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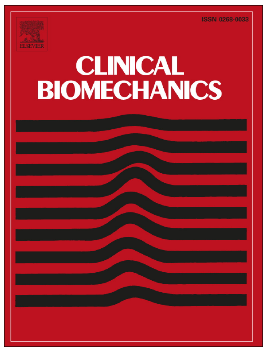

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Scapular-focused exercise treatment protocol for shoulder impingement symptoms: three-dimensional scapular kinematics analysis

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ABSTRACT

Background: The present study aimed to describe the effects of a periscapular strengthening and neuromuscular training protocol in three-dimensional scapular kinematics and resting positioning in participants with shoulder impingement symptoms. Self-reported function was also evaluated.

Method: The study group comprised 50 subjects with shoulder impingement syndrome (control group, n=25; treatment group, n=25). The treatment group underwent 8 weeks of neuromuscular training and periscapular strengthening. Scapular kinematics was measured using an electromagnetic tracking device, and the Brazilian version of the Shoulder Pain and Disability Index (SPADI-Br) questionnaire was carried out before and after the treatment.

Findings: In the resting position, treated subjects had lower ($p<0.01$) internal rotation of the scapula compared to the control group, with a large effect size (2.4). On the coronal plane, the treated group had less scapular upward rotation ($p<0.01$) and less internal rotation ($p<0.05$), with a medium effect size. On the sagittal plane, the treated group had less internal rotation ($p<0.01$), less upward rotation ($p<0.05$), and less scapular anterior tilt ($p<0.01$), with a medium effect size. On the scapular plane, a reduction in upward rotation ($p<0.01$) after the intervention was observed, with a large effect size. Moreover, a reduction in the total SPADI-Br score was found, with a mean difference of 32.4 [24.4; 40.4] points ($p<0.01$) after the implementation of the protocol and a large effect size (2.0).

Interpretation: The results provide biomechanical support for the clinical rationale for indicating therapeutic exercises focused on the periscapular muscles to improve scapular dynamics.

Keywords: exercise, impingement, motion analysis, scapula, shoulder, function

1. INTRODUCTION

People with shoulder impingement syndrome (SIS) present differences in movements of the scapula when compared with asymptomatic individuals (Graichen et al., 2001; Hébert et al., 2002; Lawrence et al., 2014; Lin et al., 2005; Ludewig and Cook, 2000; Lukasiewicz et al., 1999; Warner et al., 1992), and these changes can contribute to impingement (Phadke et al., 2009; Schmitt and Snyder-Mackler, 1999). Patients with SIS report disability, especially during overhead movements, which may hinder activities of daily living and for some sports gestures (Moezy et al., 2014).

The presence of impact symptoms has been demonstrated by several electromyographic studies to initiate changes in periscapular muscle activity, such as an increase in upper trapezius muscle activity (Lin et al., 2011; Ludewig and Cook, 2000) and reduction in lower trapezius (Cools et al., 2007b; Lin et al., 2011) and serratus anterior activity (Lin et al., 2011; Ludewig and Cook, 2000). Changes on the scapula movement can be observed via reducing the upward rotation in the frontal and scapular plane, between 30° and 60° of arm elevation (Lawrence et al., 2014), and reduction of the posterior tilt (Borstad and Ludewig, 2002; Endo et al., 2001; Lawrence et al., 2014) and reduction of external rotation in the arm elevation and lowering (Lopes et al., 2015) when compared with healthy subjects.

Evidence exists on the effectiveness of exercises designed to restore sensorimotor mechanisms in the shoulder to treat SIS through the use of feedback, because they promote coordinated activation of the muscles involved (Myers and Oyama, 2008; van Vliet and Heneghan, 2006). Therefore, the focus of treatment for the syndrome is on performing exercises, including stretching, strengthening, and neuromuscular control exercises (Dong et al., 2015; Escamilla et al., 2014; Ginn et al., 1997; Haik et al., 2016; Hanratty et al., 2012; Kromer et al., 2009).

