RESEARCH PAPER

The Role of Graded Motor Imagery in Managing Shoulder Dysfunction Post-Mastectomy: Evidence from a Randomized Controlled Study

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ABSTRACT

Introduction: Functional limitation of upper body is widely recognized as a common postoperative consequence of surgical treatment for breast cancer. Following surgery, nearly 67% of patients have upper limb/ shoulder dysfunction, such as numbness, painful sensations, weakening of the muscles, and limited motion range [1].

Objective: This study aimed to investigate whether graded motor imagery affected shoulder dysfunction following a mastectomy.

Subjects and methods: Fifty-four patients, aged between 35 to 55, experiencing shoulder dysfunction following mastectomy, were split into two equivalent groups using a random selection process. Group (A): 27 patients underwent graded motor imagery (GMI) in addition to a conventional physiotherapy program, two sessions weekly for 6 weeks. Group (B): 27 patients underwent conventional physiotherapy program, two sessions weekly for 6 weeks. Conventional physiotherapy program included capsular stretching and active assisted ROM exercises, including codman/ pendular exercises involving forward-backward movement, side-to-side movement, and circular movements, as well as wall climbing (finger ladder), shoulder wheel, and wand exercises. Measures of shoulder pain, disability, range of motion, and muscular strength were taken both before and following the intervention.

Results: The findings indicated that graded motor imagery had a favorable impact on shoulder dysfunction. Individuals showed decreased levels of shoulder pain and achieved greater mobility in the joint. Furthermore, increases in muscle strength were observed ($p > 0.05$).

Conclusion: Graded motor imagery was with significant improvements in shoulder pain, range of motion, and muscle strength, indicating its therapeutic value in shoulder rehabilitation.

Key words: Motor Imagery-shoulder dysfunction-chronic pain- mastectomy- mirror therapy.

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INTRODUCTION

Cancer of the breast is considered the most commonly cancer diagnosed worldwide and a major contributor to cancer-associated mortality. It includes a group of cancerous diseases that arise in the breast tissue. Depending on the features of the diagnosis, management typically entails a mix of radiotherapy, chemotherapy, hormonal therapy, targeted treatments, and surgical intervention (either mastectomy or breast-conserving surgery) [2].

Mastectomy is the entire surgical eradication of the breast's glandular tissue in order to remove any malignant growths from the breast and/or the glandular tissue itself [3]. After mastectomy, 17% to 32% of patients experience reduced shoulder mobility and function, which can be caused by lymphedema, post-surgical stiffness, thoracic wall pain, and nerve-related muscle atrophy. These functional limitations can last both immediately after surgery and in the long term [4].

Several treatment methods have been investigated to treat shoulder pain and limited mobility. Aerobic and resistance workout, conditioning, water-based therapy, modified gymnastics, yoga, and Pilates have all proven effectiveness in alleviating symptoms and functional efficiency [5].

Graded motor imagery (GMI) is one of the methods that encourages neuroplasticity and functional recovery. By modifying neuronal oscillations and strengthening synaptic connections, it promotes neuroplasticity and supports cortical reorganization. It facilitates the recovery of cognitive and motor abilities by strengthening neural pathways related to attention and executive function through regular mental stimulation and practical, hands-on instruction. Within this context, GMI helps to lessen the severity of pain and improve physical function through promoting reorganization of the sensory and motor cortices. Its effectiveness has been demonstrated in patients with musculoskeletal pain and other conditions linked to central sensitization [6,7].

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Despite these findings, there is still little quantitative data on how graded motor imagery affects shoulder function after mastectomy. In order to provide insight into a possible therapeutic approach for post-operative rehabilitation, the study was undertaken in order to determine the efficacy of graded motor imagery in enhancing shoulder function and reducing pain in patients following mastectomy.

SUBJECTS AND METHODS

Study design

The efficacy of GMI in reducing shoulder dysfunction after breast cancer removal surgery was evaluated in a randomized, double-blind, trial with inclusion of controls by using a computer-driven block method to ensure unbiased group allocation. The study was carried out from June 2025 to January 2026 at Sehr Al Hayah to Support Cancer Patients Charity, Cairo, Egypt.

