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Impact of Graded Motor Imagery Training Paradigm on Shoulder Pain and Quality of Life in Patients with Chronic Stroke

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Shoulder Pain,
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ABSTRACT:

Background: Stroke is a major cause that affect quality of human being all over the universe. The most significant component of upper- extremity problems leading to disability is shoulder pain. The shoulder joint has a great range of movement and minimal joint stability that is susceptible to a number of post-stroke problems, including joint pain, subluxation, and restricted range of motion. Purpose: The study was conducted to examine the impact of graded motor imagery training on shoulder pain as well as quality of life after stroke. Subjects: Forty-two patients with chronic stroke were included in the study. Patients have been selected from Merit university outpatient clinic. Methods: Patients in this study were randomized into 2 groups; Group (A) study groups: 21 patients were given Graded motor imagery training paradigm and traditional therapy (take-oriented active/passive range of motion training), while Group (B) control group: 21 patients were received task-oriented active/passive range of motion training only. Results: A significant improvement on shoulder pain as well as quality of life in group A compared with group B. ($p<0.05$). Mean values of KVIQ scale after therapy were 4.71 and 4.48 in groups A and B. Mean values of active shoulder flexion ROM after therapy were 169.86 and 163.05 in groups A and B. Mean values of the Shoulder Pain and Disability Index (SPADI) after therapy were 19.19 and 25.43 in groups A and B. Mean values of time selection of affected side (sec) after therapy were1.59 and 1.85 in groups A and B. Mean values of accuracy of response of affected side were 98.81 and 94.52 in groups A and B. Conclusion: Graduated motor imagery training improved quality of life and reduced shoulder pain in patients with chronic stroke, according to the study, and may be useful adjuncts to conventional physical therapy protocols to improve shoulder function.

Introduction

About 15 million individuals experience a stroke every year, making it one of the top causes of disability and death globally, placing a significant strain on the social health care system. At the same time, 12-49 percent of stroke survivors report debilitating shoulder pain as a result of their condition. Typically occurs 2 to 3 months following a stroke and can lead to patients leaving rehabilitation programs early, spending more time in the hospital, having impaired limb function, and having a negatively impaired quality of life,[19].

The number of patient endure from stroke is continuously expanding all over the universe. A stroke patients always have major complication lead to disabilities. Limited upper limb function is one of the major complications post stroke, and only 5% of patients having stroke restore the full functional range of the paralyzed extremity. This can affect the function of activities and reduce the patient's quality of life, [17].

Recent research has shown that patients with persistent joint pain had higher levels of neural activation in the amygdala, anterior cingulate cortex, insular cortex, as well as somatosensory cortex. It is a reflection of the modified afferent sensory stimuli's altered peripheral sensory transmission, as well as the outcome of the body's higher sensory representation's plasticity and perceptual modifications, [2].

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The behavioral reaction to pain and damage is one of the cognitive-affective characteristics that are influenced by the mesolimbic-prefrontal regions. The activation of these higher brain regions is associated with a poor prognosis in chronic pain situations. These regions are involved for processing fear, negative conditioning, emotions, and attention problems. They also assist the maintenance of symptoms in patients [2].

For the purpose of providing clinical benefit in complicated regional pain syndrome (CRPS), graded motor imagery (GMI) preparation progresses from advancement of advanced sensory cortex organization to focused sensory discrimination training. Progressively activated cortical motor networks are stimulated by graded motor imagery without inducing the pain-defending response. The only way to understand the overly intricate nociception system and the disrupted brain circuits is through GMI [11].

The applications of GMI have three levels for clinical use. It requires left along with right judgment, that stimulates the premotor cortex without engaging key motor zones. The 2nd stage of GMI is anecdotal motions that activate motor cortex sections in comparison to those triggered during actual movement achievement, [11].

Mirror treatment activates the motor cortex and gives the cortex a powerful visual input during the third stage of graded motor imagery; nevertheless, brain imaging in healthy individuals has strengthened activation for all stages of GMI. It has been observed that early pain reduction is achieved by therapeutic strategies such as the visualization approach, and that the same brain components are involved in motor imagery with proprioception and visualization, [11].