Studies have assessed the effects of neuromuscular control and scapula-focused exercises on the scapular kinematics of individuals with shoulder impingement syndrome (Roy et al., 2009b; Worsley et al., 2013). Worsley et al. (2013) examined the effect of scapular motor control training in a group of 16 individuals with shoulder impingement syndrome who underwent a 10-week treatment compared to a healthy control group. After treatment, the individuals from the SIS group had less pain, improved function, and increased posterior tilt of the scapula. However, in this study, manual therapy was included as part of the motor control program, and a small sample size was used, considering kinematic variables. Roy et al. (2009b) assessed the effect of motor control training of only 8 subjects with SIS, and an improvement of function and pain and increase in posterior tilt of the scapula were found. However, this study did not assess the scapular muscle strength. Thus, evidence related to the effect of neuromuscular control and scapula-focused exercises on the scapula kinematics is limited.

A recent systematic review of clinical trials validated a moderate evidence for muscle strengthening in the treatment of patients with shoulder impingement. However, the evidence is conflicting with regard to the effectiveness of scapular-focused treatment approach for scapular positioning measure, pain, and shoulder function (Reijneveld et al., 2017). Therefore, the primary objective of the present study was to assess the effect of a combined protocol for the periscapular muscle strengthening and neuromuscular training during the scapular resting position and kinematics. The secondary objective was to evaluate the effectiveness of this protocol in the increase of periscapular muscle strength and improvement of shoulder pain and function. We hypothesized that a treatment protocol would generate changes in scapular kinematics, including an increment of upward rotation, posterior tilt, and external rotation of the scapula and improvement of periscapular muscle strength, pain, and shoulder function.

2. METHODS

2.1. Subjects

A total of 50 symptomatic subjects completed the study, 25 in the untreated group (12 men and 13 women) and 25 in the treatment group (15 men and 10 women). The participants were deliberately and consecutively recruited. Table 1 shows the demographic data for both groups.

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Patients with impingement syndrome were recruited using the medical referral forms for physiotherapy treatment provided by the local public health system. The sample size was based on previous studies that used the same kinematic assessment method. Previous studies demonstrated that 25 subjects are required for a significance level of 0.05 (Borstad and Ludewig, 2005; Ludewig et al., 1996; Ludewig and Cook, 2000). This study was approved by the Institutional Review Board and was conducted in accordance with the National Health Council Resolution 466/12 (Reference Number: 5607/2013), and the rights of the subjects were protected. All participants were informed about the study and signed an informed consent form prior to participating.

The Neer and Hawkins-Kennedy impingement tests, the painful arc test, Jobe's test, and the external rotation resistance test were used to confirm the shoulder impingement symptoms. The subjects were included if they presented positivity in at least three of the five tests (Michener et al., 2009).

The exclusion criteria were the following: (1) individuals with a history of trauma or shoulder surgery, (2) positivity in instability tests and total or partial tendon tear of the rotator cuff and biceps, (3) individuals who engage in activities or sports movements involving the upper limbs, (4) individuals who have neurologic or systemic diseases, (5) reproduction of shoulder pain whose primary origin is the cervical or thoracic region, (6) presence of wrist dysfunction (e.g., carpal tunnel syndrome), (7) physical therapy of the shoulder in the last six months, (8) <120° of glenohumeral flexion or abduction range of motion at the shoulder, validated via a goniometer (Marques, 2014).

2.2. Instrumentation

The orientation and position of the thorax, scapula, and humerus of the subjects were assessed using the three-dimensional motion capture system 3SPACE® Liberty® (Polhemus Inc, VT, USA). Each sensor has a sampling frequency of 120 Hz with 0.03 inch accuracy for position and 0.15° RMS for orientation, according to the manufacturer. For the data collection, five electromagnetic sensors were used, which were attached to the body segments to be analyzed, and one sensor coupled with an 8 cm wooden pen was used to digitize the anatomical points.

A load cell (Kratos Equipamentos®, São Paulo, Brazil, 100 kg) was used to confirm whether the training protocol increased the capacity to generate isometric torque of the middle trapezius, lower trapezius, and serratus anterior muscles. The muscles were evaluated basing on the positions of the manual function test described by Kendall et al. (2007). The position test described by Cools et al. (2007a) was used to evaluate the serratus anterior muscles.

