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Trial therapy on laterality and motor imagery and selective glenohumeral muscle activation in patients with massive rotator cuff tear: case series

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ABSTRACT

Introduction: Massive rotator cuff tear (MRCT) is a degenerative clinical condition, corresponding to a 5 cm tear, or which compromises two or more tendons of the rotator cuff (RC), generating loss of functionality and disabling pain.

Objective: To describe changes in pain and shoulder function following a 6-week program of laterality and motor imagery therapy and selective glenohumeral activation exercises in subjects with massive rotator cuff tears.

Methods: This study is a descriptive investigation, designed on case series, with a sample of 50 participants diagnosed with massive rotator cuff tear. Patients underwent a selective glenohumeral exercise program plus laterality and motor imagery therapy for 6 weeks. The variables of function, pain, abduction and shoulder flexion AROPM were measured at the sixth week and sixth month of evolution.

Results: There were significant differences in pain intensity, shoulder function, flexion AROM and shoulder abduction AROM, after the intervention ($p > 0.05$). Statistically significant differences were found for all outcome measurements between intervention and the sixth follow-up month ($p < 0.05$). Only pain showed statistically significant differences between the sixth week and the sixth month of monitoring ($p = 0.01$).

Conclusion: The application of trial therapy regarding laterality and motor imagery added to a program of selective glenohumeral stabilizing exercises over 6 weeks could improve shoulder function, decrease pain and increase flexion and shoulder abduction AROM in patients with massive rotator cuff tear.

Key words: Graded motor imagery, therapeutic exercise, chronic pain, massive rotator cuff tear.

RESUMEN

Introducción: El desgarro masivo del maguito rotador (DMMR) es una condición clínica degenerativa que corresponde a una ruptura de 5 cm, o una que compromete a dos o más tendones del manguito rotador (MR), generando pérdida de funcionalidad y dolor incapacitante.

Objetivo: Describir los cambios en el dolor y función de hombro posterior a un programa de 6 semanas de terapia de juicio de lateralidad e imaginería de movimiento y ejercicios de activación selectiva glenohumerales en sujetos con rotura masiva del manguito rotador.

Métodos: Este estudio es una investigación descriptiva y diseño serie de casos, con una muestra de 50 participantes con diagnóstico de ruptura masiva de manguito rotador. Los pacientes realizaron un programa de ejercicios selectivos glenohumerales más terapia de juicio de lateralidad e imaginería de movimiento durante 6 semanas. Se midieron las variables de función, dolor, ROM de abducción y flexión de hombro, a la sexta semana y al

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sexto mes de evolución.

Resultados: Existen diferencias significativas en la intensidad del dolor, función de hombro, AROM de flexión y AROM de abducción de hombro, posterior a la intervención (p > 0,05).

Existen diferencias estadísticamente significativas para todas las medidas de resultados entre la intervención y el sexto mes de seguimiento (p < 0,05). Solo el dolor presentó diferencias estadísticamente significativas entre la sexta semana y el sexto mes de seguimiento (p = 0,01).

Conclusión: La aplicación de la terapia de juicio de lateralidad e imaginería de movimiento adicionada a un programa de ejercicios selectivos estabilizadores glenohumerales durante 6 semanas podría mejorar la función de hombro, disminuir el dolor y aumentar los AROM de flexión y abducción de hombro en pacientes con ruptura masiva del manguito rotador.

Palabras clave: Imaginería motora graduada, ejercicio terapéutico, dolor crónico, ruptura masiva manguito rotador.

INTRODUCTION

Massive rotator cuff tear (MRCT) is a degenerative clinical condition that can compromise the subcapularis, supraspinatus, infraspinatus and teres minor, which corresponds to a tear of 5 cm, or an injury of two or more tendons of the rotator cuff (RC) (1). Its prevalence is considered to be between 10% and 40% among the population aged between 50-55 years old, reaching 60% in persons above 70 years old (2). Its clinical presentation is evidenced by crippling pain, a reduction in active range of motion (AROM) in anterior flexion and external rotation, functional impotence (3,4) and in some cases pseudoparalysis (5). In the year 2005, Werner defined the term as an active and passive elevation of the shoulder lower than 90°, caused by massive damage to the rotator cuff. Since then, the literature has used the term to describe this restriction in mobility and which is often associated with pain, degenerative deterioration and loss of external rotation (5). Such deterioration is generally accompanied by bone marrow edema and fatty infiltration in the tendon, causing an increase in the humeral head as one of its main medical complications (6).