For excruciating motor problems, mirror therapy is used with the motor imagery approach as part of a process known as Graded Motor Imagery. Using this procedure, the specialist can help patients activate their brain cells in a gradual and specific way [5].

Material and Methods

Subjects:

Forty-two patients with chronic Stroke with shoulder pain and functional disability joined the study with age range 45-65 years with the duration of insult more than 3 month. **Group (A) study group**: received GMI training paradigm and traditional treatment (task-oriented active/passive ROM training), while **Group (B) control group**: received task-oriented active/passive ROM training only. The criteria for exclusion were Patient having shoulder stiffness after chronic stroke, bilateral shoulder pain due to multiple strokes, loss of hand movement post stroke, problems related to mental health or psychology. In addition, the patient discontinued participation in the trial exceeding three sessions. 6-Patients with any systemic diseases that could compromise the study's aims. The study was approved by the Faculty of Physical Therapy Ethics Committee at Cairo University (No: P.T.REC/012/004519) and the Clinical Trials Registry (NCT05479942).

<u>Instrumentation:</u>

Kinesthetic as well as Visual Imagery Questionnaire (KVIQ), recognise Online program, electronic digital goniometer, along with the Shoulder Pain and Disability Index (SPADI).

Procedures:

<u>Evaluation:</u>

<u>Measurement procedures:</u>

1- **Kinesthetic and Visual Imagery Questionnaire (KVIQ):** A self-evaluation questionnaire based on the Kinesthetic and KVIQ was used to evaluate the patients' abilities in motor imagery. The questionnaire was divided into two regions (visual and kinesthetic), and it required participants to imagine shoulder flexion and extension movements. Utilizing a five-point ordinal scale ranging from 1 D (no image/sensation) to 5 D (image/sensation), subjects rated the vividness as well as clarity of the visual representation (visual motor imagery) and the intensity of the physical sensation (kinesthetic motor imagery), simulating the experience of seeing or doing the movement, [8].
2- **Recognise Online program:** The Recognize web application shows various portions of the body that correlate to the patient's damaged limb (left and right). Throughout this section of GMI, a number of pictures are displayed to the patient, each one corresponding to the injured limb. Data measurement and analysis (response time and accuracy). During Recognize Online practice, the same program measured reaction time and response accuracy (right answers). The results indicated the mean value of each trial on such parameters for each patient separately for each treatment session, [1].

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3- **Electronic digital goniometer:** With the patient seated in a chair, we measured their shoulder ROM. The test began with the subject's upper extremity in a neutral position and involved active shoulder flexion. There were two assessments in each session, [5].

The Shoulder Pain and Disability Index (SPADI): It is a self-reporting questionnaire that evaluates functional abilities and pain levels. Five questions on the pain scale assess different levels of pain. The eight-question functional exercise evaluation is based on the individual's reported level of difficulty with a variety of ADLs requiring the use of their upper extremities. The SPADI is an reliable and accurate method to assess the shoulder in a specific area; it usually takes patients around 5 to 10 minutes to finish, [3].

Treatment

A- **Graded motor imagery training paradigm:** it is the most up-to-date method of rehabilitation for a variety of complex pain and mobility problems, it originates from cutting-edge research and clinical studies. The term "graded motor imagery" refers to a technique whereby an individual visualizes themselves performing a movement in their minds rather than physically performing the activity. There are three separate stages to the treatment process, [13].

1. **Left/right discrimination (Implicit motor imagery):** it is, the capacity to differentiate between the left and right sides of their affected body parts. It appears that this ability is critical for the typical healing of pain. If one trains their brain well over an extended period of time, it can change and adapt to new situations. The data were collected utilizing the Recognize Online program after its administration to the shoulder area, [5]

   Procedure: The patient sits in a chair with a backrest in front of a touch-screen I-pad. It was instructed that students should use their right and left fingers to press the corresponding buttons on the screen in order to make a swift and precise selection, regardless of whether a picture of a right or left shoulder was displayed, [5].

