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Virtual Reality and Maitland Mobilization on Shoulder Dysfunction Post Mastectomy

Ahmed ElSayed ElSaid Abd ElDayem[1]*, Karim G. Moustafa[2], Karim Ibrahim Saafan[1,3], Haidy Nady Ashem[1]

[1] Department of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University, Egypt

[2] Department Of Reproductive Health, Medical Research Institute, National Research Centre, Egypt

[3] Department of Physical Therapy for Surgery, Burn and Integumentary, Faculty of Physical Therapy, Horus University, Egypt

*__Corresponding author:__ Ahmed ElSayed ElSayed Abd ElDayem, **Mobile**: (+20)01025370270,

E-mail: Ahmed AbdElDayem@pt.cu.edu.eg,

ABSTRACT

Background: Worldwide attention for postmastectomy shoulder dysfunction. Potential evidence regarding Maitland mobilization for its therapeutic benefits shoulder restrictions. Virtual reality is an innovative approach that facilitates simulation of functional tasks.

Objective: To determine efficacy of Maitland mobilization, and virtual reality on shoulder dysfunction postmastectomy.

Patients and methods: Sixty patients of both genders (57 females, and 3 males) suffering from postmastectomy shoulder dysfunction selected from Damietta Governmental Hospital, participated in this study, their age ranged 40-65 years. They were randomly allocated into three equal groups; Group A received Maitland mobilization, plus conventional physical therapy protocol; Group B received virtual reality, plus conventional physical therapy protocol, and Group C received Maitland mobilization and virtual reality, plus conventional physical therapy protocol.

Outcome measures: Shoulder mobility using digital goniometer, and shoulder dysfunction using shoulder pain and disability index.

Results: Unsignificant differences were revealed at baseline analysis. All groups had revealed a significant increase in shoulder mobility, and a significant improvement in shoulder dysfunction post treatment. While, there was significant improvements with favor for group C, over group A, over group B posttreatment in term of shoulder mobility, and dysfunction.

Conclusion: Both Maitland mobilization and virtual reality therapy are effective in shoulder dysfunction post mastectomy management, where Maitland mobilization, virtual reality, plus conventional physical therapy program was superior in terms of shoulder mobility, pain, and functional capability.

Keywords: Digital Goniometer, Maitland Mobilization, Shoulder Dysfunction, Shoulder Pain and Disability Index, Virtual reality.

INTRODUCTION

Cancer breast is the most commonly diagnosed malignant tumor with global prevalence nearby 15%, where untreated malignant neoplasm or cancer threatens host's life worldwide. Various mastectomy techniques were recognized as the first-line of treatment through reconstructive surgical intervention conducted for optimal management of breast malignancies **(1)**. Post mastectomy as an invasive intervention, numerous complications including seroma, pneumothorax, harm to axilla's neurovascular anatomy, shoulder pain, restricted mobility, fibrosis, lymphedema, and biomechanical shoulder dysfunctions might develop **(2)**.

Recent reports ensured that almost breast cancer survivors nearby 91% had physical impairments i.e., shoulder dysfunction postmastectomy was firstly described by Ewing and Martin in 1952, also it could have effect on the mechanics of the shoulder region because of tethering of soft tissues. Therefore, most of malignancies survivors suffer from shoulder dysfunction that may limit their active share in their rehabilitation facilities. That visualizes urgent need for a safe and more accessible alternative to traditional rehabilitation **(3)**.

Virtual reality (VR) is a novel, non-pharmacological, non-immersive to fully immersive, depending on the degree to which the user is isolated from the surrounding physically when interacting with the virtual environment, based on an innovative digital technology established by Morton Heiling in 1962 **(4)**.

Its sensory experiences are artificially created, promoting users to manipulate the objects that immerse individuals in a computer generated, multisensory, three-dimensional world wherein they interact with virtual environment **(5)**. VR is a valid method for targeting sedentary behaviors in malignancies` survivors post mastectomy **(4,5)**.

Numerous clinical trials stated additional pleasure among individuals who performed VT training, based on reported enjoyment and expressed extra positive feels towards exergaming in comparison to traditional procedures **(6)**.

A combined physiological and psychological therapeutic gains were ensured in terms of physical exertion across VT training strategy in line to encourage

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sedentary of overcome fear of targeted therapeutic procedures [5,6].

VR is addressed for required conservative intervention for improved effectiveness of rehabilitative programs in modern societies in line to adopted accelerated practice advances for management whom suffering from shoulder pain. It is considered a well-established and cost-effective approach [6]. Numerous clinical trials stated that patients get greater enjoyment and feel more positive toward VR compared with other forms of physical training [7].

Maitland mobilization is an effective manual treatment technique that restores pain-free mobility via several repetitions, resulting in enduring recovery. It is predicated on the assessment and rectification of any small positional articulation defect. This exceptional equipment concentrates on realigning positional defects in joints by providing a specifically directed glide to the painful joint, evaluating and changing force intensity, while the patient actively engages in joint mobility [8].