Ethics

The Research Ethics Committee of [Cairo University's Faculty of Physical Therapy] in Egypt approved the study (No: P.T.REC/012/005749). The study protocol complied with the Helsinki Declaration on ethical research involving human subjects. All patients received detailed information concerning the objectives, methodology, and benefits of the study, as well as their freedom to discontinue participation at any time and for any reason. Also, they provided written consent prior to study initiation. The study was recorded on ClinicalTrials.gov (NCT07240129).

Recruitment and Randomization

An oncologist at Al Qasr El Eini Hospital referred 64 mastectomy patients to the trial. Ten of these were ineligible to participate: four did not fit the eligibility criteria, and six refused to engage in the study. Thus, fifty-four patients with shoulder dysfunction following mastectomy were enrolled in the study (Figure 1) and allocated at random into two similarly sized groups using SPSS software for Windows, v 27 (IBM SPSS, Chicago, IL, USA). Allocation was blinded by keeping the randomization codes in sequentially numbered, sealed, transparent envelopes. To maintain objectivity, randomization was performed by an assessor not engaged in either the evaluation or treatment interventions.

Eligibility for inclusion was determined according to the following criteria: women aged 35–55 years with unilateral mastectomy, chronic shoulder pain lasting over three months (after a year of surgery), and restricted shoulder mobility. Cognitive comprehension was required, and each patient gave informed consent. The exclusion criteria were as follow: Patients were excluded if they had undergone bilateral mastectomy, had psychopathological or neurological disorders (e.g., hemiplegia), other orthopedic conditions affecting the shoulder (such as inflammation in tendon, joint dislocation/ osteoarthritis, or referred pain), or motor impairments (e.g., tremor, dyskinesia). Additional exclusions included metastatic disease, lymphedema, diabetes mellitus, significant visual impairments preventing reading even with corrective lenses, or prior exposure to graded motor imagery (GMI) treatment.

Measured outcomes

Primary measured outcomes were shoulder pain, assessed using (VAS), and active ROM (flexion, abduction, and external rotation), measured with clinometer app, while secondary measured outcomes were upper limb functionality, assessed by the shoulder pain and disability index (SPADI) scale, and shoulder flexor and abductor muscles strength that were measured by handheld dynamometer. All outcomes were assessed at baseline and post-intervention.

Primary measured outcomes

Visual analog scale

- The VAS allows patients to quantify their pain on a 10-cm line, with 0 representing no pain and 10 the worst pain imaginable, with scores determined by measuring the distance from the zero point [8].

Smartphone clinometer application for measuring shoulder ROM

- Shoulder ROM was measured using a mobile phone with a clinometer app. For flexion and abduction, patients stood with the elbow extended while the phone was aligned along the distal humerus; they were instructed to raise the arm forward (flexion) or sideways (abduction) as far as possible, and the angle was recorded. For external rotation, patients lay on their back with the shoulder and elbow at 90° abduction and flexion, respectively. The phone was positioned along the distal forearm just below the styloid processes, and patients rotated the arm backward toward the floor; the resulting angle was recorded from the app [9].

Secondary measured outcomes

The Shoulder Pain and Disability Index (SPADI) for measuring shoulder disability

- SPADI is a self-reported measure of shoulder pain and function comprising 13 items—5 for pain and 8 for functional disability—rated using a 0–10 (VAS) scale. Each subscale's score is computed and added together to get a final score between 0 and 100, with greater numbers denoting more disability. [10].

Handheld dynamometer (HHD) for measurement of shoulder flexor and abductor muscles strength

- Strength of shoulder flexor and abductor muscles was assessed via an isometric protocol. Patients sat on a chair with back support, with the tested arm positioned at 90° flexion for flexors and 90° abduction for abductors. A device was placed on the distal arm approximately 5 cm above the elbow. Participants performed a 5-seconds maximal isometric contraction, following an auditory cue, with three trials separated by 1-minute rest intervals. The average of the three measurements was recorded [11][12].