Simultaneously, some electromyographic studies have reported increased activity of the Latissimus dorsi and pectoralis major muscles (7,8), in order to counteract the increased humeral head and thus prevent greater mechanical contact. In line with this, greater electromyographic activity of the medium and anterior deltoid muscles has been reported (9,10) to facilitate arm abduction and elevation in compensation. Nevertheless, all these biomechanical and neuromuscular alterations are adaptive strategies developed in the central nervous system (CNS) (11,12) which seek to re-program the pattern of muscle activation of the rotator cuff and scapular musculature to compensate for this motor deficit and to maintain functionality of the upper limb (12,13). However, these same motor deficits may be used to generate a new strategy to re-program motion through the Latissimus dorsi, pectoralis major and infraspinatus muscles, which seek to depress the humeral head (7-9,11).

At present, one strategy used in physical therapy (PT) to re-program the nervous system in chronic pain pathologies and neuromotor deficits is graded motor imagery (GMI) (14,15) which corresponds to a sequential series of cortical exercises aimed at re-establishing neuroplastic changes in order to reduce the feeling of pain and re-distribute dysfunctional muscular activity (16,17). Accordingly, it has been shown that the areas of the body are represented in the cortex through a neural network (18) and which in patients suffering pain present differences in topographic representations of the somatosensory cortex, by comparison with patients without pain (19). These changes may be seen in brain maps, which increase or decrease their representation at cortical level (20) and it is postulated that these changes lead to the development and maintenance of chronic pain and loss of functionality (21, 22).

GMI uses a number of cortical re-programming strategies, which are divided into three stages: the first to recognize parts or movements of the left or right half of the body (laterality evaluation); secondly, to visualize, statically or dynamically, a part of the body, imaging normal joint movements, and thirdly it concludes with mirror therapy (23-25). At present, certain studies have shown that GMI reduces pain (14,26), improves sensitivity (14), increases mobility (24) and function among subjects with chronic pain (27). This therapy is based on diminishing CNS hyperactivity, allowing patients to tolerate active therapies to normalize mobility and functional alterations, achieving a reduction in pain (28). This gives rise to our question: in patients with massive rotator cuff tear, can changes take place in shoulder pain and function by adding a 6-week program of graded motor imagery to selective glenohumeral activation exercises?

OBJECTIVE

To describe changes in shoulder pain and function by adding a 6-week program of trial therapy on laterality and motor imagery to selective glenohumeral activation exercises in subjects with massive rotator cuff tear.

METHODS

This study corresponds to a descriptive study with a case series design.

Sample

The study was carried out in the kinesiology laboratory of the Universidad de las Américas in Manuel Montt 948, Providencia, Santiago, during the period from September 2016 to April 2017. The sample was made up of 50 subjects: 18 men and 32 women, with a mean age of 68.3 years old, with medical and imaging diagnosis of massive rotator cuff tear.

The sample was obtained by non-probabilistic means, as it was carried in order of patients' arrival. All subjects included in the study accepted and signed their informed consent. Furthermore, they only received 500 mg paracetamol every 8 hours in the event of presenting intolerable pain, and each dose was prescribed by the orthopedic clinician of the primary healthcare center they attended to control and treat their clinical condition. Only 9 patients (18%) reported having taken the medication in the doses prescribed. This prescription is not considered co-intervention because the patients' medication was only in the case of necessity and as indicated by their doctor, not as a co-intervention external to the treatment, which could give rise to a potential source of bias.

The baseline characteristics are shown in Table I. Patients' age ranged between 60 and 75 years old, with a mean age of 68.3. As regards the sample, 64% was female and 36% male.