2. **Explicit motor imagery:** Basically, it's like planning to move but not actually doing it. If you're in pain, it could be difficult to carry out imagined movements. This is probably due to the fact that 25% of your brain's neurons are mirror neurons', which begin firing when you think about moving or simply watch another one else move. When you imagine motions, you utilize similar brain regions as when you move. This is frequently why athletes envision an activity and then perform it. The next level in the GMI program was mentally performing a series of voluntary movements. The goal was for the patients to replicate physically as well as functionally the shoulder flexion via a carefully guided program, [6].

   Procedure: For the majority of the program, patients sat on a chair with their eyes closed. Patients were provided with detailed scripts outlining the movements and activities to foster the development of their visual imagination. The imagery was improved even more by watching the therapist do the movements [16]. Motor imaging of main motions placed an emphasis on verbal guidance and action observations, [16].

3. **Mirror therapy:** By positioning your left hand behind the mirror while placing your right hand in directly in front of it, you may fool your brain into believing that the reflection of your right hand within the mirror is your left. Right now, when you start moving your right hand, you're using your left hand to exercise your brain. The GMI training has been recommended as a therapeutic approach for stroke survivors' shoulder pain and movement difficulties, [10].

   Procedure: The patients were positioned directly in front of a 180 centimeter by 50 cm mirror. Sharp glass, used to make the mirror, does not distort the body it reflects. Prior to the program's execution, the degree of resemblance between the two sides of the body was assessed; if it was found to be lacking, the quality of the illusion would be diminished, and the patients' upper limbs' objects would be deleted. The procedure was designed to give patients the false impression that they were looking at an injured shoulder when, in reality, the healthy side was reflected. To do this, the therapist spent the first visit thoroughly explaining the complicated technique, [5].

A- **Traditional therapy (task-oriented active/passive range of motion training):**

- Patient done 3 tasks: **Procedure:** Patient swigging water from a glass, elbow extended and shoulder flexion 90° 15 repetitions of carrying a glass of water

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to a 90° shoulder flexion position and using an extended elbow to wipe the table with a towel.

- Practice shoulder flexion and abduction active ROM, and passive ROM training, [7].

Statistical analysis

The study employed the unpaired t-test to compare subject characteristics among groups, and the Chi-squared test to compare categorical data. The data was tested for normal distribution utilizing the Shapiro-Wilk test. To evaluate the homogeneity among groups, Levene's test was used. To examine the effects within and across groups on KVIQ, active shoulder flexion ROM, SPADI, and recognizing shoulder application, a two-way mixed MANOVA was utilized. Multiple comparisons were done after applying Bonferroni corrections. A p-value less than 0.05 was used to conduct all statistical tests. All statistical analyses were conducted using SPSS version 25 for Windows (IBM SPSS, Chicago, IL, USA), a statistical software for the social sciences.

4. Results:

- *Subject characteristics*:

Groups A and B's subject characteristics are shown in Table (1). When comparing the groups according to age, pain duration, gender, affected side, as well as distribution of computer use familiarity, there was no statistically significant difference ($p > 0.05$).

Table 1. Subject characteristics of control and study groups:

	Group A	**Group B**	**p-value**
	Mean ± SD	**Mean ± SD**	
Age (years)	58.52 ± 4.99	59.05 ± 3.81	0.70
Duration of pain (month)	5.24 ± 1.81	5.10 ± 2.34	0.83
Sex distribution, n (%)			
Females	3 (14%)	3 (14%)	1
Males	18 (86%)	18 (86%)	
Affected side, n (%)			
Dominant side	7 (33%)	8 (38%)	0.74
Non-dominant side	14 (67%)	13 (62%)	
Familrity with computer use, n (%)			
Excellent	1 (5%)	0 (0%)	
Moderate	7 (33%)	8 (38%)	0.59
None	13 (62%)	13 (62%)	

SD, Standard deviation; p value, Level of significance.