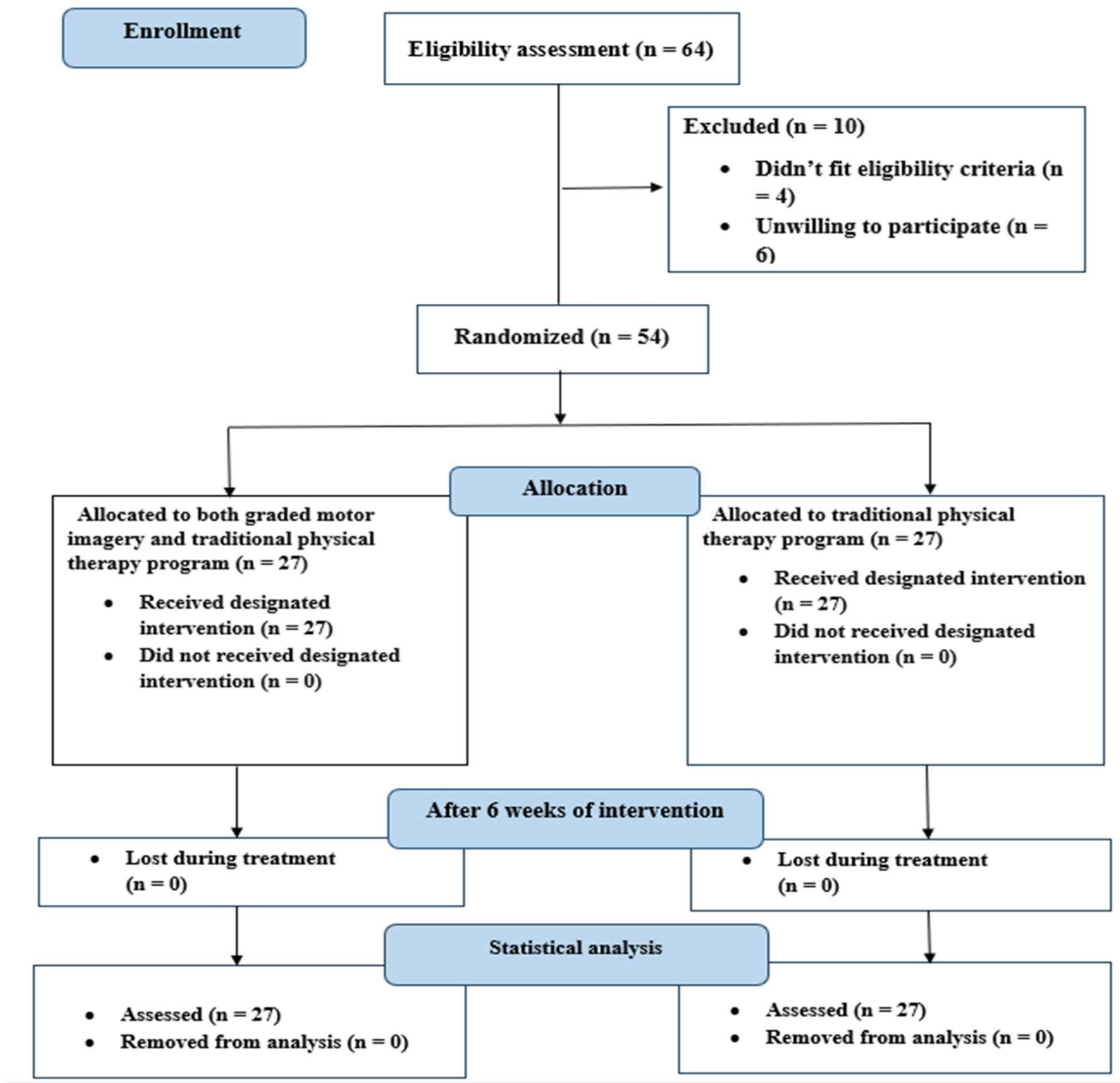

Fig. 1. CONSORT flow chart of the study

Interventions

In Group A, the 27 patients received graded motor imagery along with conventional physiotherapy program. While in Group B the 27 patients received only the conventional physiotherapy program. The conventional physiotherapy program included capsular stretching and active assisted ROM exercises, including codman/ pendular exercises involving forward-backward movement, side-to-side movement, and circular movements, as well as wall climbing (finger ladder), shoulder wheel, and wand exercises. Patients received 12 therapy sessions across six weeks, with two sessions per week.

Graded motor imagery (GMI) program

The program comprised a three-step process, with each step implemented over two weeks and lasting 30 minutes per session. The steps were as follows:

1. **Left/right judgements:**

The intervention included left/right discrimination tasks using photographs of the affected shoulder. Patients were shown flashcards depicting left and right shoulders and asked to identify each correctly.

2. **Imagined movements:**

The intervention included movement visualization of the affected shoulder without actual movement. Patients were shown randomized images of both shoulders and instructed to mentally rehearse smooth, pain-free, full-range movements represented in the images.

3. **Mirror therapy:**

Patients were instructed to observe movements of the unaffected limb in a stand mirror (137 length* 78 width). This created the illusion that the affected limb was moving pain-free, thereby providing positive visual feedback that movement could occur without pain [8].

Conventional physiotherapy program

The program was composed of a group of exercises that carried out in 45 minutes/ session, two times/ week for 6 weeks as follows:

- **Posterior Capsule Stretching:**

Patients lay on the affected side with the shoulder and elbow flexed to 90°. A glenohumeral internal rotation force was applied passively until a stretch was felt in the posterior shoulder. Each stretch was maintained for 30 seconds, performed three times, with 30-second rest intervals between repetitions [13].

- **Range of motion exercises:**

a. **Codman/ pendular exercise:**