TABLE I
DEMOGRAPHIC ANALYSIS OF THE SAMPLE AT BASELINE

Sample size	50 subjects: 100 %
Male gender	8 men: 36 %
Female gender	32 women: 64 %
Age (mean)	60-75 (68.3 years old)
Condition evolution time (mean)	Range from 7 to 10 years (9.4 years)
Pain – VAS	Mean 5.5 cm (SD 1.06)
Function – Constant Score	Mean 38.46 (SD 16.32)
Range of flexion mobility	Mean 70.64° SD (15.65°)
Range of abduction mobility	Mean 57.43° SD (15.84°)

As regards dominance, 94% was right-handed and 6% left-handed, and the compromised shoulder was in relation to patients' dominance.

With respect to complications associated with the intervention, in the second week of treatment, 3 patients reported more intense pain, although this did not require a visit to the orthopedic clinician to assess their condition. At 6 months' monitoring, no patient reported complications associated with the intervention received. As regards losses, all patients completed the study and monitoring assessments, avoiding attrition bias.

Inclusion criteria

- Subjects with medical and imaging diagnosis of massive rotator cuff tear, through nuclear magnetic resonance or ultrasound scan.
- Men and women 60 years old or above.
- Subjects able to follow simple orders.
- Subjects who have accepted and signed informed consent.

Exclusion criteria

- Subjects whose rotator cuff had previously undergone surgical intervention.
- Subjects who have received treatment with corticosteroids by any route of administration in the foregoing 6 months.
- Subjects who present central or peripheral neurological alterations.
- Subjects who present massive rotator cuff tear due to acute traumatic circumstances such as, for example, proximal humerus fracture.

Study variables

The following variables were studied:
- Pain intensity.
- Shoulder function.
- Shoulder flexion and shoulder abduction range of motion.

Material used for the study

To evaluate pain intensity, the visual analog scale (VAS) was used, which consists of a 10-cm long horizontal line, the left end representing 0 or no pain, and the right end representing 10 or the worst pain imaginable. The distance in centimeters from the point of "no pain" to the point marked by the patient represents pain intensity. This evaluation may or may not include points between each centimeter, though for some authors this detracts from precision (29). Each patient was asked to draw a vertical line showing the degree of pain experienced at the time of evaluation.

This simple, easily-reproducible method of one-dimensional evaluation is recommended for inclusion to assess all patients with upper limb pathologies (29-32).

Shoulder function was evaluated through the Constant-Murley score, owing to its reliability in clinical practice (30). It has a total score of 100 points, providing a positive correlation: the higher the score, the greater the function.

This scale includes four parameters:

- Pain: where a verbal assessment scale is used, assigning 15 points to no pain, slight pain 10 points, moderate pain 5 points and severe pain 0 points.
- Daily activities: this includes four categories and may go up to 20 points, starting with work activity from 0 to 4 points, leisure activity from 0 to 4 points, sleep from 0 to 2 points and hand position from 2 to 10 points, counting two by two.
- As regards range of mobility, four movements are evaluated, anterior elevation from 0 to 10 points, lateral elevation from 0 to 10 points, external rotation from 0 to 10 points and internal rotation from 0 to 10 points, only taking into consideration active range of motion (AROM). To measure anterior and lateral elevation, the test's authors recommend using a goniometer, with the patient sitting upright and supported by the back of a chair, to compensate for torsal inclination (30).
- Active shoulder flexion and abduction were evaluated by means of goniometry with the patient in a sitting position, and to allow consistency of measurement pre- and post-intervention, and anatomical bony processes were marked on each patient's skin, as this provides good reliability in goniometric shoulder evaluations (33,34).
- To determine statistically significant differences, the minimum change detectable for shoulder flexion reported was 8 degrees, and the minimum clinical difference detected depends on each patient's pathology (33).

Program of intervention

The intervention consisted of a kinesic program, focusing on trial therapy on imagery of laterality of mobility and three selective glenohumeral stabilizing exercises for six weeks. Patients attended therapy 4 times per week with a duration of 60 minutes per session. No other modality of physiotherapeutic intervention was applied.

All measurements of results were recorded before the intervention, at the end of the intervention (week 6) and after 6 months' evolution. All evaluations mentioned were registered by a professional orthopedic clinician external to the study, with more than 10 years' clinical experience.

