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Original Research Article

The Short-term Effect of Graded Motor Imagery on the Affective Components of Pain in Subjects with Chronic Shoulder Pain Syndrome: Open-Label Single-Arm Prospective Study

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Abstract

Objective. To determine the short-term effect of graded motor imagery (GMI) on the affective components of pain and range of motion in subjects with chronic shoulder pain syndrome. **Design.** Open-label single-arm prospective study. **Setting.** The Physical Therapy Laboratory, Universidad de las Americas. **Subjects.** One hundred seven patients with chronic shoulder pain syndrome. **Methods.** The subjects received a six-week GMI program based on laterality training, imagined movements, and mirror therapy. We assessed pain intensity using a visual analog scale (VAS), fear of movement was assessed using the Tampa Scale of Kinesiophobia (TSK), and catastrophizing was assessed using the Pain Catastrophizing Scale (PCS). The patient's flexion active range of motion (AROM) was also recorded. **Results.** At the end of treatment, the VAS showed a decrease of 4.2 cm ($P < 0.001$, Cohen's $d = 3.3$), TSK showed a decrease of 17.0 points ($P < 0.001$, Cohen's $d = 2.8$), catastrophizing showed a decrease of 19.2 points ($P < 0.001$, Cohen's $d = 3.2$), and shoulder flexion AROM showed an increment of 30.3° ($P < 0.000$, Cohen's $d = 1.6$). **Conclusions.** We conclude that a short-term GMI program improves the affective components of pain and shoulder flexion AROM in patients with chronic shoulder pain syndrome.

Key Words: Graded Motor Imagery; Chronic Pain; Catastrophizing; Chronic Shoulder Pain Syndrome

Introduction

Chronic shoulder pain syndrome is a frequent and disabling condition characterized by nonspecific and persistent pain in the shoulder and has been described as the third most common musculoskeletal condition, with incidence rates of up to 2.5% [1,2]. In many patients with persistent pain, a clear origin of nociceptive input is lacking or is not severe enough to explain the pain and other symptoms experienced [3].

Central sensitization (CS) has been proposed to explain the clinical characteristics linked to chronic shoulder pain [3]. There is some evidence suggesting that CS might play a role in persistent complaints among patients with shoulder pain and could be the cause of neuronal

plasticity and central reorganization in these patients [4,5]. As in other shoulder conditions, pain may induce structural and functional changes in the motor cortex that could partly explain changes in motor control and affect muscle activation [6]. Furthermore, some studies on shoulder pain patients showed a decrease in cortical excitability of the primary motor cortex [7–10] and a reorganization of the somatosensory cortex during pain periods [11,12]. Finally, a positive correlation between pain chronicity and reduced motor cortex excitability has been observed in these patients [9].

Regarding the affective components, some studies have reported that patients with chronic pain show high levels of neural activation in the somatosensory secondary cortex, anterior cingulate cortex, insular cortex, and amygdala. These findings may reflect the altered peripheral sensory transmission of the modified afferent sensory stimuli and may be a result of the plasticity of the sensory representation of the body and perceptual changes [13–16]. The mesolimbic–prefrontal areas are also involved in the cognitive affective aspects of pain and injury, including the behavioral response to them. These brain areas induce the processing of fear, emotions, negative conditioning, and attention dysfunction [17,18] and support the maintenance of symptoms in patients [14,19], with their activation being a negative prognostic factor in chronic pain conditions [20,21].

Graded motor imagery (GMI) is a therapeutic tool that has been successfully used in a number of conditions with suspected CS [22–26]. The aim of GMI is to facilitate sensory and motor cortex reorganization [24,27,28], which has been associated with a decrease in pain intensity and marked changes in cerebral areas of discriminative pain processing on functional magnetic resonance imaging [24]. Additionally, some studies have shown that GMI decreases pain intensity and improves function in patients with musculoskeletal pain [29–32]. GMI therapy is divided into three stages: laterality training, imagined movements, and mirror therapy. However, only one study has assessed the effects of mirror therapy on the affective components of shoulder pain, and no study has considered the effects of a complete GMI intervention [33]. Thus, our study considered all stages of GMI and is the only study to date that has evaluated this therapeutic tool in chronic shoulder pain conditions.

Objective

The aim of this study was to analyze the short-term effects of a GMI program on the affective components of pain and range of motion in patients with chronic shoulder pain syndrome.