Codman pendular exercises use gravity to passively mobilize the glenohumeral (GH) joint to minimize stress on injured tissues. Manual scapular stabilization in a forward-leaning standing position helps direct the stretch to the GH joint. The arm is moved in anterior–posterior, lateral, or circular directions to provide gentle traction, pain relief, and early joint motion [14][15].

b. **Wall Climb (Finger Ladder) Exercise:**

For shoulder flexion, patients stood facing the ladder; for abduction, they stood sideways. The affected hand was placed on a low rung and advanced upward slowly to the maximum reachable height. Following a 5-seconds hold, the limb was gradually lowered to baseline. The exercise was repeated 10 times [16].

c. **Shoulder wheel exercise:**

Patients performed clockwise and counterclockwise shoulder rotations with a shoulder wheel, standing sideways for flexion and facing forward for abduction, with resistance increased progressively for strengthening [17].

d. **Wand exercises:**

Patients performed assisted shoulder exercises using a stick to improve flexion, abduction, and outward rotation, with the unaffected arm guiding the affected arm. In standing, patients lifted the extended arm overhead for flexion and laterally to the highest possible point for abduction. In supine, the arm rested on the plinth and the elbow bent to 90°, the unaffected arm assisted the affected arm outward to perform external rotation [14].

Sample size calculation

To determine the necessary sample size, a power analysis for a repeated-measures MANOVA (within-between interaction) was executed via G*Power (v 3.0.10). With the parameters set at a 0.5 effect size, alpha level = 0.05, and a statistical power of 0.95, a minimum of 54 total subjects was prescribed, split equally into two groups of 27.

Statistical analysis

The participants' characteristics were compared between groups using an unpaired t-test. The distribution of surgery type, surgical side, and hormonal therapy were compared between groups via the chi-squared test. The Shapiro-Wilk test was utilized to confirm data normality, and Levene's test was applied to assess homogeneity among groups. A two-way mixed-model MANOVA was conducted to examine both within-group and between-group effects across VAS pain scores, ROM of shoulder, SPADI disability scores, and strength of shoulder muscles. Subsequent multiple comparisons were adjusted using the Bonferroni method. The level of statistical significance was established at $p < 0.05$. Statistical analyses were carried out using SPSS software v 27.0 for Windows (IBM SPSS, Chicago, IL, USA) [18].