The present pain intensity of the participants was monitored using the numeric pain rating scale (Turk et al., 2003). They also answered the Brazilian version of the Shoulder Pain and Disability Index (SPADI-Br) questionnaire (Martins et al., 2010; Puga et al., 2013) before and after 8 weeks of applying the exercise protocol.

2.3. Experimental Procedure

The 3D kinematics data collection was performed before and after 8 weeks of neuromuscular training and muscle strengthening. The sensors were attached to the skin on the arms and the trunk with tape, and two bilateral sensors were attached to the flat surface of the acromion of the scapula and two sensors to the insertion of the deltoid muscle. The fifth sensor was attached to the flat face of the sternum, just below the jugular notch (Ludewig and Cook, 2000). The positioning of the sensors, construction of the biomechanical model, and digitization of the anatomical structures were performed according to the recommendations of the International Society of Biomechanics (Wu et al., 2005).

The subjects remained in the upright position, with shoulders relaxed and arms at the side of the body. In the resting position, a collection lasting 5 seconds was performed. Then, the participants performed 5 arm elevation and lowering cycles, bilaterally, with each cycle lasting 4 seconds, in the coronal, sagittal, and scapular planes.

Isometric torque in the muscles was assessed with the use of a nonelastic band, attached to the floor with the load cell and to the distal extremity of the upper limb, perpendicular to the floor. To assess the middle trapezius muscle, the subjects remained in prone position, with arms at 90° of abduction and external rotation of the humerus (Kendall et al., 2007). To assess the lower trapezius muscle, the subjects remained in the supine position, with arms at 130° of abduction (Kendall et al., 2007). To assess the serratus anterior muscle, the subjects were seated on a chair, with feet resting on the floor and flexion of the arm at 135° (Cools et al., 2007a).

2.4 Exercise Program (Appendix 1)

The training lasted for 8 weeks and consisted of 1-hour sessions, three times a week, on nonconsecutive days. The subjects were treated individually. The neuromuscular exercises were (1) towel slide, (2) PNF scapular, (3) inferior glide, and (4) scapular clock. The strengthening exercises were (1) diagonal D1, (2) push-up plus, (3) full can, (4) prone horizontal abduction with external rotation from 90º to 135º, (5) side lying external rotation with abduction at 0º, (6) diagonal D2 eccentric, (7) scapular punch, and (8) horizontal rowing. Appendix 1 contains the instructions for performing the exercises.

In each session, two neuromuscular control and three muscle-strengthening exercises were selected, due to the time allotted. Dumbbells and elastic bands were used for the muscle-strengthening exercises. The initial stipulated load was 60% of the one-repetition maximum; in the second week, the load was increased between 60% and 80% of the one-repetition maximum (American College of Sports Medicine, 2009). During the first 3 weeks, 3 series of 10 repetitions were performed. In the fourth week, the exercises progressed to 3 series of 12 repetitions and in the fifth week to 3 series of 15 repetitions. The load progression of the push-up plus exercise occurred with the feet elevated on supports at a height of 20 cm and 40 cm (Lear and Gross, 1998).

The progression of the neuromuscular exercises consisted of adding more repetitions. The stimuli applied by the therapist were given according to the needs of the subjects, to ensure correct performance of the exercises. From the first to the third week, 10 repetitions were performed. In the fourth week, 12 repetitions were performed for each exercise, and from the fifth to the eighth week, 15 repetitions were performed for each exercise.

Since the intent of the present research was not to study the clinical effectiveness of the proposed protocol but rather its biomechanical effect, a symptomatic and untreated group was included to compare the variables of the resting position of the scapula and rotations in relation to the thorax during the raising and lowering of the arm. The untreated group was evaluated in the same way as the treated group, and the data collection was repeated after 8 weeks to control for the effects of the natural evolution of the condition on the biomechanical variables.