Impact of treatment on KVIQ, active shoulder flexion ROM, SPADI and recognize shoulder application:

A two-way mixed MANOVA revealed a statistically significant interaction among treatment and time ($F = 6.05$, $p = 0.001$). There was a statistically significant main impact of time ($F = 2800$, $p = 0.001$). The main effect of treatment was statistically significant ($F = 2.77$, $p = 0.02$).

Within group comparison

There was a significant improvement in KVIQ, active shoulder flexion ROM and accuracy of response of affected and non-affected sides of group A and B after treatment in comparison with pretreatment ($p < 0.001$).

The percent of change of KVIQ, active shoulder flexion ROM and accuracy of response of affected and non-affected sides of group A was 182.04, 116.85, 60.85 and 9.16% respectively, and that of group B was 161.99, 104.66, 57.54 and 11.86% respectively.

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There was a significant decline in SPADI and time selection of affected and non-affected side of group A and B after treatment in comparison with pretreatment ($p < 0.001$). The percent of change of SPADI and time selection of affected and non-affected side of group A was 75.94, 48.87 and 29.57% respectively, and that of group B was 69.01, 42.55 and 19.44% respectively. (Table 2-3).

Between group comparison

Prior to therapy, there was not a significant distinction among the groups ($p > 0.05$). After treatment, group A's affected side showed a significant improvement in active shoulder flexion ROM and accuracy ($p < 0.01$), while group B's affected side showed a significant decrease in SPADI and time selection of affected and non-affected sides ($p < 0.001$). Following treatment, there was no discernible variation in either group's KVIQ or accuracy of the unaffected side ($p > 0.05$). (Table 2-3).

Table 2. Mean KVIQ, active shoulder flexion ROM, SPAD pre, post treatment of group A, and B:

	Pretreatment	Post treatment			
	Mean ±SD	**Mean ±SD**	**MD**	**% of change**	**p value**
KVIQ					
Group A	1.67 ± 0.48	4.71 ± 0.46	-3.04	182.04	0.001
Group B	1.71 ± 0.46	4.48 ± 0.51	-2.77	161.99	0.001
MD	-0.04	0.23			
	p = 0.75	***p = 0.12***			
Active shoulder flexion ROM (degrees)					
Group A	78.33 ± 8.25	169.86 ± 5.17	-91.53	116.85	0.001
Group B	79.67 ± 7.51	163.05 ± 6.33	-83.38	104.66	0.001
MD	-1.34	6.81			
	p = 0.59	***p = 0.001***			
SPADI (%)					
Group A	79.76 ± 5.11	19.19 ± 3.79	60.57	75.94	0.001
Group B	82.05 ± 4.55	25.43 ± 4.46	56.62	69.01	0.001
MD	-2.29	-6.24			
	p = 0.13	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; p value, Probability value.

Table 3. Mean time selection and accuracy of response pre and post treatment of group A and B:

	Pre treatment	Post treatment			
	Mean ±SD	**Mean ±SD**	**MD**	**% of change**	**p value**
Time selection of affected side (sec)					
Group A	3.11 ± 0.46	1.59 ± 0.21	1.52	48.87	0.001
Group B	3.22 ± 0.44	1.85 ± 0.24	1.37	42.55	0.001
MD	-0.11	-0.26			
	p = 0.47	***p = 0.001***			

Time selection of non-affected side (sec)					
Group A	1.97 ± 0.18	1.39 ± 0.08	0.58	29.57	0.001
Group B	1.93 ± 0.28	1.55 ± 0.09	0.37	19.44	0.001
MD	0.05	-0.16			
	p = 0.54	***p = 0.001***			
Accuracy of response of affected side (%)					
Group A	61.43 ± 14.24	98.81 ± 2.69	-37.38	60.85	0.001
Group B	60 ± 16.12	94.52 ± 5.68	-34.52	57.54	0.001
MD	1.43	4.29			
	p = 0.76	***p = 0.003***			
Accuracy of response of non-affected side (%)					
Group A	90.95 ± 8.75	99.29 ± 3.39	-8.33	9.16	0.001
Group B	88.33 ± 6.77	98.81 ± 3.12	-10.48	11.86	0.001
MD	2.62	0.48			
	p = 0.28	***p = 0.58***			

SD, Standard deviation; MD, Mean difference; p value, Probability value.