Intervention on laterality and motor imagery

As regards GMI, the first stage consisted of restoring laterality, which is the capacity to recognize a part of the body as belonging to the left-hand or right-hand side, and to do so the software *Recognise* of the *Neuro Orthopaedic Institute (NOI)* group was used (23). Each patient sat down facing a computer for 15 minutes, where they were requested to quickly identify whether the images corresponded to a shoulder on the right or left side; these

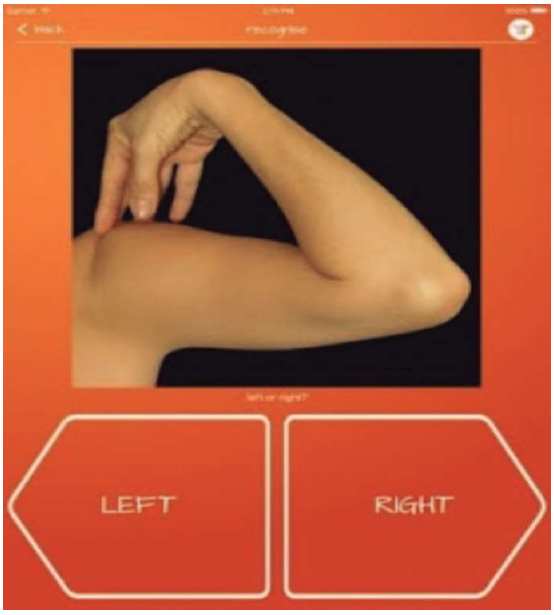

Fig. 1. Image of the imagery of right shoulder laterality, from the software *Recognise* by the *Neuro Orthopaedic Institute* (NOI) group.

images appeared in different positions and daily situations, presenting very defined forms or abstract images (Figure 1).

During the second stage, the therapist asked them to imagine painless motions of the affected upper member for 15 minutes. First, they were told to visualize shoulder movements that are carried out in the 3 planes of mobility, beginning with flexion-extension, then abduction-adduction and finally rotation movements, subsequently imagining actions focusing on daily life activities, such as for example to reaching to an object on a shelf, hanging up an item of clothing (25).

Selective glenohumeral stabilizing exercises

This program of selective exercises has been proposed on the basis of the analyses of electromyographic studies by Campbell et al. (7), Park et al. (8) and Hansen et al. (9).

Selective activation of humeral depressors (7,8)

Patients were positioned seated on a chair and were asked to flex their shoulders to 60° and their forearm flexed to 130°, then resting their elbows on a table. They were then asked to press their elbows dowards, without pain, for 10 seconds, repeating this 10 times (Figure 2).

Selective activation of anterior deltoids and serratus major (9)

Patients were positioned seated on a seat chair with armrests, their arms in a neutral position and their forearms at pronation, and flexion at 90°; they were asked to make an anterior push with their open hand onto a cushion, without painless, for 10 seconds, repeating this 10 times (Figure 3).

Selective activation of the middle deltoids (9)

The patients were positioned seated on a chair and were asked to carry out a shoulder abduction in the scapular plane. The initial position was with their elbow in flexion from 70° to 90° in neutral position of their forearm, and 45° of abduction of their shoulder leaning on a wedge, and then asked to carry out an active abduction movement from that range in the scapular plane to 90°, or the maximum abduction possible without pain. A series of 6 repetitions were carried out (Figure 4).

Fig. 2. Selective exercise to activate humeral depressors, latissimus dorsi, teres major and pectoralis major.

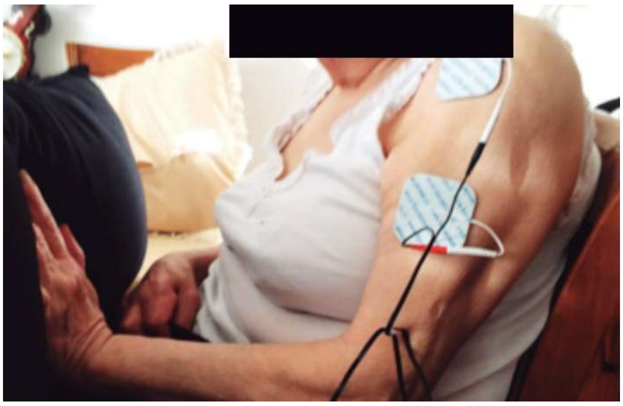

Fig. 3. Exercise for selective activation of the anterior deltoids and serratus major.