Methods

This open-label single-arm prospective study was approved by the Ethics Committee of the University of the Americas. Between October 2018 and July 2019, one hundred seven patients with chronic shoulder pain syndrome were prospectively recruited. The patients' condition was diagnosed by an orthopedic surgeon based on imaging studies that included anteroposterior projection radiographs, axial and outlet, ultrasonography of soft tissue, and nuclear magnetic resonance imaging. The inclusion criteria were i) patients aged >60 years with shoulder pain of at least six months' duration secondary to tendinopathy and/or partial rotator cuff tear; ii) ability to follow simple orders; iii) ability to sign to provide informed consent. Patients with other pathologies of the shoulder joint complex (full-thickness rotator cuff, adhesive capsulitis, and glenohumeral instability); with a history of acute trauma, previous surgery, or previous fracture in the affected shoulder; with a history of radiotherapy on the same side as the affected shoulder; or with rheumatoid arthritis or any other inflammatory disorder of the joints or symptomatic cervical spine pathology were excluded.

All measurements were performed by external therapists.

Measurements

Two evaluations were carried out, one at the beginning and one at the end of the GMI program. To determine the degree of CS that the patients presented, a specific CS questionnaire was used [34].

For the assessment of pain intensity, a visual analog scale (VAS) was used, consisting of a horizontal line 10 cm in length; the left end represented 0 or without pain, and the right end represented 10 or the worst imaginable pain. Each patient was asked to draw a vertical line along the scale, which represented the magnitude of pain experienced at the time of evaluation. The minimum detectable change (MDC) for patients with shoulder pain has been reported to be 2.5 points, whereas the minimum clinically important difference (MCID) has been reported to be 1.1 points [35].

To evaluate the participant's pain-related fear of movement, the original 17-item Tampa Scale of Kinesiophobia (TSK) was used [36]. Each item is scored on a four-point Likert-type scale that ranges from strongly agree (1) to strongly disagree (4). Total scores range from 17 to 68, and higher scores indicate more fear of movement and/or (re-)injury. In patients with shoulder pain, the MDC for the TSK has been reported to be 5.6 (36), and the MCID has not been established.

Catastrophizing of pain was measured using the Spanish version of the Pain Catastrophizing Scale (PCS) [37,38]. The PCS is a self-administered questionnaire that evaluates inappropriate coping strategies and catastrophic thinking about pain [38]. The PCS uses a Likert scale of 13 items, comprising three dimensions: a) rumination, b) magnification, and c) hopelessness. This scale can range between 13 and 62 points, with low scores

indicating low catastrophizing. In patients with shoulder pain, the MDC for PCS is 9.1 points [39]; however, the MCID has not been established.

Shoulder flexion was measured using the active range of motion (AROM) [40] of each patient's affected arm assessed using a goniometer with the patient in a seated position. To ensure consistency of pre– and post–GMI program measurements, skin marks were placed during measurements. The MDC for shoulder flexion has been reported to be 8°, and calculation of the MCID depends on patient pathology [41].

GMI Program

All patients were prescribed a GMI program based on the manual published by Moseley et al. [28,42]. The entire GMI program was performed three times a week for six consecutive weeks and included the following three steps: laterality training, imagined movements, and mirror therapy.

Laterality training is the first step in the GMI program to improve the accuracy of the patient's cortical representation of his/her body. The patient trains by looking at left and right images of body parts in different positions. We used the application Recognise created by the Neuro Orthopaedic Institute (NOI). The application records both accuracy and response time and allows the user to set the difficulty of the images by modifying context and background. Each person trained one hour per day in short sessions using 20 images. The laterality training progressed by increasing the number and difficulty of the images (Figure 1).

The treatment progressed to the imagined movement sessions. This stage of GMI is aimed at preparing the patient to move. The exact cues given were as follows: "Imagine your shoulder is involved in the pictured postures without actually moving. Imagine each posture twice and repeat the entire process three times per day." The patient was asked to imagine movements in anterior flexion, abduction, and shoulder rotations [43].

The last stage of the GMI program is mirror therapy. Mirror therapy involves using a mirror to observe the movement of the unaffected body part. This creates the illusion that the shoulder is moving pain-free. The patients were instructed to look at the mirror image of the unaffected shoulder and move that shoulder in flexion movements. Patients performed mirror therapy once per session for 30 minutes (Figure 2). The patients were not instructed to continue the therapy at home, as the intervention was intended to be supervised.