Maitland's rhythmic passive oscillations are categorized from Grade I to IV based on intensity, applied to the shoulder to alleviate pain and stiffness, hence influencing circulatory perfusion. The mechanism influences blood circulation, as the flow within the vessels supplying nerve fibers and the synovial fluid surrounding the avascular articular cartilage is generated through a pressure gradient. This process facilitates the exchange of articulating fluids, thereby reversing the cycle of ischemia, edema, and inflammation, reducing joint effusion, and alleviating pain by diminishing pressure on the nerve endings [9].

The suitable choice of mobilizing technique for therapy may only occur following a comprehensive assessment and examination [10]. Recently, it could be advised for modulating painful complains and improving shoulder mobility plus functional capacity among frozen shoulder population [11].

Actual need of current study developed due to lack in quantitative knowledge about the efficacy of Maitland mobilization and virtual reality in improving shoulder pain and range of motion in patients post mastectomy [12].

The present study might help surgeons and physical therapists to enhance the protocol of treatment for cases of shoulder pain and range of motion post mastectomy. Lake of time and self-motivation to active exertion are the main excuse for being physically inactive among post-surgical intervention populations who are still complaining of pain. Thus, what have been challenging for researchers is to find more motivational, more encouraging, and time efficient types of exercise training.

A combination of physiological and psychological benefits of physical activities makes both Maitland mobilization and virtual reality an appealing strategy to encourage post mastectomy individuals to exercise. Up to the researcher`s knowledge there is a gap in the body of knowledge about effect of Maitland mobilization and virtual reality on shoulder pain and range of motion outcomes in post mastectomy individuals [13]. The need of this study developed from the rarity of data in the published articles about the combination of Maitland mobilization with virtual reality in management of shoulder dysfunction post mastectomy. Thus, the current study aimed to determine the therapeutic efficacy of Maitland mobilization versus virtual reality on shoulder dysfunction postmastectomy, to identify the most effective treatment program for shoulder dysfunction postmastectomy.

PATIENTS AND METHODS

Study design

A randomized, prospective, pre/post-treatment, controlled study was conducted from June 2023 to June 2024 at the Outpatient Clinic of Damietta Governmental Hospital, Damietta.

Ethical considerations:

This study adhered to the Helsinki Declaration and received clearance from the Ethics Committee of the College of Physical Therapy, Cairo University (approval No.: P.T.REC/012/005682). Subsequent to obtaining ethical approval, individuals furnished informed consent prior to enrollment.

Participants

Sixty participants suffering from postmastectomy shoulder dysfunction were enrolled based on specific inclusion criteria: they included both genders '57 females, and 3 males', aged 40 to 65 years, underwent modified radical mastectomy from one-month earlier suffering from shoulder pain and limited range of motion, and free of any comorbidities such as systemic or neurological diseases.

Patients were excluded if they had hyperthyroidism, diabetes mellitus, parkinsonism, spinal cord injury, brain damage, congestive heart failure, anxiety, alcoholism, or if they had received any treatment with medications affecting sweating (e.g., thyroxin, anxiolytics) that had not been discontinued at least four weeks prior to this study. Additionally, those with cardiac conditions such as arrhythmia, ischemic heart disease, low exercise tolerance, low respiratory reserve, lymphedema, sensory disorders, or who were pregnant or lactating were also excluded.

Sample size calculation

A sample size of 60 patients was calculated using G*POWER statistical software (version 3.1.9.4; Franz

Faul, Universität Kiel, Germany) to provide sufficient statistical power

The sample size estimation relied on shoulder range of motion evaluated with a universal goniometer, as well as shoulder pain intensity and functional disabilities assessed through the shoulder pain and disability index data from prior studies by **Wankhade *et al.*** [14] **and de la Crespo *et al.*** [15].

The analysis was conducted with 80% power at an α = 0.05 significance level, involving two outcome measures across three groups, and an effect size of 0.74, utilizing F-test MANOVA for repeated measures within and between interactions. The necessary sample size was established at 20 participants per group.

Randomization

All participants received information on the study's features, aims, and advantages, along with their ability to withdraw or refuse participation at any time. Subsequent to the execution of the permission forms, demographic data were acquired. An independent researcher utilized computer-generated random cards contained within sealed and opaque envelopes to randomly and equitably allocate the 60 individuals to Groups A, B, or C. The envelopes were sealed and numbered consecutively to guarantee disguised distribution, keeping participants oblivious to their group assignments. The participant flow is depicted in Figure 1 in accordance with the CONSORT 2010 principles [16].