2.5. Data Analysis

Only the data from the painful shoulder were analyzed. The measurements showed good intersession reliability with the standard error of the measurement of 2.4º to 3.6º, 3.2º to 5.2º, and 4º to 5.5º for scapula tilt, upward rotation, and internal rotation, respectively (Biazotto et al., 2014). For each subject, the data from raising and lowering of the painful shoulder were also analyzed. This study involved 3 repetitions of scapular vs. glenohumeral orientation that were compared on three different planes of motion (sagittal, coronal, and scapular), considering the influence of age, sex, and body mass index. The fixed factors examined were the angles of 30°, 60°, 90°, and 120° for elevation and 90°, 60°, and 30° for lowering of the humerus in relation to the thorax. Statistical analysis was performed to identify between-group differences, and their respective 95% confidence intervals were calculated using the linear mixed model using interaction terms of treatment groups versus time. For the comparisons, the orthogonal contrast post hoc test was used with the PROC MIXED procedure of SAS™ software, version 9.1 (SAS Institute, Cary, NC, USA). The level of significance was set at 5%. Effect size and minimal important difference were calculated for each variable in the study (Armijo-Olivo et al., (2011). Effect size was defined as small (up to 0.2), medium (0.5), and large (greater than or equal to 0.8) (Cohen, 1992).

The muscular strength values collected by the load cell were normalized by the body mass of each individual. The error measurement was determined using the standard error of measurement and minimum detectable change. The Statistical Package for Social Sciences™ version 16.0 (IBM Software Group, Chicago, USA) was used to calculate the intraclass correlation coefficient ($ICC_{3,3}$) of the load cell values for 25 subjects with a confidence interval (CI) of 95%

(Terwee et al., 2007). The interpretation of the ICC values was based on the Fleiss classification (1996).

The Shoulder Pain and Disability Index questionnaire (SPADI-Br) is composed of 13 questions and contains two domains: pain and disability. The score of the questionnaire ranges from 0 to 100, with very high scores indicating worse function (Martins et al., 2010). The numeric pain scale runs from 0 to 10, with 0 indicating no pain and 10 representing the worst pain (Turk et al., 2003).

3. RESULTS

3.1. Resting Position and Scapular Kinematics

In the resting position assessment, a reduction ($p<0.01$) was observed in the scapula internal rotation movement of the treated subjects in relation to the untreated group, with a large effect size (Table 2).

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Differences were observed in the elevation of the humerus in the coronal plane for upward rotation and internal rotation movements of the scapula. The treated group had less upward rotation of the scapula at 90° ($p<0.01$) of arm lowering and less internal rotation at 30° ($p=0.04$), 90° ($p=0.03$) and 120° ($p<0.01$) of arm elevation, with a medium effect size, in comparison to the untreated group.

In the sagittal plane, the treated group had lower upward rotation at 60° ($p=0.01$) with a large effect size, at 90° ($p=0.04$) and 120° ($p=0.04$) of arm elevation, and at 60° ($p=0.02$) and 30° ($p=0.01$) of arm lowering with a medium effect size, when compared to the untreated group. The treated group had less internal rotation ($p<0.01$) at 30°, 60°, 90°, and 120° of arm elevation and at 90°, 60°, and 30° of arm lowering, with a medium effect size. A less anterior tilt ($p<0.01$) at 120º of arm elevation was also observed, with a medium effect size.

In the scapular plane, the treated group had less upward rotation of the scapula compared with the untreated group at 120º of arm elevation ($p<0.01$), with a large effect size. Table 3 shows the data corresponding to scapular kinematics that showed post-treatment differences in the three planes examined.

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3.2. Muscular Strength

Muscular strength increased in the treated group after carrying out the protocol, with medium effect sizes for the middle trapezius, lower trapezius, and serratus anterior muscles. The load cell values showed excellent intersession reliability (>0.75) for both groups, and the mean pre- and post-treatment differences were larger than the values for standard error of measurement and minimum detectable change for the treatment group.