RESULTS

- Participants demographics:

As shown in Table (1), groups A and B were well-matched in their demographic and clinical profiles. Age, BMI, surgical type, surgical side, and hormonal therapy distribution weren't statistically different ($p > 0.05$).

Table 1. Comparison of subject characteristics between group A and B:

	Group A	**Group B**			
	Mean ±SD	**Mean ±SD**	**MD**	**t- value**	**p-value**
Age (years)	47.70 ± 4.10	48.37 ± 3.56	-0.67	-0.63	0.53
BMI (kg/m²)	33.72 ± 3.48	32.79 ± 3.53	0.93	0.98	0.33
Type of surgery, n (%)					
Modified Radical Mastectomy	19 (70%)	19 (70%)		($\chi^2 = 0$)	1
Partial Mastectomy	6 (22%)	6 (22%)			
Radical Mastectomy	2 (8%)	2 (8%)			
Side of surgery, n (%)					
Dominant	14 (52%)	14 (52%)		($\chi^2 = 0.08$)	0.77
Non- dominant	13 (48%)	13 (48%)			
Hormonal therapy					
Hormonal therapy	21 (78%)	23 (85%)		($\chi^2 = 0.49$)	0.48
None	6 (22%)	4 (15%)			

SD, Standard deviation; MD, Mean difference; χ^2, Chi squared value; p value, Probability value

Effect of treatment on VAS, shoulder ROM, SPADI and shoulder muscles strength:

Treatment and time significantly interacted, according to two-way mixed MANOVA ($F = 41.39$, $p = 0.001$, $\eta p^2 = 0.88$).

Main effects were also significant for both time (F = 436.14, p = 0.001, ηp²= 0.98) and treatment (F = 6.20, p = 0.001, ηp² = 0.52).

Comparison within group

Following treatment, both Groups [A and B] showed significant reductions in VAS, pain, disability, and total SPDI scores compared to their baseline levels (p < 0.001). (Table 2).

Additionally, both Group A and Group B demonstrated significant improvements following treatment compared to baseline measurements in shoulder flexion, abduction and outward rotation ROM, alongside enhanced strength in shoulder flexors and abductors. (p < 0.001). (Table 3-4).

Comparison between groups

Following the intervention, patients in the group A experienced a highly significant decrease in pain and disability compared to the group B. This improvement was reflected in lower VAS scores (ES = 1.17, p < 0.001) and marked drops across all SPADI subscales, including pain (ES = 1.20, p < 0.001), disability (ES = 1.27, p < 0.001), and overall score (ES = 1.44, p < 0.001). (Table 2).

In addition, following treatment analysis showed that Group A had significantly greater gains than Group B in shoulder flexion ROM (ES = 1.10, p < 0.001), shoulder abduction ROM (ES = 2.33, p < 0.001), shoulder external rotation ROM (ES = 0.99, p < 0.001), shoulder flexors strength (ES = 1.22, p < 0.001) and shoulder abductors strength (ES = 1.81, p = 0.001). (Table 3-4).

Table 2. Mean VAS, pain, disability and total SPADI scores pre and post treatment of group A and B:

