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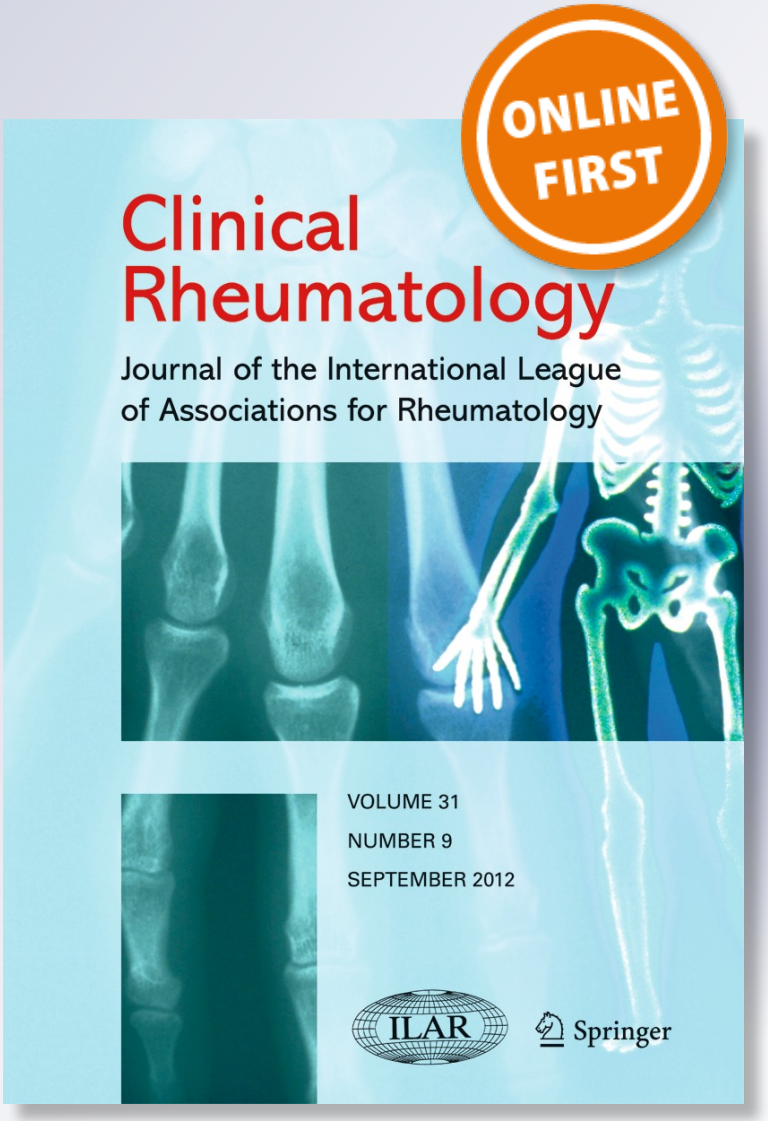

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ORIGINAL ARTICLE

Scapular-focused treatment in patients with shoulder impingement syndrome: a randomized clinical trial

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Abstract The purpose of this clinical trial is to compare the effectiveness of a scapular-focused treatment with a control therapy in patients with shoulder impingement syndrome. Therefore, a randomized clinical trial with a blinded assessor was used in 22 patients with shoulder impingement syndrome. The primary outcome measures included self-reported shoulder disability and pain. Next, patients were evaluated regarding scapular positioning and shoulder muscle strength. The scapular-focused treatment included stretching and scapular motor control training. The control therapy included stretching, muscle friction, and eccentric rotator cuff training. Main outcome measures were the shoulder disability questionnaire, diagnostic tests for shoulder impingement syndrome, clinical tests for scapular positioning, shoulder pain (visual analog scale; VAS), and muscle strength. A large clinically important treatment effect in favor of scapular motor control training was found in self-reported disability (Cohen's d=0.93, p=0.025), and a moderate to large clinically important improvement in pain during the Neer test, Hawkins test, and empty can test (Cohen's d 0.76, 1.04, and 0.92, respectively). In addition, the experimental group demonstrated a moderate (Cohen's d=0.67) improvement in self-experienced pain at rest (VAS), whereas the control group did not change. The effects were maintained at three months follow-up.

Keywords Impingement · Motor control · Physical therapy · Scapula · Shoulder pain

Introduction

Shoulder impingement syndrome is commonly referred to as painful arc syndrome, subacromial impingement syndrome, supraspinatus syndrome, swimmer's shoulder, or thrower's shoulder [1–5]. Shoulder impingement syndrome is commonly reported in the general population, and a common cause of disability at work and during daily activities [6–8]. Although the reported prevalence figures on shoulder complaints diverge strongly, shoulder pain can be

Trial registration: Clinical trials ISRCTN20736216

The study protocol was reviewed and approved by the Medical Ethics Committee of the UZ Brussel University Hospital, Brussels Free University (Vrije Universiteit Brussel), approved on 15 October 2008 (ref: BUN B14320084388).

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seen as an important medical and socioeconomic problem in Western society.