Discussion:

This study looked at the impacts of GMI training on quality of life and shoulder pain management. The 42 patients in the current study, who were divided into two equal-quantity groups, had chronic stroke, shoulder discomfort, and functional handicap. They ranged in age from 45 to 65.

The results of this study supported those of **Thieme et al. (2016)**, who found that graded motor imagery was useful in lowering limb pain patients' discomfort and impairment. They also recommended that GMI approaches be taken into consideration while treating acute pain following trauma and surgery. According to **Bowering et al.'s (2013)** recent systematic study, GMI and mirror therapy by themselves may be useful in the management of chronic pain. Additionally, **Louw et al. (2017)** showed that in patients presenting with shoulder discomfort, Short-term mirror therapy significantly improved pain perception, pain catastrophization, fear avoidance, as well as active shoulder flexion ROM, [6].

Further According to studies, people with chronic stroke may benefit from short-term bilateral training regimens to improve upper extremity motor function. Since mirror treatment involves moving both limbs, it's possible that this is one of the ways it helps stroke patients restore their motor function, [14].

During motor imagination in stroke patients, some investigations found ipsilateral activation of primary motor, primary sensory, supplementary motor, in addition to pre-supplementary motor regions. Studies that challenge the neurophysiology of mirror therapy, on the other hand, discovered that mirror box observation did not enhance the somatosensory afferents responsible for the kinesthetic sensations and that mirror box therapy does not have the ability to rise M1 excitability in healthy subjects. Nevertheless, when self-movement was observed in both the "mirror" and "no-mirror" scenarios, the Mirror neuron system was triggered in a way that was comparable to when someone else's movement was observed, [14].

Previous research on mirror therapy also found activation in the precuneus as well as posterior cingulate gyrus, two regions of the brain associated with the higher-level representation of self along with space perception [9]. In order for patients to better understand their motor performance, mirror therapy is suggested as a means to reinforce their mental image of space and the exercises they are practicing on [12], all the while avoiding the potential drawbacks associated with learned non-usage of

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a limb. Consequently, this method increases neuroplasticity, One benefit of mirror therapy is that it induces a kinesthetic awareness, whereby both sides' upper extremities seem to be moving in synchrony, [9].

Numerous studies have demonstrated that motor imagery and mental exercise help stroke victims' upper limb function. Converging evidence from studies indicates that the executive motor system is activated when one imagines performing a motor act. This includes the cerebellum, the supplementary motor area, the premotor, cingulated, superior, inferior parietal, sensorimotor, as well as primary motor cortices. Based on these results, researchers have hypothesized that motor imagery training, or mental practice, may aid in the acquisition of new motor abilities or aid in the promotion of motor recovery following central nervous system impairment. Research has demonstrated that engaging in mental exercises and images can engage the cortical representation along with musculature, establish correlations with the imagined actions, enhance learning and performance, increase the accuracy and velocity of motor skill learning. It might be appropriate for individuals who have had hemiparetic strokes as well because it uses little energy, is affordable, and doesn't require any specialized facilities or equipment, [16].

According to studies, mirror treatment, or motor imagery, enhances motor function by stimulating the motor system at the central command level, that results in faster and more regulated actions later on. It is also proposed that during active movement, mirror therapy offers visual biofeedback that affects kinesthesis. Additionally, it makes the application of more well-known techniques like forced use and motor copy easier. Through the facilitation of plastic reorganization of the brain's cortex in response to visual feedback, mirror therapy enhances the functional outcome [14].

6. Conclusion

According to the study's findings, a graded motor imagery training paradigm can effectively alleviate shoulder discomfort and enhance the quality of life for patients who have had a chronic stroke. It may also be a valuable addition to traditional physical therapy protocols for improving shoulder function.

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