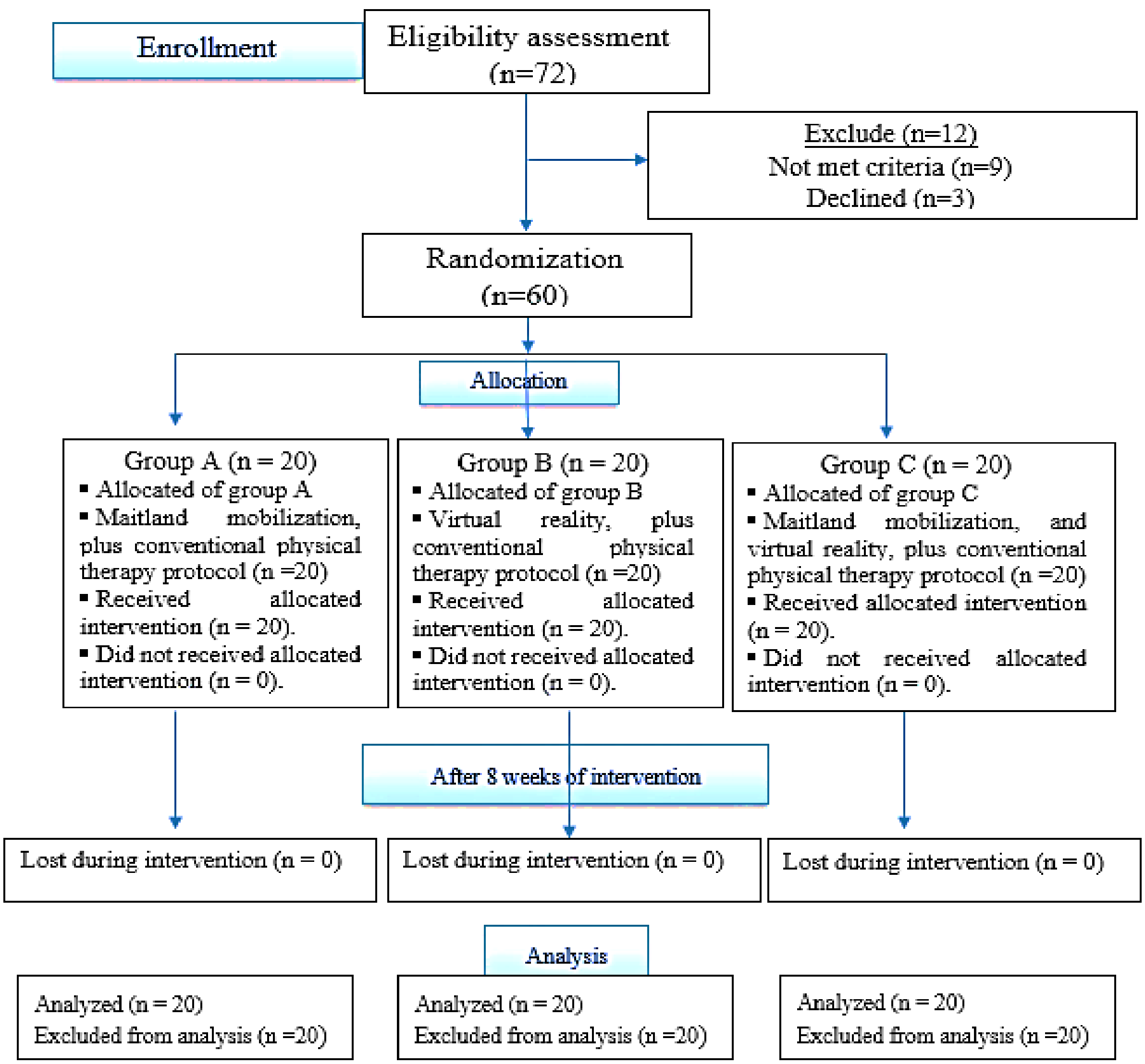

Fig. 1. CONSORT flow chart of the study.

Outcomes measures

Measurements were conducted prior to and subsequent to the 8-week intervention.

Primary outcome measures

Digital goniometer

Digital goniometer is a widely practical universal device, it is 6 inches, 2.53 oz, 1x360 degree stainless steel goniometer [Outlev/ Outlev-01, China] was used in this study [17].

This study employed a digital goniometer, a protractor with either a 180° or 360° scale, with a single axis that connects two arms. One arm is fixed while the other arm is adjustable around the axis or fulcrum of the protractor. The assessment was performed for shoulder flexion, abduction, and external rotation [18].

The Shoulder Pain and Disability Index (SPDI)

The SPDI is a patient-administered questionnaire of 13 items that evaluate pain intensity and the degree of difficulty in performing activities of daily living that need the use of the upper extremities. The pain subscale has 5 items, whereas the disability subscale consists of 8 items. The SPDI score totals 50, whereas the disability scale totals 80 [19].

Therapeutic Equipment

Xbox Kinect 360 Console, sensors and monitor for display

This study utilized virtual reality with the Microsoft Xbox Kinect 360 system, which was launched by Microsoft (Redmond, WA, USA) in November 2011. Kinect is a motion-sensing input device designed for the Xbox 360 game system. It allows users to manipulate and engage with Xbox 360 games and apps without the necessity of physically contacting a gaming controller or any item. Kinect does this with a natural user interface that monitors the user's bodily movements and employs gestures and vocal instructions using speech recognition[20].

Intervention

In this study, patients were randomly assigned to three groups, each consisting of 20 participants: Group A received Maitland mobilization with a standard physiotherapy regimen that incorporated active range of motion exercises, including pendulum movements, shoulder shrugs, scapular pinches, and hand-behind-head reach exercises. Group B participated in virtual reality with the traditional physiotherapy regimen. Group C received Maitland mobilization, virtual reality treatment, and a standard physiotherapy regimen. All groups adhered to a treatment protocol consisting of 24 sessions over a duration of 8 weeks, with three sessions each week.