Impingement syndrome is broadly described as an encroachment of the subacromial tissues as a result of the narrowing of the subacromial space. However, the literature describes both subacromial [9] and internal impingement [10]. Whereas the subacromial or external impingement is the mechanical encroachment of soft tissue in the subacromial space [9], internal impingement comprises encroachment between the humeral head and the scapular glenoid rim [10] Shoulder impingement syndrome can also be classified into primary or secondary impingement. Structural narrowing of the subacromial space is seen in the primary impingement syndrome, whereas more functional disorders are the basis of the secondary impingement syndrome [11]. In addition, several clinical studies have pointed out an association between secondary impingement symptoms and a variety of underlying mechanisms. These include altered mobility patterns in the dominant shoulder of an overhead athlete [12], scapular dyskinesis [13–15], insufficient scapular motor control [16], rotator cuff pathology [17, 18], poor posture [2], and even metabolic problems (diabetes and blood lipids) and lifestyle issues (smoking and obesity) [5]. Scapular dyskinesis has been termed as visible alterations in scapular position and motion patterns [15]. In addition, other associated pathological conditions that could lead to impingement symptoms are shoulder instability, biceps pathology, superior labrum anterior–posterior lesions, and glenohumeral internal rotation deficits [11].

A recent study suggests that reducing scapular mobility reduces the acromiohumeral distance during arm abduction and therefore increases the risk for shoulder impingement syndrome [19]. Changes in scapular positioning and motor control are considered important risk factors for developing shoulder impingement syndrome [16, 20–29]. In addition, shoulder impingement symptoms are associated with altered upper and lower trapezius muscle activity [30]. Decreased activity of the serratus anterior and middle and lower trapezius muscles; increased activity of the upper trapezius muscle may adversely affect scapular positioning, including reduced scapular upward rotation, increased anterior tilt and scapular winging [20, 25, 31]. A 4-week exercise program, mainly based on motor control principles for the scapulothoracic joint, has been advocated for the treatment of shoulder impingement syndrome [32]. Bernhardsson et al. [33] support this finding by stating that incorporating scapular control with an eccentric strengthening program for the rotator cuff muscles can be effective in decreasing pain and increasing function in patients with shoulder impingement symptoms. However, randomized controlled studies examining the effectiveness of a scapular-focused treatment approach for shoulder impingement syndrome are currently unavailable.

A variety of physiotherapeutic treatment modalities have been suggested for the treatment of shoulder impingement syndrome including electrotherapy, exercise therapy, massage, joint mobilizations, joint manipulations, extracorporeal shockwave treatment, ultrasound treatment, laser treatment, and sling exercise treatment [34–37]. Several systematic reviews have evaluated the effectiveness of these modalities in shoulder disorders [34–37]. However, there is limited evidence to support the efficacy of the majority of these therapeutic interventions on shoulder impingement syndrome [35–38]. The current remaining evidence states that exercise has a statistically and clinically important effect on pain reduction and improving function. In addition, manual therapy seems to augment the effects of exercise [34].

The aim of this study was to evaluate the effects of a scapular-focused treatment approach in comparison with a control therapy in patients with shoulder impingement symptoms. The scapular-focused treatment approach addressed the treatment of scapular dyskinesis in patients with impingement symptoms that are likely to suffer from scapular dyskinesis. Control therapy comprised of exercise therapy and manual therapy, interventions known to be of benefit for patients with shoulder impingement syndrome [34]. We hypothesize that a treatment protocol focusing on this subgroup of impingement patients, elects greater pain relief and reduced self-reported disability than a control therapy.

Methods

Participants and randomization

Participants were recruited through physicians, orthopedic surgeons, and physical therapists working in private medical clinics or private physiotherapy practices in Antwerp, Belgium between October 2008 and July 2009. Selection criteria for participation were: (1) informed consent, (2) age 18 years or older, (3) ability to complete questionnaires (no dementia, sufficient knowledge of the Dutch language), and (4) shoulder impingement symptoms lasting at least 30 days (from onset of symptoms, one after the other). Each patient needed a prescription of the physician or orthopedic surgeon for their impingement symptoms. In addition, the presence of this prescription implicated that patients with shoulder pain onset due to trauma, a history of shoulder fractures or dislocation, cervical radiculopathy, degenerative joint disease of the shoulder, surgical interventions on the shoulder, or inflammatory arthropathy were excluded from the study. Infiltration of the shoulder in the previous 3 weeks, non-steroidal anti-inflammatory drugs use, or patients undergoing shoulder treatment (including physical

therapy) 1 year prior to the first assessment were also excluded from the study. All participants received an information leaflet and provided written informed consent. Subjects were free to withdraw from the study at any time. The study protocol was reviewed and approved by the Medical Ethics Committee of the University Hospital Brussels (ref: BUN B14320084388).

A randomized clinical trial with a blinded assessor was conducted (Fig. 1). The patient took a form (with a letter A (n=23) or B (n=23)) indicating allocation to either groups from a closed envelop. A list with patient numbers and the group allocation that resulted from this randomization procedure was stored in a sealed envelope. Only the therapist had direct access to the randomization list. In this way, patients were randomly allocated to either treatment group A or B. Finally, treatment groups comprised of 10 and 12 patients. Both treatment groups were treated by the same therapist.