Statistical Analysis

Descriptive statistics for demographic and clinical characteristics were used for the baseline and final outcome measures. The continuous variables are presented as means and standard deviation, and the categorical variables as number and percentage. We first assessed the normal distribution of the data with the Kolmogorov-Smirnov test. The paired *t* test was used to explore the differences between baseline and final measurements, establishing a significance level of 0.05 with 95% confidence intervals (CIs). Finally, we calculated Cohen's *d* for the effect of GMI intervention, considering the effect to be trivial (<0.2), small (0.2–0.5), medium (0.5–0.8), or large (>0.8) [44]. Additionally, an analysis was performed to determine the percent change in MCID for each outcome and the percent pain reduction from pre-

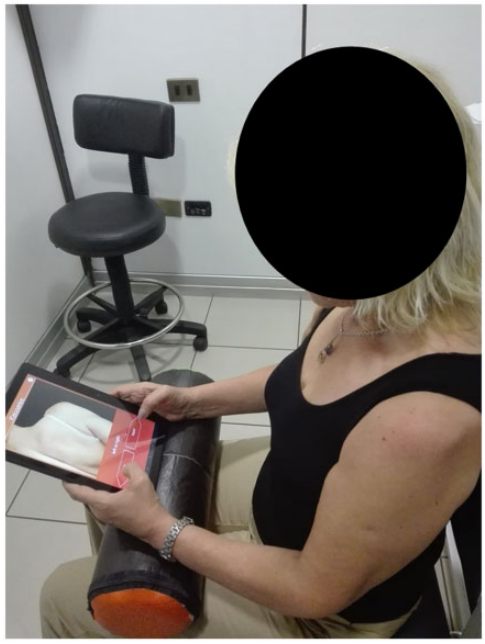

Figure 1. Laterality training.

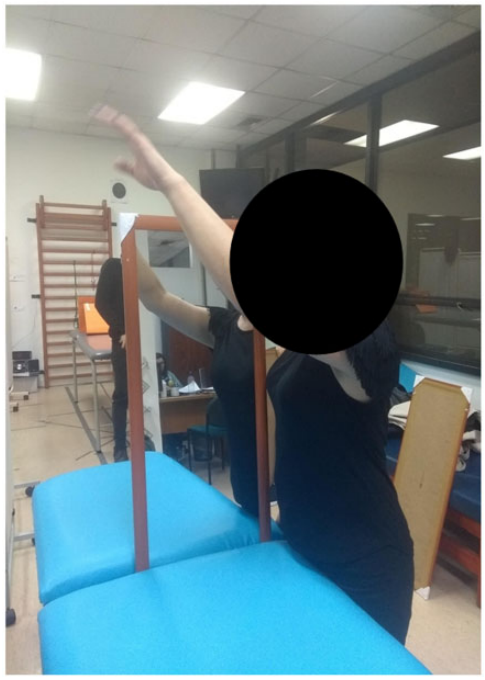

Figure 2. Mirror therapy.

to postintervention. Statistical analyses were performed using IBM SPSS software, version 22.

Results

The baseline characteristics of the studied group are presented in Table 1. The sample consisted of 107 patients with chronic shoulder pain syndrome, of which 68 were women (63.6%), with a mean age (SD) of 65.6 (5.3) years and mean score on the CS questionnaire (SD) of 45.2 (6.4). The most common type of shoulder problem was partial rotator cuff tear (69.1%). It should be noted that there was no loss or withdrawal during the study. Furthermore, at the end of the GMI program, no patient informed the authors of any complications associated with the treatment received.

Table 2 shows the pre- and post–GMI program outcomes. The pain intensity measured by the VAS showed a decrease of 4.2 cm (Cohen's $d = 3.3$, 95% CI = 2.87–3.85), the TSK scale showed a decrease of 17.0 points (Cohen's $d = 2.8$, 95% CI = 2.41–3.27), the PCS showed a decrease of 19.0 points (Cohen's $d = 3.2$, 95% CI = 2.74–3.68), and the shoulder flexion AROM showed an increase of 30.3° (Cohen's $d = 1.6$, 95% CI = 1.31–1.89). Of the total patients, 103 (96.2%) showed a decrease in VAS pain intensity based on the MCID. Similarly, 101 (94.3%) showed a decrease in pain-related fear of movement based on the MCD, as measured by the TSK; 104 (97.1%) showed a decrease in catastrophizing of pain based on the MCD, as measured by the PCS; and 97 (90.6%) showed improvement in shoulder flexion active range of motion based on the MCD. Finally, Table 3 shows the proportion of patients who experienced pain reduction of at least 50%.

Table 1. Demographic data of the patients

Data	Patients (N = 107)
Female, No. (%)	68 (63.6)
Male, No. (%)	39 (36.4)
Age, mean (SD), y	65.7 (4.8)
CS	45.2 (6.4)
Duration of symptoms, mean (SD), mo	58.8 (3.4)
Rotator cuff tendinopathy, No. (%)	9 (30.9)
Rotator cuff tear (partial) No. (%)	45 (69.1)

CS = Central Sensitization Questionnaire.

Discussion

The results of our study show that a short-term GMI program based on the manual published by Moseley et al. [28,42] can improve affective components of pain and shoulder flexion AROM among patients with chronic shoulder pain syndrome.