Maitland mobilization

Forty participants in groups A and C underwent the Maitland graded oscillation technique applied to the glenohumeral (GH) joint, utilizing anteroposterior (A-P), posteroanterior (P-A), and longitudinal caudal glides, as well as posterior and anterior glides for the sternoclavicular joint, and anterior glides for the acromioclavicular joint. This regimen consisted of fifteen glides over a duration of 30-40 minutes, conducted three times per week for eight weeks. Prior to the initiation of Maitland mobilization, a briefing was held to educate the patients on its concepts [21].

Tab. 1. Maitland mobilization [21]

Articulation	Maitland mobilization technique	Sets	Repeats
Glenohumeral	Anteroposterior glide; Patient in supine, researcher held patients` lower humerus from medial side posteriorly, putting patients` forearm facing across body. Elevate up to 20 from coronal plane towards trunk while bending knee, also cupped heel of other hand over humerus, and fingers stretched out around acromion process.	15 glides; 2-3 oscillations per second for 1-2 minutes, 3-4 times per direction Oscillations grades: I-II to alleviate pain, irritability, III-IV to lengthen joints` capsule.	3 sets per week; along 8 weeks.
	Posteroanterior glide; Patient in prone, researcher held lower humerus anteriorly from volar with forearm facing across body, other cupped hand heel behind humerus head, then stretched out fingers above in front acromion process.		
	Longitudinal caudal glide; Patient in supine, researcher facing held lower humerus end medially, then placed forearm with patients` forearm, cupped other hand heel superiorly over humeral head with extended fingers posteriorly and caudal oscillation performed.		
Scapulothoracic	Posterior glide; Patient in side-lying, researcher standing, superior hand across acromion, inferior hand scoop under medial border, inferior scapular angle moving via inferior angle or acromion process.		
Sternoclavicular	Posterior glide; Patient in supine, researcher thumb on anterior end of clavicle proximally, flex index, and place middle phalanx along its caudal to support thumb. Push via thumb in posterior, Superior glide; same, thumb push in superior direction. Anterior glide; Patient in supine, researcher fingers superior, thumb inferiorly around clavicle. Thumb and fingers lift clavicle. Caudal glide; Finger press inferiorly.		
Acromioclavicular	Anterior glide; Patient in sitting, researcher behind stabilizing acromion with lateral hand fingers, other hand thumb push downward across upper trapezius, place posterior to clavicle medial to pushing in anterior direction.		

Virtual reality

Forty participants within groups B and C received virtual reality in a series of Kinect adventure games and designed for Xbox 360 Kinect console, and projected onto a 24-inch screen LED-Lit monitor, along 30-40 min, 3 sets/ week along 8 weeks. Before the commencement of virtual reality, a preparatory phase ensuring device safety, explanation of tools, procedures were conducted to gain patients` confidence, and cooperation [22].

Tab 2. Virtual reality: Application phase [22]

Initial	Virtual reality application phase exercises	Repeat
Ensure familiarization session, scoring system via explaining Kinect recording system across	Active shoulder Shrug exercise; Researcher instructed patient to raise bilateral shoulders up using visual and auditory VR feedback.	3 sets per week; along 8 weeks.
	Active Shoulder Blade Pinchers exercise; Researcher instructed patient to pinch bilateral shoulders` blades backward using visual and auditory VR feedback.	
	Codman`s/ Pendulum ‘Active Internal and External rotation’; Researcher instructed patient to move affected extremity in a circular maneuver using visual and auditory VR feedback.	
	Behind back shoulder internal rotation exercise ‘Sitting or Standing’; Researcher instructed patient to pinch shoulders` blades backward using visual and auditory VR feedback.	

Conventional physical therapy program

All sixty participants completed conventional physiotherapy regimens for a duration of 8 weeks, attending three sessions weekly. This program is composed of 30-40 minutes supervised active ROM in form of **a;** Pendulum exercise; patient bent over at wrist, then let his/ her arm hangs down owing to imitate through swing affected arm gently, then in a circular movement. **b**; Shoulder shrug exercise: active shrug both shoulders upward. c; Shoulder blade pinches; Pinch bilateral shoulder blades backward while standing. d; Hand-behind head reach exercise; Clasp both hands and tried to move arms behind head with elbows facing forward [21,22].

Statistical analysis

One-way ANOVA test was employed to compare subject characteristics between groups. Basic statistics (mean, standard deviation, median) were calculated for quantitative variables. The Shapiro-Wilk test was utilized to assess the normality of the data distribution. Levene's test was employed to assess the homogeneity of variances among groups. A mixed MANOVA was utilized to examine the effects of the intervention on shoulder range of motion and shoulder pain disability index. Post-hoc tests using Bonferroni correction were carried out for subsequent multiple comparison. All statistical analyses were conducted at a significance threshold of $p < 0.05$, employing SPSS version 25 for Windows (IBM SPSS, Chicago, IL, USA).