Shoulder impingement syndrome diagnosis

For the diagnosis of shoulder impingement syndrome, the algorithm for clinical reasoning in the examination of impingement-related shoulder pain of Cools et al. [11] was partially used. The following criteria were set up for diagnosis:

- The Hawkins test, Neer test, and Jobe test were performed. At least two out of three tests had to be positive for inclusion.
- Apprehension, relocation, release test for anterior shoulder instability had to be negative for the presence of apprehension.
- The full can test had to be negative.
- Biceps tendinopathy was excluded, using the Speed's test and O'Brien test.

Based on these criteria, patients were likely to have scapular dyskinesis as the secondary cause of their shoulder impingement symptoms.

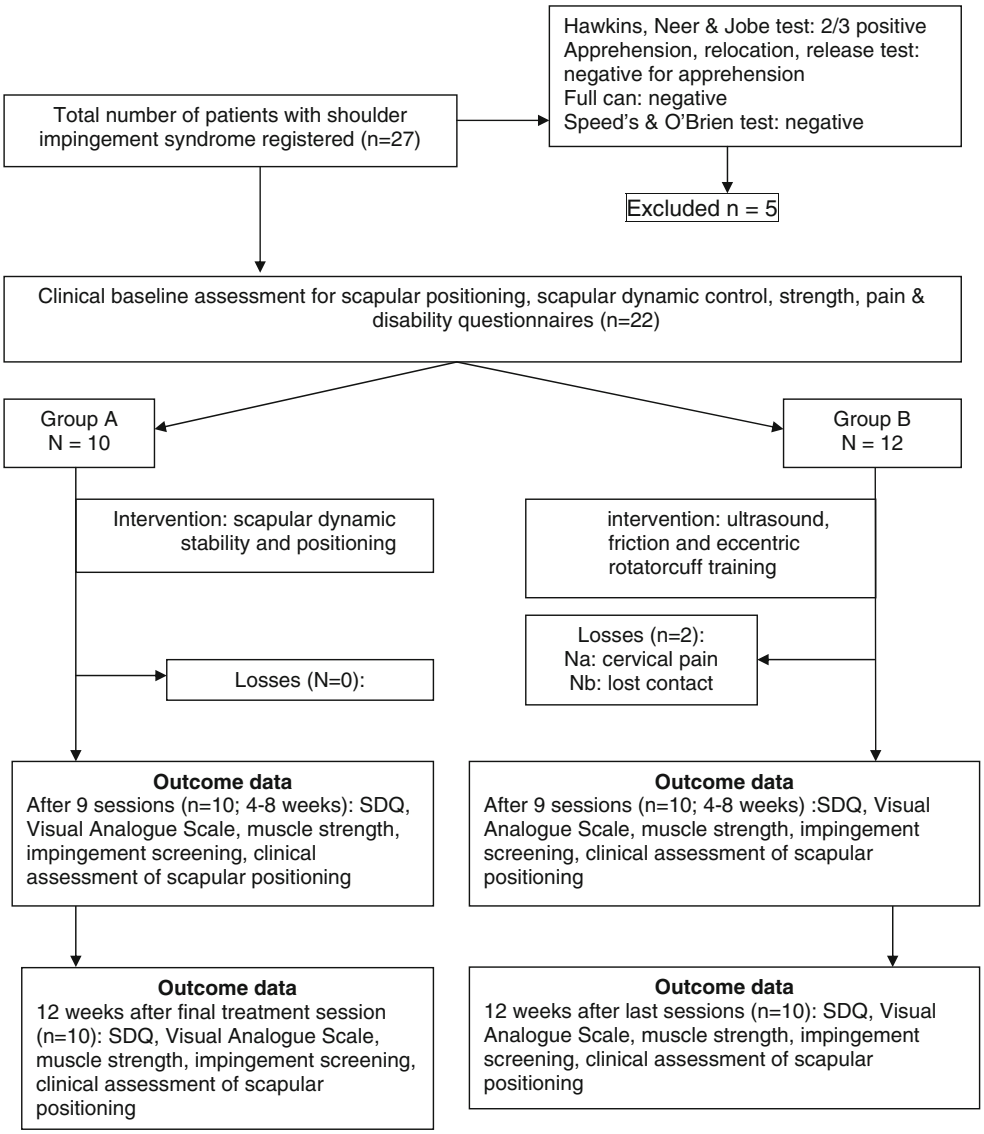

Fig. 1 Flowchart of the study protocol

Follow-up

Evaluations were carried out at baseline, immediately post-treatment, and 3 months post-treatment. All assessments were performed by the same examiner blinded for group allocation. The order of the assessments (primary and secondary outcomes) was randomized to avoid order effects.