	Group A	**Group B**			
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	**p value**	**ES**
VAS					
Pre treatment	7.07 ± 0.83	6.85 ± 0.86	0.22 (-0.24: 0.68)	0.34	
Post treatment	2.93 ± 0.87	3.96 ± 0.90	-1.03 (-1.52: -0.55)	0.001	1.17
MD (95% CI)	4.14 (3.77: 4.53)	2.89 (2.51: 3.27)			
	p = 0.001	***p = 0.001***			
SPADI					
Pain					
Pre treatment	64.54 ± 9.93	63.56 ± 7.65	0.98 (-3.85: 5.83)	0.***68***	
Post treatment	28.16 ± 6.68	37.87 ± 9.25	-9.71 (-14.12: -5.30)	0.001	1.20
MD (95% CI)	36.38 (33.64: 39.12)	25.69 (22.94: 28.43)			
	p = 0.001	***p = 0.001***			
Disability					
Pre treatment	58.57 ± 8.01	56.90 ± 9.55	1.67 (-3.14: 6.48)	0.49	
Post treatment	23.42 ± 4.37	29.95 ± 5.85	-6.53 (-9.35: -3.71)	0.001	1.27
MD (95% CI)	35.15 (32.18: 38.14)	26.95 (23.97: 29.93)			
	p = 0.001	***p = 0.001***			
Total score					
Pre treatment	61.56 ± 8.23	60.23 ± 7.26	1.33 (-2.91: 5.57)	0.53	
Post treatment	25.79 ± 4.88	33.91 ± 6.32	-8.12 (-11.20: -5.04)	0.001	1.44
MD (95% CI)	35.77 (33.34: 38.20)	26.32 (23.89: 28.75)			
	p = 0.001	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, probability value; Cohen effect size

Table 3. Mean shoulder flexion, abduction and external rotation ROM pre and post treatment of group A and B:

ROM (degrees)	**Group A**	**Group B**			
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	**p value**	**ES**

Flexion					
Pre treatment	110.67 ± 13.96	112.30 ± 15.87	-1.63 (-9.79: 6.53)	0.69	
Post treatment	152.85 ± 16.02	135.59 ± 15.25	17.26 (8.72: 25.80)	0.001	1.10
MD (95% CI)	-42.18 (-45.69: -38.68)	-23.29 (-26.81: -19.79)			
	p = 0.001	***p = 0.001***			
Abduction					
Pre treatment	100.93 ± 5.29	99.89 ± 5.75	1.04 (-1.98: 4.06)	0.49	
Post treatment	138.30 ± 10.31	117.85 ± 6.82	20.45 (15.67: 25.22)	0.001	2.33
MD (95% CI)	-37.37 (-39.92: -34.82)	-17.96 (-20.51: -15.42)			
	p = 0.001	***p = 0.001***			
External rotation					
Pre treatment	70.37 ± 12.73	71.00 ± 10.88	-0.63 (-7.10: 5.84)	0.85	
Post treatment	86.26 ± 6.77	78.78 ± 8.27	7.48 (3.35: 11.61)	0.001	0.99
MD (95% CI)	-15.89 (-18.63: -13.14)	-7.78 (-10.52: -5.03)			
	p = 0.001	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, probability value; Cohen effect size

Table 4. Mean shoulder flexors and abductors strength pre and post treatment of group A and B:

Strength (N)	**Group A**	**Group B**			
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	**p value**	**ES**
Flexors					
Pre treatment	697.27 ± 108.26	708.72 ± 90.70	-11.45 (-66.00: 43.09)	0.67	
Post treatment	1001.11 ± 97.35	883.04 ± 96.87	118.07 (65.03: 171.10)	0.001	1.22
MD (95% CI)	-303.84 (-325.07: -282.61)	-174.32 (-195.55: -153.08)			
	p = 0.001	***p = 0.001***			
Abductors					
Pre treatment	681.59 ± 101.87	703.06 ± 105.99	-21.47 (-78.24: 35.30)	0.45	
Post treatment	994.90 ± 119.25	791.68 ± 104.97	203.22 (141.87: 264.57)	0.001	1.81
MD (95% CI)	-313.31(-332.46: -294.14)	-88.62 (-107.77: -69.46)			
	p = 0.001	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, probability value; Cohen effect size

DISCUSSION

This study evaluated the efficacy of graded motor imagery (GMI) in mitigating shoulder pain and improving active ROM, function, and muscle strength following a mastectomy. Although both the intervention and control cohorts exhibited significant advancements in pain reduction and functional recovery ($p < 0.001$), the GMI group demonstrated superior outcomes.