RESULTS

Participant characteristics:

Table 3 presents the characteristics of participants in both groups. There were no notable variations between the groups for age, weight, height, and BMI ($p > 0.05$).

Table 3. Comparing the characteristics of participants between A, B, C groups:

Demographic data	Group A (n = 20) Mean±SD	Group B (n = 20) Mean±SD	Group C (n = 20) Mean±SD	F-value	p-value
Age (years)	52.35±5.33	53.5±4.41	52.95±4.7	2.01	0.14
Weight (kg)	78.9±6.63	78.55±7.38	77.5±7.99	0.62	0.54
Height (cm)	170.7±2.01	170.35±3.25	169.55±3.87	1.74	0.18
BMI (kg/m^2)	27.03±1.62	27.02±1.72	26.99±1.67	0.01	0.99

BMI, body mass index; Data are mean± SD for all demographics. P-Value < 0.05 indicate statistical significance.

Effects of the intervention on shoulder flexion, abduction, internal and external rotations, and SPDI:

Mixed MANOVA revealed significant interaction effects between treatment and time (F= 243.66, p = 0.001, partial eta squared = 0.96), alongside significant main effects of treatment on groups (F= 115.64, p = 0.001, partial eta squared = 0.92), and time (F = 2820.97, p = 0.001, partial eta squared = 0.99).

- Within group comparisons:

All groups A, B and C exhibited significant improvements in shoulder ROM 'flexion, abduction, internal and external rotation', and SPDI score post-treatment compared to pre-treatment (Table 4).

Tab 4. Mean shoulder ROM, and SPDI scores before and after treatment of A, B, C groups:

Variable	**Group A** (n = 20)		**Group B** (n = 20)		**Group C** (n = 20)		F value	P value	η 2
	Pre	Post	Pre	Post	Pre	Post			
Flexion (°)	110.9 ± 1.92	143.35±2.95	110.5 ± 2.04	134.05±1.99	110.55 ± 1.8	164.35±3.52	0.02	<0.001	0.92
MD (95% CI)	-32.45 (-33.48, -31.42)		-23.55 (-23.5, -23.6)		-53.8 (-55.52, -52.05)				
Abd (°)	90.85 ± 1.88	114.6± 3.47	90.45 ± 1.85	101.2±2.26	90.5 ± 1.67	122.75±2.05	0.02	<0.001	0.93
MD (95% CI)	-23.75 (-25.34, -22.16)		-10.75 (-11.16, -10.34)		-32.25 (-32.63, -31.87)				
Int. Rott (°)	43.6 ± 1.6	63.05±2.59	43.2± 1.68	55.5±1.71	42.8 ± 1.47	71.15±1.52	0.03	<0.001	0.91
MD (95% CI)	-19.45 (-20.44, -18.46)		-12.3 (-12.33, -12.27)		-28.35 (-28.4, -28.3)				
Ext Rott (°)	44.7 ± 1.84	64.95±2.42	44.7± 1.49	57.3±1.72	44.35 ± 1.63	75.95±1.39	0.03	<0.001	0.06
MD (95% CI)	-20.25 (-20.83, -19.67)		-12.6 (-12.83, -12.37)		-31.6 (-31.36, -31.84)				
SPDI (score)	54.25 ± 1.33	22.55 ± 1.85	54.2± 1.28	32.25 ± 1.52	54.1 ± 1.45	15.35 ± 1.69	0.02	<0.001	0.04
MD (95% CI)	31.7 (31.18, 32.22)		21.95 (21.71, 22.19)		38.75 (38.51, 38.99)				

SPDI: Shoulder Pain and Disability Index; **η 2:** partial eta squared. MD: Mean difference, CI: Confidence interval. P-Value < 0.05 indicate statistical significance. Data are mean± SD. Data are mean± SD.

- Between group comparisons:

There were moderate significant differences between pretreatment, and posttreatment outcome measures regarding Maitland mobilization, plus conventional physical therapy program. There were mild significant differences regarding pretreatment, and posttreatment outcome measures regarding virtual reality, plus conventional physical therapy program. Finally, there were highly significant differences regarding pretreatment, and posttreatment outcome measures regarding Maitland mobilization, and virtual reality, plus conventional physical therapy program (Table 5).

Tab. 5. Between groups' effects posttreatment

Variable	**Group A versus group B**		**Group A versus group C**		**Group B versus group C**	
	MD (95% CI)	**p-value**	**MD (95% CI)**	**p-value**	**MD (95% CI)**	**p-value**
Flexion (degree)	9.3 (10.26, 8.34)	<0.05	-21 (-21.57, -20.43)	<0.001	-30.3 (-31.83, -28.77)	<0.001
Abduction (degree)	13.4 (14.61, 12.19)	<0.005	-8.15 (-6.73, -9.57)	<0.01	-21.55 (-21.34, -21.76)	<0.001
Internal Rotation (degree)	7.55 (8.43, 6.67)	<0.05	-8.1 (-7.03, -9.17)	<0.01	-15.65 (-15.46, -15.84)	<0.001
External Rotation (degree)	7.65 (8.35, 6.95)	<0.05	-11 (-9.97, -12.03)	<0.001	-18.65 (-18.32, -18.98)	<0.001
SPDI (score)	-9.7 (-9.37, -10.03)	<0.05	7.2 (7.36, 7.04)	<0.05	16.9 (16.73, 17.07)	<0.001

SPDI: Shoulder Pain and Disability Index; MD: Mean difference, CI: Confidence interval. P-Value < 0.05 indicate statistical significance. Data are mean± SD.