Primary outcome

All participants completed the Shoulder Disability Questionnaire (SDQ), a self-reported questionnaire [39]. The SDQ has previously been used in patients with shoulder impingement syndrome [40–42] and covers 16 items to evaluate functional status disability in patients with shoulder disorders. The 16 items describe a possible pain provocation during the last 24 h of the patient's daily activities. The questionnaire is completed with yes, no, or not applicable response. Completion took between 5–10 min. The score is calculated by the summation of all yes answers, divided by all answered questions (yes or no), and subsequently multiplied by 100. This results in a score between 0 (no disabilities) to 100 (severe disabled). The SDQ is suggested to be responsive and ready for use in clinical trials and longitudinal studies [39, 43]. In this study, the Dutch version of the SDQ was used. Cross-sectional comparison showed similar overall validity and patient acceptability as the UK version [44]. Test–retest reliability of the SDQ appears to be sufficient; that is, there is little variation in scores in patients who, according to our external criterion, are considered to be clinically stable [43]. The minimal clinically important difference has been reported to be 18.75 (an improvement of at least three items on the SDQ) [39].

Secondary outcomes

Verbal numeric rating scale during impingement screening

If an impingement test was scored positive, the patient was asked to rate his pain using a verbal numeric rating scale (VNRS) with 0 being no pain and 10 being the worst pain imaginable. The reported reliability of a VNRS for symptom severity in an upper extremity orthopedic population is excellent [45]. The minimal clinically important difference in pain has been reported to be 1.3 [46].

Visual analog scale A visual analog scale (VAS; 100 mm) was used for the assessment of the severity of shoulder pain both at rest and during shoulder activity. The VAS pain score is believed to be reliable, valid, and sensitive to change [47]. The minimal clinically important difference in VAS pain scores has been reported to be 17 mm [48].

Visual observation for tilting and winging

Scapular position was observed to identify its resting position. Observation of scapular position during humeral movement was noted to assess the kinematical rhythm between glenohumeral abduction and scapular upward rotation. We aimed at observing scapular deviations from the ideal resting position: (1) the inferior angle of the scapula becomes prominent dorsally (rotating about the horizontal axis—tilting); (2) the entire medial border of the scapula becomes prominent dorsally (rotating about the vertical axis—winging) [49]. These observations can be reliably assessed at rest and during unloaded movement in musicians [49].

Forward shoulder posture (acromial distance)

The acromial distance was measured using a protocol with sufficient inter- and intra-rater reliability [50, 51]. The measurement of the distance between the posterior border of the acromion and the table (acromial distance) was performed in supine. In this position, the assessor measured the distance between the most posterior aspect of the posterior border of the acromion and the table bilaterally (measured vertically with a sliding caliper—Manutan™ (Manutan nv, 19 Doverstraat, Brussels, 1070, Belgium); accuracy, 0.03 mm). The assessor repeated this procedure with the patient actively retracting both shoulders whilst keeping the thorax fixed against the table. The data collected during this measurement were adjusted by dividing by the body length, creating an Acromial Distance Index, which resulted in a score entered as centimeters per centimeter (Fig. 2).

Pectoralis minor muscle length

The distance from the fourth rib to the coracoids process was measured with a measuring tape. This distance (in centimeter) is divided by the subjects height and multiplied by 100. This results in a pectoralis muscle length index (PMI). A patient has a short pectoralis muscle length when the PMI is 7.65 or lower [31] (Fig. 3).

Scapular upward rotation (inclinometry)

One gravity referenced inclinometer (Plurimeter-V (Dr. Rippstein, 1093 La Conversion, Switzerland), accuracy to 1°, very good reliability), [52] was used to measure humeral elevation, and a second inclinometer was used to reliably measure upward rotation of the scapula. Patients were asked to move both arms into abduction and to stop at 45°, 90°, 135°, and at full range of humeral abduction. At each of these positions, the degree of upward rotation of the scapula was measured using the second inclinometer. The scapulohumeral rhythm was calculated by dividing the total humeral elevation by the scapular upward rotation.

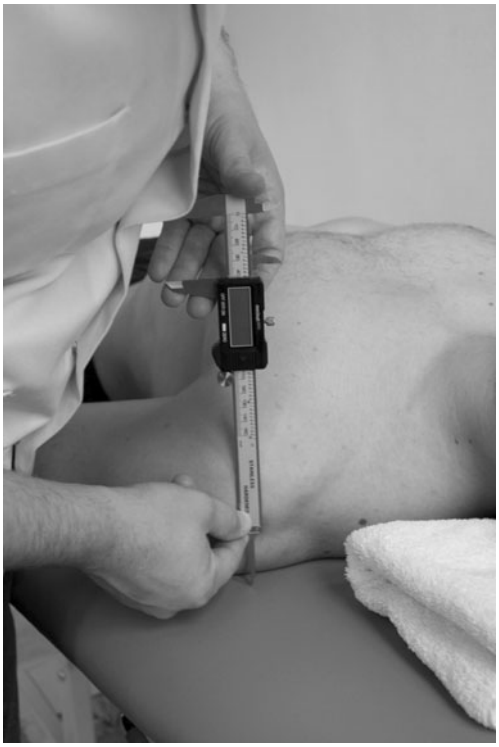

Fig. 2 Measurement of forward shoulder posture (acromial distance)

Men were tested with their trunk bare, women wore a sports bra or a halter top so that the scapula remained visible and shoulder movements were not hampered by clothing. Previous study concluded that palpation was a valid method to find the location of the scapula, so all reference points used during the inclinometry and acromial distance were palpated [24].

