: Data acquisition, screening of records and assistance in data synthesis and results table development

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