DISCUSSION

The primary conclusions of the study indicated that the integration of Maitland mobilization, and virtual reality therapy to the conventional physical therapy program had statistically significant improvements in terms of shoulder mobility, pain, and functional capability in patients suffering from shoulder dysfunction post mastectomy. Post-treatment comparisons showed significant improvements in shoulder mobility (flexion, abduction, internal and external rotation), pain, and functional capability for Group C, over group A, over group B ($p < 0.001$).

Indeed, current study findings could be explained based on the well-known accessory shoulder articulations mobilization therapeutic benefits on nociceptive pain ‘inhibition role’, plus mechanoreceptors at spinal cord and brain stem levels, particularly Grade I, and II. In addition, Maitland mobilization is responsible for improving shoulder mobility, mainly Grade III, and IV those also known to facilitate synovial fluid flow thus enhance nutrients supply to shoulder articulations` cartilage [(8)]. This aligns with the outcomes by **Zahoor *et al.*** [(23)], who stated that Maitland mobilization is a rehabilitation approach that is effective in management of idiopathic adhesive capsulitis. Also, **Ali *et al.*** [(24)] who recently investigated Maitland mobilization efficacy in terms of pain intensity level, shoulder mobility, and functional disability on individuals suffering from adhesive capsulitis.

A recent clinical trial conducted on forty-two postmastectomy women suffering from shoulder dysfunction had received Maitland mobilization approach. They reported substantial improvements in terms of shoulder mobility and functional capabilities after one month by 68.22% for shoulder flexion, 44.97% for shoulder abduction, 43.32% for shoulder internal rotation, 65.02% for external rotation, and 56.59% regarding functional capabilities, respectively and that in group B received traditional physical therapy exercise training protocol was 44.38% for shoulder flexion, 28.71% for shoulder abduction, 31.45% for shoulder internal rotation, 38.19% for external rotation, and 34.57% regarding functional capabilities, respectively [(25)]. Consequently, they demonstrated that the use of Maitland mobilizations is more effective than only employing a traditional physical therapy regimen in improving shoulder dysfunction regarding range of motion, pain, and function post-mastectomy.

Maitland mobilization oscillatory glide effectively modulates pain intensity by increasing the release of endogenous analgesics such as endorphins. Additionally, oscillatory motions activate mechanoreceptors linked to myelinated alpha-beta and alpha-delta fibers. The impulses elicited by Maitland mobilization obstruct the pain signal and disrupt the pain cycle by engaging the pain gate, so alleviating discomfort in daily activities, reducing pain during particular tasks, and facilitating arm movement and lifting motions. A decrease in the patient's pain corresponded with a reduction in SPDI scores [(26)]. Maitland mobilization provokes Golgi tendon organ, boosting synovial fluid nutrition, and reducing adhesion. At the end of Maitland mobilization results in reflex musculoskeletal inhibition [(27)].

Additionally, **Jagtap and Varadharajulu** [(28)] had studied thirty diabetic participants suffering from frozen shoulders with moderate irritability levels. They stated that Maitland mobilization combined with conventional physical therapy protocol significantly permits neurophysiological modulation of pain intensity levels and improves functional recovery among diabetic population suffering from frozen shoulder with moderate tissue irritability.

On the other hand, a recent clinical trial ensured that Maitland mobilization technique was superior in treating frozen shoulder over mulligan technique in term of pain intensity level, unless it is not documenting any detrimental therapeutic benefits, which was the 1st clinical trial that examined Maitland mobilization on postmastectomy individuals regarding shoulder dysfunction rehabilitation [(29)].

Recently, augmented virtual reality has been introduced into rehabilitation field to ensure its effective and personalized computerized-generated three-dimension-environment that in turn specified highly interactive required experience [(30,31)]. In addition, VR permits an optimal support for efficient patient motivation to have an active engagement in the prescribed rehabilitation protocol that support current revealed results [(32,33)].

The application of virtual reality in musculoskeletal therapy delivers a multi-sensory experience and presents potential for recovery.

Brady *et al.* [(5)] have asserted that they offer significant insight into clinicians' acceptance of immersive VR as a medium for rehabilitation. No one exercise program has demonstrated definitive superiority in the management of shoulder pain, VR based interventions have been shown to be effective in managing acute and persistent pain.

Virtual reality technology provides a means to enhance exercise prescription in the rehabilitation of musculoskeletal shoulder discomfort. A recent comprehensive evaluation by **Longo *et al.*** [(6)] advocated the use of VR during the early healing and intermediate periods of surgical rehabilitation. The metaverse, augmented reality, and virtual reality provide significant possibilities for the future of orthopedic surgery. Virtual reality offers immersive experiences to folks worldwide in many circumstances. Recent evidence-based treatments for shoulder diseases include virtual reality as a kind of conservative therapy, first implemented to facilitate remote mentorship and supervision for orthopedic surgeons specialized in shoulder surgeries [34]. On the other side, evidence strengthened the rehabilitation for shoulder disorders based on exercise program that enhanced by shoulder joint mobilization targeting shoulder dysfunction patients` daily needs, clinical manifestations and existing shoulder restrictions[35].