Scapular motor control (kinetic medial rotation test)

Scapular motor control was assessed during active medial rotation of the affected side. The participant was supine and with the humerus abducted to 90° and the elbow was 90° flexed (hand to the ceiling). The humerus was positioned in the plane of the scapula with the scapula and glenohumeral joint in the neutral position. The participant was asked to perform 60° of internal rotation at the glenohumeral joint (measured with an inclinometer) whilst keeping the scapula still in its neutral position. The kinetic medial rotation test (KMRT) was scored positive when scapular forward tilt, downward rotation, or elevation was observed (Fig. 4).

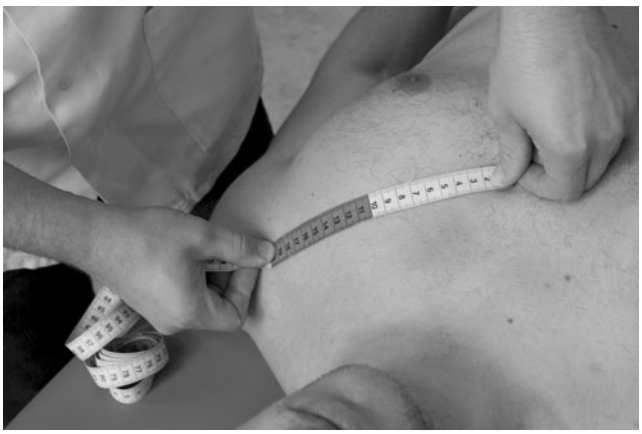

Fig. 3 Measurement of the pectoralis minor muscle length

Isometric elevation strength

Isometric elevation strength was measured in the Jobe's test position (arm elevated to 90° in the plane of the scapula and internally rotated by pointing the thumb down) using a hand-held dynamometer (100 # Analoge Dial Gaurge 12–0393). The hand-held dynamometer was placed just above the wrist (Fig. 5).

Interventions

Experimental group: scapular-oriented treatment protocol A

The treatment protocol for group A consisted of manual mobilizations, stretching, and motor control training of the scapula. Each session lasted for approximately 30 min. All exercises were individually tailored, based upon the results of the clinical evaluation.

1. Passive manual mobilization: The scapula was mobilized to improve passive scapular upward rotation and posterior tilting
2. Stretching: home stretching exercises for the levator scapulae (Fig. 6) and rhomboids muscles (Fig. 7).

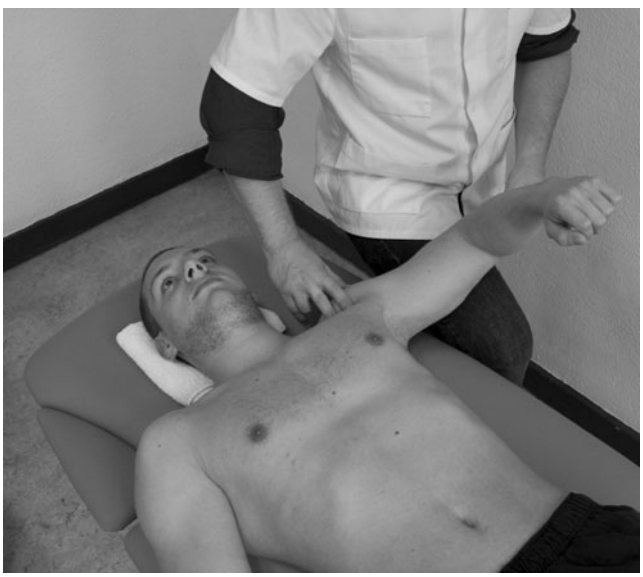

Fig. 4 Evaluation of scapular motor control (medial rotation test)

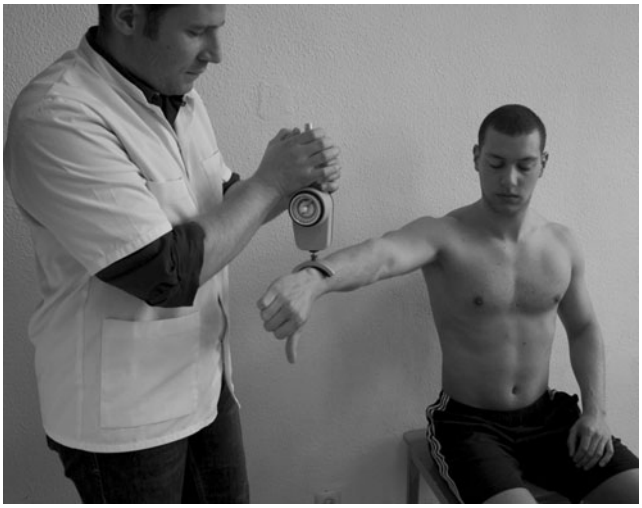

Fig. 5 Isometric elevation strength (hand-held dynamometry)