3.3. Shoulder Pain and Disability Index (SPADI-Br) and Numeric Pain Rating Scale

In the untreated group, no evidence of change was observed in the total score on the SPADI-Br questionnaire, with a mean difference of 13.6 [5.52; 21.67] points ($p<0.1$) and a medium effect size. In the treatment group, a reduction in the total score was found, with a mean difference of 32.4 [24.4; 40.4] points ($p<0.01$) after the protocol and a large effect size, indicating improved shoulder function in the treatment group. In relation to pain, no evidence in the reduction of pain was found in the untreated group, with a mean difference of 1.4 [0.2; 2.3] points. In the treatment group, the mean difference was 3.7 [2.5; 4.5] points (Table 4).

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4. DISCUSSION

The 8-week scapular-focused exercise treatment protocol generated changes in the resting position and scapular kinematics of individuals with shoulder impingement syndrome when compared with the untreated group. The results of this study also indicated that these differences occurred mainly for internal rotation of the scapula in sagittal plane.

In the coronal plane, a reduction was observed in the upward rotation of the scapula of the treated group during the eccentric phase of the 90º movement when compared to the untreated group. This reduction of upward rotation of the scapula in the treated group may represent a better length-tension relationship on the scapulohumeral muscles and a better recruitment, motor control, and co-activation of the transverse trapezius and serratus anterior responsible for stabilizing the movement (de Morais Faria et al., 2008; Worsley et al., 2013)

In the present study, the electromyographic activity of the scapulothoracic muscles was not assessed, so whether this alteration occurred by increasing or decreasing the activity of the scapulothoracic muscles could not be determined. (de Morais Faria et al., 2008; Worsley et al., 2013). Worsley et al. (2013) evaluated the activation time of the serratus anterior and lower trapezius muscles and noted a significant increase in the duration of activity of the serratus anterior muscle in the coronal, sagittal, and scapular planes and of the lower trapezius in the sagittal and scapular planes. Since the present study investigated only two muscles and the muscle activation time, future studies should assess the activity of the scapulothoracic muscles of the subjects who perform the exercise protocol focusing on the scapula in the long term. In the sagittal plane, a reduction of upward rotation at 90º in the treated group was observed, which supports the previous study that observed changes in the same plane and humeral angulation (Worsley et al., 2013).

Previous studies that have applied treatment focused on the periscapular muscles, including neuromuscular control training and muscle strengthening in individuals with SIS, demonstrated that protocols resulted in some reduction of pain and improved shoulder function (Bae et al., 2011; Başkurt et al., 2011b; Roy et al., 2009; Worsley et al., 2013). However, with regard to scapular position and movement, four studies found inconsistencies (Başkurt et al., 2011; Moezy et al., 2014; Shah et al., 2014; Struyf et al., 2013). The studies used the lateral scapular slide test (Başkurt et al., 2011; Shah et al., 2014), kinetic medial rotation test (Struyf et al., 2013), and static measurements of shoulder position, including inclinometry (scapular upward rotation) (Struyf et al., 2013), forward shoulder translation, and scapular protraction and rotation (Moezy et al., 2014). The present study is the first to use 3D reconstruction methodology, sample size, power analysis, and differences greater than minimal important difference (MID) and equipment measurement errors, sufficient to provide some biomechanical evidence that the specific exercises for this musculature generate changes in the position and kinematics of the scapula.

The proposed strengthening and motor control protocol was determined through the selection of exercises focused on the scapulothoracic joint and periscapular muscles that are used in clinical practice (De Mey et al., 2013; Escamilla et al., 2009; Kibler et al., 2008; Reinold et al., 2009; Voight and Thomson, 2000). However, there is no consensus with regard to neuromuscular control exercises, and for this reason, exercises that included visual, auditory, or kinesthetic feedback were used, with an emphasis on the retraction of the scapula during their execution.