Clinical relevance:

This study's findings revealed substantial improvements in all assessed variables, underscoring the beneficial effects of Maitland mobilization and virtual reality treatment on patients with shoulder dysfunction following mastectomy. The findings suggest that including both Maitland mobilization and virtual reality into conservative physical therapy might enhance recovery outcomes for this specific demographic when integrated into rehabilitation programs.

Strengths and limitations:

This study illustrated the benefits of Maitland mobilization and virtual reality, emphasizing their effectiveness without negative consequences and offering preliminary evidence for their incorporation as an essential component of rehabilitation for patients with shoulder dysfunction following mastectomy. The research had limitations, including insufficient follow-up, a brief treatment duration, and restricted generalizability due to the small sample size and unique demographic included, along with individual variability in patient reactions to therapy.

To enhance the evidence for both Maitland mobilization and virtual reality therapy in the rehabilitation of shoulder dysfunction following mastectomy, additional studies should incorporate extended treatment durations, larger sample sizes, and follow-up evaluations to validate the efficacy of these interventions. Extended research in more heterogeneous populations will be essential to augment these findings. Furthermore, subsequent research is recommended to evaluate the cost-effectiveness of both Maitland mobilization and virtual reality treatment in comparison to conventional rehabilitation approaches, which is crucial for comprehending their economic feasibility and prospective advantages.

CONCLUSION

In accordance with the study's metrics, results, and limitations, both Maitland mobilization and virtual reality therapy are effective in shoulder dysfunction post mastectomy management, where Maitland mobilization, virtual reality, plus conventional physical therapy program was superior in terms of shoulder mobility, pain, and functional capability.

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REFERENCES

1. **Tommasi C, Balsano R, Corianò M *et al.* (2022):** Long-term effects of breast cancer therapy and care: Calm after the storm? J Clin Med., 11:7239.
2. **Liszka M, Samborski W (2018):** Assessment of biomechanical parameters of the shoulder joint at the operated side versus non-operated side in patients treated surgically for breast cancer. Rep Pract Oncol Radiother., 23:378.
3. **Dennett A, Harding E, Reimert J *et al.* (2021):** Telerehabilitation was safe, feasible and increased exercise uptake in cancer survivors: A process evaluation (Preprint). JMIR Cancer, 7: e33130.
4. **Qian J, McDonough J, Gao Z (2020):** The effectiveness of virtual reality exercise on individuals` physiological, psychological and rehabilitative outcome: A systematic review. Int J Environ Res Public Health, 17(11):4133-4139.
5. **Brady N, Dejaco B, Lewis J *et al.* (2023):** Physiotherapy beliefs and perceptive on virtual reality supported rehabilitation for the management of musculoskeletal shoulder pain: A focus group study. PLoS One, 18(4):284445-284453.
6. **Longo G, Carnevale A, Andreoli F *et al.* (2023):** Immersive virtual reality for shoulder therapy program executed with oculus quest 2. BMC Musculoskeletal Disorders, 24(1):859-864.
7. **Tokgoz P, Wahnert D, Elsner A *et al.* (2023):** Virtual reality for upper extremity rehabilitation: a prospective pilot study. Health care J., 11(10):1498-1495.
8. **Çelik D, Mutlu K (2016):** Does adding mobilization to stretching improve outcomes for people with frozen shoulder? A randomized controlled clinical trial. Clin. Rehabil., 30: 786-794.
9. **Jivani R, Hingarajia N (2021):** Effect of spencer muscle energy technique versus Maitland's mobilization technique on pain, disability in patients with frozen shoulder: A comparative study. International Journal of Physiotherapy and Research, 9(4):3928-3936.
10. **Almureef S, Ali M, Shamsi S *et al.* (2020):** Effectiveness of mobilization with conventional physiotherapy in frozen shoulder: A systematic review. Int J Recent Innov Med Clin Res., 2(4):22-29.
11. **Abbas M, Hassnain U, Bilal S *et al.* (2024):** Effect of Maitland mobilization with and without spencer muscle energy techniques in treatment of frozen shoulder. Internat Conference Integrated Care, 4(1): 1342-1346.
12. **Lang A, Murphy M, Dickerson C *et al.* (2021):** Shoulder dysfunction in breast cancer survivors: Can treatment type or musculoskeletal factors identify those at higher risk? Rehabilit Oncol., 9(3): 143-151.