3. Stretching of the pectoralis minor muscle length: both hands of the therapist crossed, one on the coracoids process and one on the sternum of the thorax (region fourth rib)
4. Scapular motor control training with emphasis on a scapular orientation exercise (SOE) as described by Mottram et al. [16] (Fig. 8): In each subject, this was judged to be the mid-position between their available range of upward and downward rotation, external and internal rotation, and posterior and anterior rotation (posterior–anterior tilting) of the scapula. The movements required to achieve the SOE (as judged by the therapist) were then explained to the subject and visual, auditory, and kinesthetic cues were used. Patients were instructed to maintain that neutral position and consequently taught to find the neutral position themselves. Patients were shown and told to avoid several incorrect muscle activation strategies. Mottram et al. showed that subjects are able to accurately repeat this movement without guidance [16]. Progressively, the holding time and then the number of repetitions were increased. Once scapular control had improved (negative KMRT), external resistance exercises were added to the program. This included training of all parts of the trapezius and serratus anterior muscles based on previous findings showing that anatomical subdivisions of the trapezius muscle can be independently activated by voluntary command (Fig. 9) [53].

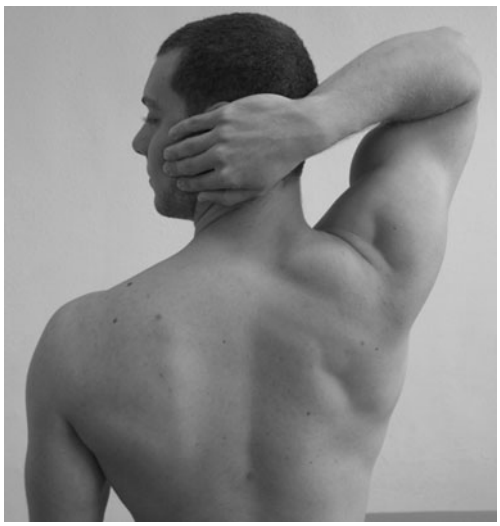

Fig. 6 Home stretching exercise for the (*right*) Levator scapula

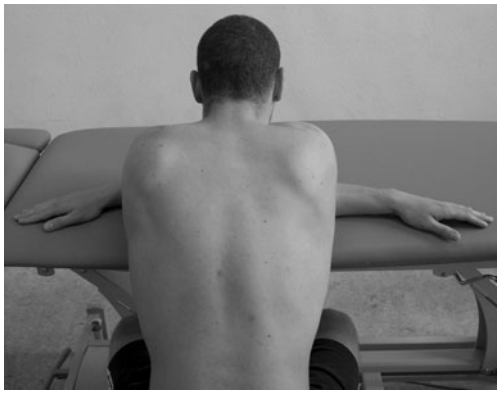

Fig. 7 Home stretching exercise for the Rhomboids

- Lower trapezius: By using the overhead arm lift, the lower trapezius activates [54]. Patient was prone, with the arm 120° elevated (in line with the lower trapezius) with a pillow under the chest, scapula in neutral. Patient lifted his hand with scapular movement and held 3–5 cm above the horizontal. If the patient could not reach this position due to pain or muscle weakness, the patient could led his arm hang from the examining table and just needed to raise his upper arm (elbow flexed) in 120° of elevation.
- Middle trapezius: Same position as for the lower trapezius, but now the abducted the arm 90°, elbow flexed (hand to the floor), scapula in neutral [54]. Patient pulled the scapula in towards the midline of the spine. The upper arm may still be supported by the bed.
- Serratus anterior: Patient was on hands and knees with both scapulas protracting around the chest wall by making the shoulder blades wide. No thoracic kyphosis may occur. Patient now shifted his weight on to one arm. Serratus anterior muscle activation could also be performed in side lying. The therapist supports the arm in 90° elevation. The patient needed to perform a scapular protraction and upward rotation while the therapist supported the arm.

If the patient could maintain his scapula in its neutral position, progression was made by extending the elbow and raising the arm above the horizontal. Other ranges of contraction could be trained by choosing different elevation