There are no published studies that have evaluated the effect of all stages of a GMI program on patients with chronic shoulder pain syndrome, but a few studies have examined the effect of some stages of GMI in similar groups of patients [31,33,45,46]. One study [31] applied a four-week program to only one patient with a frozen shoulder, consisting of neuroscience education, tactile discrimination, and graded motor imagery. At the end of the treatment, the patient showed a decrease in pain and improvement in shoulder function. Another study [33] applied a mirror therapy program to shoulder pain patients; patients showed an immediate, significant improvement in pain, pain catastrophizing, fear avoidance, and shoulder flexion AROM. Another study [45] applied a GMI program, added to standard physical therapy, to 16 patients with subacromial impingement syndrome. Patients showed a decrease in pain and an improvement in shoulder function at the end of treatment. Another study [46] treated 30 patients with adhesive capsulitis with 10 sessions of mirror therapy in addition to physical therapy treatment. At the end of the treatment, patients showed a decrease in pain intensity and improvement in shoulder function in the short term. Finally, Bowering et al. [25] conducted a systematic review aimed at examining the effectiveness of GMI vs standard physical therapy in patients with musculoskeletal pain. This review concluded that there is a need for more studies in other populations, as current evidence is limited.

Our study shows a greater clinical significance than previous studies on pain [31,33,45,46] and could be explained by the effect of GMI on the central nervous system, as some effects of GMI are associated with a decrease in the sensorial activity of structures related to emotional–affective factors of pain, such as catastrophizing and fear of movement [10,47–49]. These findings suggest a role of the amygdala, somatosensory cortex, and insula as facilitators of chronic pain development, including the sensitization of central nervous system pain pathways [50]. This therapeutic tool will thus allow us to reduce the menace sensation or "danger" and tissue restriction [28,47], in

Table 2. Comparison of results at baseline and end of the sixth week

Outcome	Baseline, Mean (SD)	At the End of Treatment, 6-wk Mean (SD)	Mean Difference (SD)	Effect Size, Cohen's *d*	95% CI for Cohen's *d*	*P*
Intensity pain (VAS)	6.4 (1.2)	2.1 (0.9)	4.2	3.3	2.87–3.85	0.00*
TSK	41.5 (4.6)	17 (6.2)	17.0	2.8	2.41–3.27	0.00*
Catastrophizing PCS	43.8 (5.2)	24.6 (2.5)	19.2	3.2	2.74–3.68	0.00*
Shoulder flexion AROM	77.1 (14.2)	107.4 (18.2)	30.3	1.6	1.31–1.89	0.00*

PCS = Pain Catastrophizing Scale; TSK = Tampa Kinesiophobia Scale; VAS = visual analog scale.
*Difference between baseline and end of treatment with *t* test for dependent samples.

Table 3. Categorical analysis of pain reduction

Relief of Pain Intensity	No. (%)
Complete	0 (0)
>50	81 (76.6)
<50	26 (23.4)

turn facilitating shoulder flexion, especially in people displaying higher levels of pain, pain catastrophizing, and fear avoidance [51]. One neuroimaging study showed a decrease in the activity of the sensorial cortex and mesolimbic circuit after GMI; these cortical changes facilitate the desensitization of the hypervigilant nervous system to promote movement [52,53].

Regarding the stages of GMI, each stage has been related to different effects in our central nervous system. Laterality training improves the accuracy of the cortical representation of the body [24], and movement imagery could activate the motor cortex and premotor cortex in a similar way to executed movements [43,54]. One meta-analysis [55] examined the pattern of activation during the motor imagery and mirror therapy stages and revealed that the supplementary motor area, premotor cortex, parietal lobe, putamen, and pallidum were activated. These findings provide strong positive sensory cortical feedback, as pain on movement decreases and provides the cortical neural network as movement is executed [31,56]. Our findings are consistent with previous studies, indicating that each GMI stage should be included in treatment, due to their joint benefits on clinical improvement of chronic pain [24,29,42].

This study has some limitations that should be acknowledged. First, as it was an open-label single-arm prospective study, it did not have a control group. Second, there was no randomized sample strategy to select the patients. Finally, there was no blinding of the participants or long-term follow-up. Therefore, the results should be cautiously interpreted and used for future research.

Conclusions

A short-term GMI program improves the affective components of pain and shoulder flexion AROM in patients with chronic shoulder pain syndrome. Our study has important clinical implications; first, it shows that a GMI program that includes all stages is an effective therapeutic strategy for these patients. Second, this therapeutic tool is effective for aspects associated with the central sensitization and affective components of pain. Furthermore, long-term studies with a control group are needed to support the clinical effectiveness of the GMI program for these types of patients.

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