Fig. 4. Exercise for selective activation of the middle deltoids.

Statistical analysis

Data was gathered and entered in the software Excel for tabulation. Statistical analysis was subsequently carried out using the software IBM SPSS statistics 32 for Windows later. Quantitative variables are presented as mean and standard deviation, and qualitative variables as number and percentage. In order to determine the statistical tests to use, the first analysis evaluated normality distribution, using the Shapiro-Wilk test (Table II). Differences were examined in total Constant scores, VAS and active ROM of shoulder flexion and abduction prior to treatment, at 6 weeks and at the sixth month. As 3 evaluations were carried out, ANOVA or Friedman's test were used for dependent samples. ANOVA used a route of repeated measurements for differences before treatment, at 6 weeks and at six months, with time as an independent variable. For the specific difference among the 3 evolution periods, Bonferroni's test was used, establishing a statistical significance of $p < 0.05$.

RESULTS

Pain

Pain intensity, measured with VAS before the intervention, was 5.5 cm SD (1, 06). At week six, it was 1.9 cm SD (1.48) and at the sixth month of monitoring it was 3.1 cm SD (0.99). There exist statistically significant differences in the three evaluations. Pre-intervention VAS versus post-intervention VAS (p = 0.01). Pre-intervention VAS versus the sixth month of monitoring (p = 0.01) and VAS at the sixth week, versus the sixth month of monitoring (p = 0.01) (Figure 5).

TABLE II
NORMALITY ANALYSIS

Normality analysis	
Varia bles	*p-valúe*
Constant Score I	0.01*
Flexion AROM I	0.18*
Abduction AROM I	0.31*
VAS I	0.31*
Constant Score F	0
Flexion AROM F	0
Abduction AROM F	0.28
Final VAS	0
Constant Score S	0
Flexion AROM S	0
Abduction AROM S	0.33
VAS S	0.01

Function

Function before intervention reported a mean Constant score of 38.46 points SD (16.32). At the sixth week it was 63.89 points SD (17.22) and at the sixth month it was 62.84 points SD (16.88). Statistically significant differences between the pre-intervention Constant score versus the post-intervention score (p = 0.01), and between the pre-intervention Constant score versus the score at the end of the sixth month of intervention (p = 0.01) (Figure 6). We should highlight the fact that, in evaluating function by Constant score, the total final value of the scale was obtained.

Flexion AROM

For the flexion AROM before intervention, the mean value was 70.64° SD (15.65°). At the sixth week it was 110.64° SD (27.98°) and at the sixth month it was 105.51° SD (24.94°). There exist statistically significant differences between the pre-intervention versus post-intervention flexion AROM (p = 0.01), and also between pre-intervention flexion AROM versus at the end of the sixth month (p = 0.02) (Figure 7).

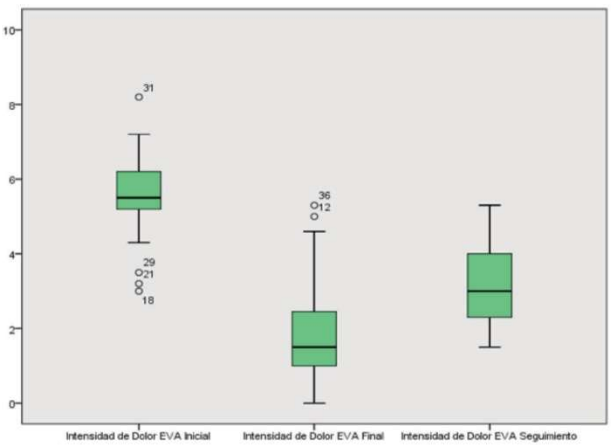

Fig. 5. Pain score (VAS), pre-intervention at the sixth week and sixth month of monitoring.