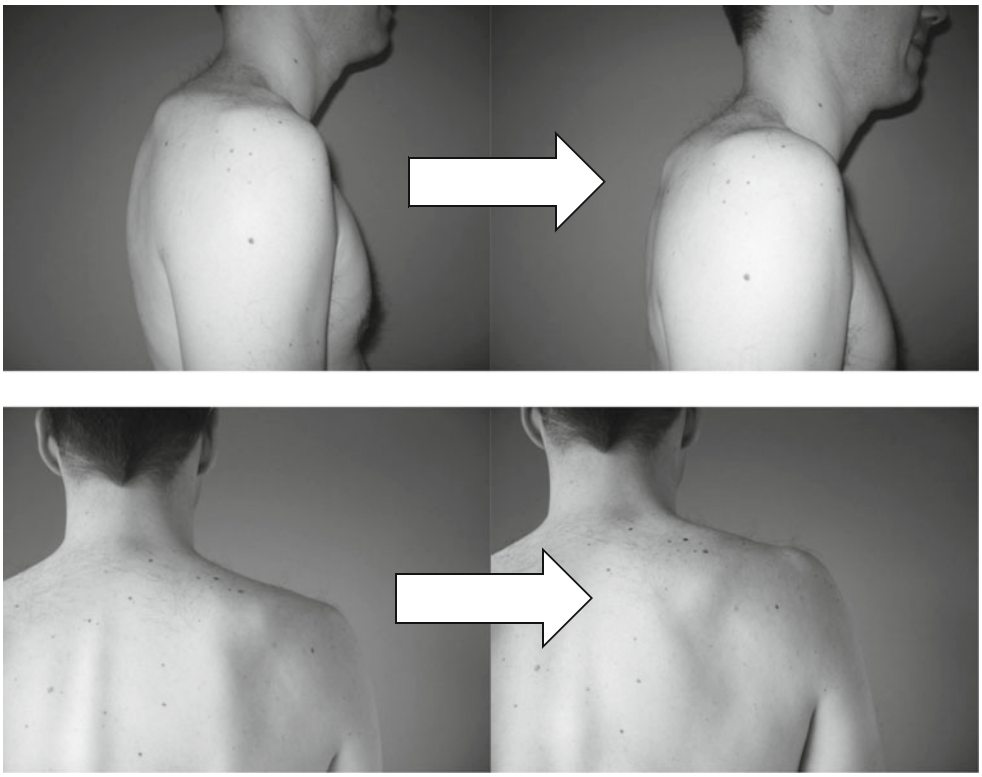

Fig. 8 Scapular orientation exercice

angles. Extra resistance was provided by using various materials (MSD-Band, MSD-Tube, MSD AB Gym ball, Versa flex stick and MSD balance trainer per board; MSD Europe bvba, Nijverheidsstraat 18, Londerzeel, Belgium). Home exercises included stretching for the levator scapulae and rhomboids muscles (one time per day), the SOE exercise (as many times as possible). If the SOE was carried out correctly, all patients in this intervention group were asked to perform the training of all parts of the trapezius and serratus anterior muscles as described above (10 repetitions; one time per day).

Control group: protocol B

The control therapy comprised of exercise therapy and manual therapy, interventions known to be of benefit for patients with shoulder impingement syndrome [34]. Exercise therapy comprised of an eccentric muscle strength training program of the rotator cuff muscles (15 min) mainly based on Jonsson et al. [55]: Strength training was performed with the use of an elastic band (MSD-Band, MSD Europe). Training was divided into the following regimen: three series of 15 repetitions, one time per day, respecting the patient's pain threshold. Between the different series, there was a resting period of 2 min. The exercises were flexion, extension, medial rotation, and lateral rotation of the shoulder (Fig. 10). During each exercise, the patient was asked to quickly move in the desired direction and consequently slowly returning to the starting position. Manual therapy comprised of passive (multidirectional) glenohumeral mobilization (5 min) and friction massage therapy (5 min). The control therapy was ended with an ultrasound therapy (5 min): ultrasound therapy was performed with intermittent pulsations (100 Hz) of a 3 cm^2 probe, 2 W/cm^2 for 5 min, focused on the subacromial region.

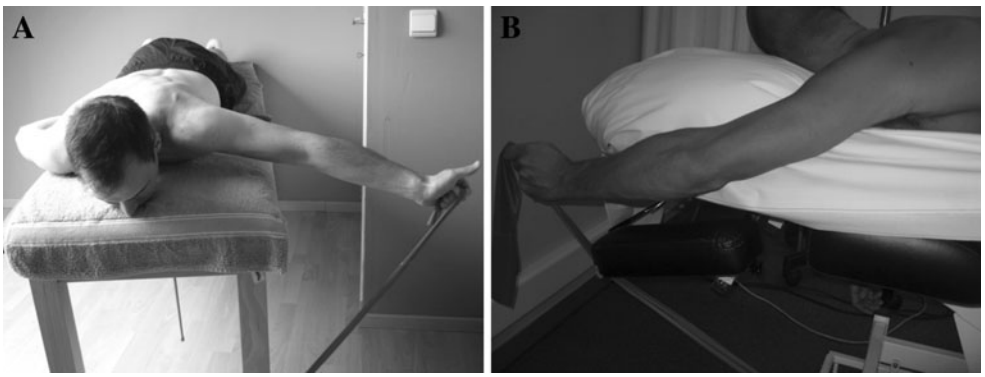

Fig. 9 Voluntary contraction of the middle (**a**) and lower (**b**) trapezius muscle