13. **Elabd M, Etoom M, Jahan M *et al.* (2024):** The efficacy of muscle energy technique and Mulligan mobilization techniques for the upper extremities and posture after breast cancer surgery with axillary dissection: A randomized controlled trial. J Clin Med., 13(4): 980.
14. **Wankhade S, Phansopkar P, Chitale N (2021):** Effect of oculus guided physical therapy in adjunct to conventional therapy in frozen shoulder patients: A research protocol. J Pharmaceut Res Internat., 33(43A): 218-223.
15. **de la Crespo A, Donegan T, Amestoy-Alonso B *et al.* (2023):** Virtual embodiment for improving range of motion in patients with movement-related shoulder pain: an experimental study. J Ortho Surg Res., 18(729):927-935.
16. **Hopewell S, Boutron I, Moher D (2020):** CONSORT and its extensions for reporting clinical trials. https://link.springer.com/rwe/10.1007/978-3-319-52636-2_188
17. **Kolber J, Hanney J (2012):** The reliability and concurrent validity of shoulder mobility measurements using a digital inclinometer and goniometer: a technical report. International journal of sports physical therapy, 7(3): 306-309.
18. **Correll S, Field J, Hutchinson H *et al.* (2018):** Reliability and validity of Halo digital goniometer for shoulder range of motion in healthy subjects. Int J Sports Phys Ther., 13(4):707-714.
19. **Goldstein P, Ringash J, Bissada E *et al.* (2014):** Scoping review of the literature on shoulder impairments and disability after neck dissection. Head Neck J., 36(2): 299-308.
20. **Aggarwal K, Lamba K, Faraz F *et al.* (2018):** Comparison of anxiety and pain perceived with conventional and computerized local anesthesia delivery systems for different stages of anesthesia delivery in maxillary and mandibular nerve blocks. India J Dent Anesth Pain Med., 18(6):367-373.
21. **Braireddy S, Nelakurthy S (2020):** A study to find out efficacy of ultrasound with Maitland`s mobilisation versus low level laser with Maitland`s mobilisation in management of adhesive capsulitis. Editorial Borard., 9(1):30-37.
22. **Carnevale A, Mannocchi I, Sassi H *et al.* (2022):** Virtual reality for shoulder rehabilitation: accuracy evaluation of Oculus Quest 2. Sens (Basel), 22(15):5511-5517.
23. **Zahoor M, Ali B, Khan A *et al.* (2021):** Effectiveness of Maitland manual therapy technique in management of idiopathic adhesive capsulitis. Annual of Allied Health Sciences, 7(1):3-7.
24. **Ali M, Hashim M, Wassem I *et al.* (2022):** Comparison of Maitland mobilization and muscle energy technique on pain, range of motion and functions in adhesive capsulitis. Pakistan Biomedical Journal, 1:129-133.
25. **Hammad M., Waked S, El Ghani E *et al.* (2023):** Maitland mobilizations on shoulder dysfunction postmastectomy. International Journal of Chemical and Biomedical Sciences, 24(9):156-164.
26. **Vyas D (2022):** To see the effectiveness of Maitland mobilization technique on shoulder complex (AC, SC, ST, GH joint) on pain and function in patient with frozen shoulder: an experimental study. International Journal of Creative Research Thoughts, (IJCRT), 10(3):545-551.
27. **Alam F, Azharuddin M, Zaki S (2024):** Effectiveness of shoulder mobilization combined with muscle energy technique in the management of adhesive capsulitis: A randomized control trial. Saudi J Sports Med., 24:35-42.
28. **Jagtap V, Varadharajulu G (2024):** Assessing the impact of Maitland mobilization combined with a conventional physiotherapy regimen using the visual analogue scale and disability of the arm, shoulder and hand scale in diabetic frozen shoulder with moderate tissue irritable level. Cureus, 16(11):74640-74646.
29. **Anwar M, Mughal W, Izhar N *et al.* (2023):** Effectiveness of Maitland mobilization technique in comparison with mulligan mobilization technique in management of frozen shoulder. Pakistan Journal of Medical Health Sciences, 17(5):57-59.
30. **Brady N, Lewis J, McCreesh K *et al.* (2021):** Physiotherapist beliefs and perspectives on virtual reality-supported rehabilitation for the assessment and management of musculoskeletal shoulder pain: a focus group study protocol. HRB Open Res., 4:40-49.
31. **Best P, Meireles M, Schroeder F *et al.* (2022):** Freely available virtual reality experiences as tools to support Mental Health Therapy: a systematic scoping review and Consensus Based Interdisciplinary Analysis. J Technol Behav Sci., 7(1):100-114.
32. **Gumaa M, Youssef A (2019):** Is virtual reality effective in orthopedic rehabilitation? A systematic review and meta-analysis. Phys Ther., 99(10):1304-1325.
33. **Cattaneo A, Fragasso M, Magni M *et al.* (2023):** Assessing the Accuracy of the Azure Kinect for Telerehabilitation after breast Cancer surgery. IOS Press., 1(2):83-88.
34. **Casari A, Navab N, Hruby A *et al.* (2021):** Augmented reality in orthopaedic surgery is emerging form proof of concept towards clinical studies: a literature review explaining the technology and current state of the art. Cur Rev Musculoskelet Med.,14:192-203.
35. **Lee H, Jeon G, Yoon J (2023):** Effects of exercise intervention (with and without joint mobilization) in patients with adhesive capsulitis: A systematic review and meta-analysis. Healthcare, 1(10):1504-1509.