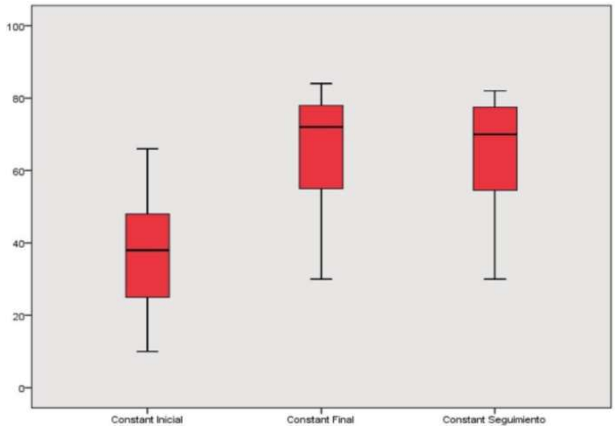

Fig. 6. Constant score for shoulder functionality, pre-intervention, at the sixth week and at the sixth month of monitoring.

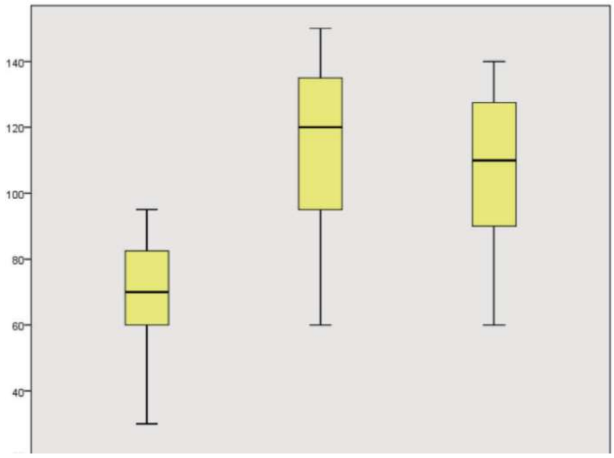

Fig. 7. Shoulder flexion AROM, pre-intervention, at the sixth week and at the sixth month of monitoring.

Abduction AROM

Abduction AROM before the intervention showed a mean value of 57.43° SD (15.84°). At the sixth week it was 90.12° SD (28.64°) and at the sixth month it was 86.92° SD (26.09°). There exist statistically significant between pre-intervention abduction AROM versus post-intervention AROM ($p = 0.01$), and also between pre-intervention abduction AROM versus the end of the sixth month ($p = 0.02$) (Figure 8).

DISCUSSION

The aim was to describe the changes in shoulder function, in pain intensity and in shoulder flexion and abduction AROM, subsequent to the intervention of selective glenohumeral activation and imagery exercises, at six weeks' treatment and at the sixth month of monitoring, in a sample of 50 subjects with medical and imaging diagnosis of massive rotator muff tear.

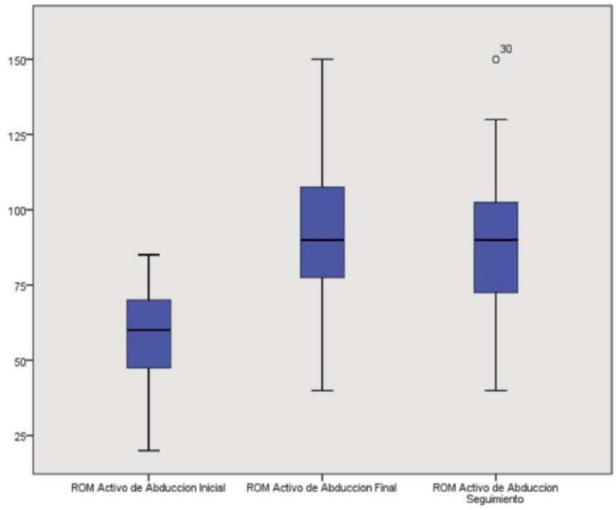

Fig. 8. Shoulder abduction AROM, pre-intervention, at the sixth week and at the sixth month of monitoring.