It was possible to carry out the protocol even with some intensity of pain present. At the end of the treatment, the participants had decreased pain in the numeric pain rating scale, with a reduction of 1.4 points in the untreated group (by natural evolution) and 3.8 points in the treated group, the latter being considered a clinically relevant change (Salaffi et al., 2004). In addition, the perception of improved function and reduced pain was evidenced by the SPADI-Br total score, with a mean difference between the groups that exceeded the minimal clinically important difference by 10 points (Roy et al., 2009a). Muscular strength increased for all the muscles assessed, which showed that the proposed exercises were effective for this specific musculature, based on the weekly load progression. An analysis by two recent systematic reviews (Bury et al., 2016; Reijneveld et al., 2017) indicated some support for scapular-focused exercise approaches, although the evidence was either conflicting or below clinical significance for variables such as pain, scapula position/movement, range of motion, and rotator cuff strength.

This study presents limitations concerning the interpretation of the data in relation to the clinical relevance because it is a quasi-experimental design. Since individuals were not randomized, the presence of bias should be considered in the clinical decision-making process. The present study covered an older age group, compatible with those found in clinical practice, and with more chronic conditions. The evaluation of the impingement symptoms through specific clinical tests confirmed the SIS diagnosis, since they are tests with good diagnostic accuracy (Michener et al., 2009). However, they were still unable to determine the actual impingement mechanism.

CONCLUSION

Motor control and muscular strengthening training lasting for 8 weeks influenced the resting position and scapular movement pattern of subjects with shoulder impingement syndrome. The participants also reported improved function of the affected shoulder. However, randomized control trials with low risk of bias are required to validate the effectiveness of the protocol.

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Table 1: Demographic characteristics of participants by groups. Values expressed as means and confidence intervals.

Table 2: Means [95% confidence intervals] of the resting position of the scapula in a standing position with arms relaxed at the sides. Comparison between control and treatment groups after eight weeks of treatment.

Table 3: Means [95% confidence intervals] of scapula rotations for measurements presenting significant difference (p<.05) in between-group comparisons of post-treatment data.

Table 4: SPADI-Br and Numeric Pain Scale comparison between control and treatment groups after eight weeks of treatment.

Table 1: Demographic characteristics of participants by groups. Values expressed as means and confidence intervals.

	Untreated Group (n=25) Mean [CI 95%]	Treatment Group (n=25) Mean [CI 95%]
Age. Y	49 [45.4; 52.5]	47.5 [43.8; 51.2]
Weight. kg	72.2 [66.2; 78.1]	74.55 [68.1; 81]
Height. m	1.65 [1.6; 1.7]	1.62 [1.60; 1.7]
BMI. kg/m^2	26.73 [25.3; 28.2]	26.34 [25.2; 27.5]

Abbreviation: BMI. Body mass index. CI: Confidence interval

Table 2: Means [95% confidence intervals] of the resting position of the scapula in a standing position with arms relaxed at the sides. Comparison between untreated and treatment groups after eight weeks of treatment.

Movement	Resting Position* (degrees)					
	Untreated Group Mean [CI 95%]	Treatment Group Mean [CI 95%]	Mean difference¥	Effect Size	CI (95%)	p-value
Upward/Downward Rotation	-0.5 [-4.0; 3.1]	0.01 [-2.7; 2.7]	0.8	0.05	[-3.9; 5.5]	0.73
Anterior/Posterior Tilt	-11.5 [-14.1; -9]	-13.3 [-15.3; -11.3]	1.8	0.4	[-1.1; 4.7]	0.22
Internal/External Rotation	37.5 [35.1; 40]	22.7 [11; 34.3]	14.2	2.4	[5.5; 23]	<0.01

*Degrees relative to the cardinal plane of the thorax. Values expressed as means and confidence intervals. ¥ Values of mean difference adjusted for age, gender and body mass index. CI: Confidence interval

Table 3: Means [95% confidence intervals] of scapula rotations for measurements presenting significant difference (p<.05) in between-group comparisons of post-treatment data.