These findings corroborate those reported by **Araya-Quintanilla et al. (2020)** who assessed the acute efficacy of graded motor imagery (GMI) in modifying pain-related emotional experience and shoulder mobility in individuals with persistent shoulder pain. Their results indicated that GMI facilitates improvements in both domains, possibly via central mechanisms involving decreased activation of neural structures implicated in the emotional-affective processing of pain, including catastrophizing and fear-avoidance behaviors [7].

The study's outcomes were in line with those of **Gurudut and Godse (2022)**, whose study findings demonstrate that integrating (GMI) into traditional physiotherapy protocols significantly enhances outcomes for patients with acute frozen shoulder. By employing cortical remapping techniques—right-left discrimination, imagined movements, and mirror therapy—GMI helps desensitize the nervous system. This approach leads to measurable improvements in shoulder mobility while simultaneously reducing clinical pain levels and fear of movement [8].

Also, the findings of this study showed beneficial effects on shoulder pain, AROM, muscle strength, and functional status after 6 weeks of treatment in both groups in favor to study group compared to control group and this is agreed with **Amir et al. (2025)** who investigated the efficacy of GMI training on pain, AROM, isometric strength of muscle, and functional status in chronic pain patients diagnosed with sub-acromial pain syndrome and they found that the addition of GMI training into conventional physiotherapy for sub-acromial pain syndrome therapy program produces superior clinical results in alleviating pain and improving functional ability. [19].

This study demonstrated measurable and significant decline in both pain levels and disability, along with improvements in shoulder (ROM) in both groups, with faster pain reduction observed clinically in the GMI group. These findings align with **Sırlan et al. (2025)** who reported that while both groups in their trial showed improvements in pain, function, ROM, and fear of pain, adding GMI in the intervention resulted in quicker alleviation of pain, enhanced both mechanical sensitivity and motor imagery abilities, and boost patient contentment. This may be attributed to the mechanisms of GMI, where right-left discrimination stimulates the premotor cortex to alter attention away from pain and restore somatosensory function, while motor imagery activates movement-planning areas like the primary motor cortex, thereby minimizing movement-related fear and pain [20].

Unlike the present study, **Yasaci and Celik (2025)** observed that an 8-week course of GMI and multimodal physiotherapy improved functional outcomes (SPADI/Q-DASH) for stiff shoulder patients. Despite these benefits, no significant improvement was observed clinically in pain during activity, and gains in ROM were minimal. Their findings suggest that while GMI enhances functional recovery, its effect on pain and joint mobility may be limited. Nevertheless, they acknowledged that these findings may have been influenced by study limitations, including a short follow-up given the propensity for frozen shoulder to reoccur, along with the need for expertise and experience [21].

Accordingly, the study provides strong evidence that GMI serves as a potent clinical tool, yielding significantly better results in shoulder rehabilitation in post- mastectomy patients than traditional protocols alone.

Clinical relevance

The clinical applicability of these findings is limited, as the majority of patients in this study underwent modified radical mastectomy. Therefore, the observed effects of the treatment may not be generalizable to patients undergoing other types of mastectomies.

Strengths and Limitations

The treatment did not cause any adverse reactions. However, it is important to take into account the study's limitations. Limited sample size and unequal distribution of surgical procedures among patients result in a lack of generalizability. Furthermore, the study of GMI treatment's long-term efficacy was hampered by the short follow-up period. Variations in surgeons' expertise, possible measurement errors during the intervention, and differences in patients' psychological status and cooperation may also have affected the results.

CONCLUSION

The study demonstrated that graded motor imagery produced beneficial outcomes for individuals who's suffering from dysfunction in shoulder after mastectomy. Participants experienced a reduction in shoulder pain along with noticeable improvements in range of motion. In addition, muscle strength showed significant enhancement, suggesting that graded motor imagery may be an effective approach for improving overall shoulder function.

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Declaration of conflict of interest

No competing interests exist.

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