The most significant changes were observed in active shoulder flexion with a mean improvement of 40° at the sixth week, and 34.87° at the sixth month, which surpasses the minimum detectable change for this variable (32). As regards shoulder function, a mean improvement of 25.43 points was observed at the sixth week and 24.38 points at the sixth month. Our results coincide with previous studies (35-38), which mention that trial therapy for laterality and motor imagery may be considered a rehabilitation method and/or tool in patients with chronic pain and with alterations in the normal patterns of mobility.

In recent years, the inclusion of focusing on neuroscience for patients with chronic musculoskeletal pain has generated debate in clinical centers, as this therapeutic proposal is based on integration of the central nervous system, as the keystone of rehabilitation, questioning the classic intervention models that refer to nociceptive mechanisms as secondary to structural damage, only considering biological and mechanical aspects (39,40). Some studies have shown that a focus based on neuroscience, such as imagery, have reported improvements in pain among subjects with chronic pain (41), non-specific shoulder pain (27), rheumatoid arthritis (42) and lumbar pain (24). Additionally, several studies have shown that IMG can help cortical neuroplasticity generated by chronic pain (22,23,37,38,42,43). However, there are no studies that consider these two interventions by themselves in regarding changes in the studied variables. This upholds the idea that this type of intervention integrates the CNS, providing an understanding of all the alterations in chronic musculoskeletal pain and which our treatment strategies must aim to integrate in brain structures, and where the CNS is the gateway for treatment under these clinical conditions (40).

With respect to selective activation exercises, one of the major characteristics is that they have a low isometric load. This has a direct effect from a biomechanical point of view, as it reduces overload on joint tissues, and can minimize mechanical demand and thus avoid the development of clinical symptoms (44-46). Accordingly, these selective exercises could make it possible to work without pain, harmlessly activating the muscles of the rotator cuff, redistributing its muscular activity (47,48). Furthermore, clinical application of exercising humeral head depression is biomechanically based on raising the humeral head as a result of deltoid torque, as massive laceration of the supraspinatus, subscapularis or infraspinatus muscle generates overactivity of the Latissimus dorsi and pectoralis major to modulate and control a rise of the humeral head (7,8). Therefore, one of the major objectives is to perform exercises to lower the humeral head, distributing the activity of these muscles mentioned above. Selective activation exercises of that of middle deltoids is based on signs of pseudoparalysis in this clinical condition, due to tearing the muscle supraspinatus and subscapularis muscle. This gives rise to considerable limitation of arm elevation motion (6). However, activating the deltiod muscle above an elevation of 45° in the scapular plane generates a reduction of contact in the subacromial area and mechanical pressure is significantly reduced (6,9).

A large majority of conservative treatments associated with this clinical condition are based on exercise, manual therapy, taping, injecting corticosteroids and electrotherapy (49-51), with questionable therapeutic success. Accordingly, it seems necessary for clinical practice to explore areas in musculoskeletal motor rehabilitation. From this point of view, recent experiences in GMI have been open to musculoskeletal rehabilitation, demonstrating its effectiveness (14,17,24,27).

As regards some, some neuroimaging studies have shown that following training with this therapeutic tool, the premotor cortex is significantly activated during laterality recognition exercises (14,52,53). As a result, these reports corroborate the idea that this tool is oriented towards reversing changes at cortical level and is a strategy that comprises the CNS for motor rehabilitation.

Limitations

Finally, in relation to the type of study, it is important to mention that this type of design does not permit inference as regards the general population due to a series of methodological factors. Firstly, it is a non-experimental study, so it does not have a comparative control group to establish the effectiveness of an intervention, nor are the subjects selected by random probabilistic sampling. Therefore, this type of descriptive design only seeks to describe one possible effect in a variable. As mentioned above, the results of our investigation should be interpreted with caution and used for future experimental investigations. Another aspect to consider is the sample's heterogeneity in relation to gender, as 36% were men (18 subjects) and 64% women (32 subjects), so it is suggested that the results should be taken with caution for subsequent applicability.

CONCLUSION

The results suggest that adding the intervention of laterality and motor imagery exercises to a program of selective glenohumeral activation exercises for 6 weeks could improve shoulder function, diminish pain, and increase shoulder flexion and abduction AROM in patients with massive rotator cuff tear.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

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