Plane	Scapular movement		Humeral Angle (°)	Untreated Group (n=25) Mean [CI 95%]	Treatment Group (n=25) Mean [CI 95%]	Mean Difference*	CI (95%) comparison	Effect Size	MID 0.5
Coronal	Upward / Downward Rotation	Lowering	90°	-47.1 [-51.7; -42.4]	-35.7 [-45.4; -26.1]	-9.5	[-16.3; -2.8]	0.6	-9.2
	Internal / External Rotation	Elevation	30°	31.9 [27.1; 36.7]	21.6 [10.9; 32.3]	11.1	[0.4; 21.9]	0.5	10.1
			90°	30.8 [23.2; 38.4]	20 [8.6; 31.3]	11.7£	[0.9; 22.4]	0.5	11.7
			120°	38.1 [27.8; 48.5]	21.4 [5.8; 36.9]	17.6	[6.9; 28.3]	0.5	16
Sagittal	Upward / Downward Rotation	Elevation	60°	-36.9 [-40.5; -33.3]	-28.3 [-32.3; -24.3]	-6.9	[-12.4; -1.4]	0.9	4.6
			90°	-45.8 [-49.2; -42.4]	-38.5 [-43; -34.1]	-5.5	[-11; -0.03]	0.7	3.8
			120°	-56.4 [-60.6; -52.1]	-48.7 [-54.2; -43.2]	-5.9£	[-11.4; -0.4]	0.7	-6
		Lowering	60°	-38.5 [-42.9; -34.2]	-30.5 [-35; -26.1]	-6.2	[-11.7; -0.8]	0.8	-5.4
			30°	-25.7 [-30.5; -20.9]	-17.4 [-21.9; -12.8]	-6.5	[-12; -1.1]	0.7	-5.7
	Internal / External Rotation	Elevation	30°	49.1 [46.1; 52.1]	31.6 [17.7; 45.4]	17.8	[5.8; 29.8]	0.7	12.1
			60°	51.8 [48.3; 55.2]	31.6 [16.8; 46.4]	20.5	[8.4; 32.5]	0.8	13
			90°	52.1 [48.1; 56.1]	31.7 [16.1; 47.3]	20.7	[8.7; 32.7]	0.7	13.8

			120°	50.8 [44.25; 57.39]	27.8 [12.07.43 .50]	23.3	[11.3; 35.3]	0.8	14.6
		Lowering	90°	50.3 [45.5; 55.2]	30.5 [15.6. 45.3]	20.2	[8.1; 32.2]	0.7	13.4
			60°	49.9 [45.9; 53.9]	31.6 [17.2; 46]	18.6	[6.5; 30.6]	0.7	12.8
			30°	48.9 [45.6 ; 52.2]	31 [17.4; 44.7]	18.2	[6.1; 30.2]	0.7	12
	Anterior / Posterior Tilt	Elevation	120°	-10.9 [-4.5; -17.3]	-4.3 [-10.6; 1.9]	-6.8	[-12; -1.5]	0.4	-7.7
Scapular	Upward / Downward Rotation	Elevation	120°	-57.0 [-47.2; -66.9]	-24.2 [-45.5; -2.8]	-30.8	[-38.9; -22.6]	0.8	-20.1

CI: Confidence interval; MID: Minimal important difference **£** mean difference inferior to the MID

Table 4: SPADI-Br and Numeric Pain Scale comparison between untreated and treatment groups after eight weeks of treatment.

		Mean [CI 95%] Pre-treatment	Mean [CI 95%] Post-treatment	Mean Difference [CI 95%]	p-value	Effect size
SPADI-Br total score (0-100)	Control	58.5 [51.4; 65.6]	44.6 [36.2, 53.1]	13.9 [5.5; 21.7]	<0.1	0.7
	Treatment	45.5 [38.8; 52.3]	13.13 [6.9, 19.4]	32.4 [24.4; 40.4]	<0.01	2.1
Pain (0-10)	Control	9 [8.4; 9.6]	7.7 [6.7, 8.6]	1.4 [0.2; 2.5]	0.02	0.7
	Treatment	7.5 [6.3; 8.6]	3.7 [2.5, 4.9]	3.8 [2.7; 5]	<0.01	1.4

CI: Confidence interval; SPADI-Br: Brazilian version Shoulder Pain and Disability Index

Highlights

- Specific exercises for treatment of shoulder impingement syndrome are proposed
- Protocol included neuromuscular and strengthening exercises applied for eight weeks
- The exercises proposed in protocol change the kinematics of the scapulothoracic joint