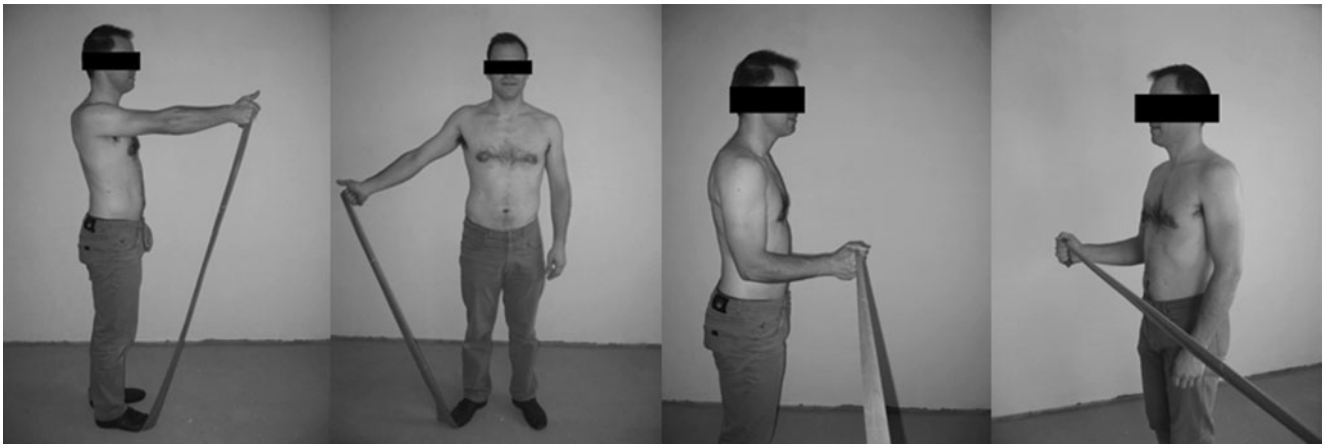

Fig. 10 Eccentric rotatorcuff training

Home exercises included an eccentric muscle strength training program of the rotator cuff muscles (15 min; one time per day). They were given an elastic band (MSD-Band, MSD Europe) and instructed to perform the same exercises that they do during the supervised therapy session (as described above).

For both treatment groups, load was increased in terms of gravity, range of motion, number of repetitions, speed, and resistance. If the subject could not perform an exercise correctly or experienced pain during exercise performance, load was not increased. The exercise was discontinued if the patient felt pain. All patients were treated during nine sessions of 30 min. Treatment frequency was organized between one and three times per week, depending on practical issues of the patient.

Statistical analysis

All data were analyzed using the Statistical Package for Social Sciences 12.00 for Windows [SPSS Inc. Headquarters, Chicago, IL, USA]. Normality of the variables was visually tested for a Gaussian distribution and additionally tested with the Kolmogorov–Smirnov test. Appropriate descriptive statistics were calculated. The significance level was set at 5 %. The sample size required for a significance level of 0.05 and a power of 0.80 to detect a significant decrease on the shoulder disability questionnaire score was calculated to be 46 subjects with shoulder impingement syndrome. However, the planned interim power analysis after 22 treated subjects revealed sufficient power (>0.80) for early ending the inclusion. Hence, further inclusion of subjects was deemed ethically incorrect. Two-factor repeated measures ANOVAs (group × time) were used to identify a treatment effect over time considering a relationship between evaluations performed in a single individual. In cases of discontinuation of treatment, the data were analyzed as intent to treat (last observation carried forward method). Effect sizes were calculated as Cohen's *d*, with *d* defined as the difference between the two means divided by the pooled standard deviation for those means. An effect size is a measure of strength of the relationship between two variables. A *d* value of 0.20 is described as small, 0.50 as medium (moderate), and 0.80 as large [56].

Results

Twenty-seven patients were diagnosed as having a shoulder impingement syndrome by a physician. Five did not comply with the inclusion criteria and were excluded (Fig. 1). In addition, 20 out of 22 subjects completed the study. Table 1 shows all baseline characteristics.

Primary outcome

All subjects completed the SDQ at baseline and nine sessions later. Between group, differences demonstrated a

Table 1 Baseline mean ± SD values

	Control group	Experimental group
Age, years	45.4±15.1	46.2±13.5
Women (men)	5 (5)	7 (5)
Body height (cm)	174.6 (13.2)	173.1 (8.2)
Body weight (kg)	78.4 (10.6)	70.5 (13.3)
Pain at rest (0–10 cm VAS)	2.4±2.5	2.8±2.8
Pain during movement (0–10 cm VAS)	6.3±1.9	5.7±2.6
Hawkins (0–10 VNRS)	3.9±3.4	5.0±1.8
Empty can (0–10 VNRS)	3.8±3.6	4.2±2.9
Neer (0–10 VNRS)	5.1±3.6	5.3±2.7
SDQ	50.9±11.85	55.9±14.58

SDQ shoulder disability questionnaire, *SD* standard deviation, *VAS* visual analog scale, *VNRS* verbal numeric rating scale

significant effect on self-reported disability in the scapular-focused group in contrast to the effect in the control therapy (p=0.025; post hoc power=0.801). After 3 months, SDQ score further decreased in both groups, up to 15.6 in the experimental group and 21.7 in the control group. No additional improvement in favor of the scapular-focused group was noticed. Table 2 shows the baseline means regarding self-reported shoulder disability (SDQ), pain at rest, pain during movement with intra- and intergroup comparisons of the treatment effect.

Although average SDQ scores decreased from 53.5 to 40.8 after nine sessions in all patients; it was only the scapular-focused group that showed a significant effect on the SDQ scores after nine sessions (Cohen's d 0.93; p= 0.006, Fig. 11).

Table 2 Baseline mean ± SD values regarding self-reported shoulder disability (SDQ), pain while at rest, pain during movement with intra- and intergroup comparisons of the treatment effect

	Before	After	95 % CI	P^a	IMPR (%)	Cohen's d^a	P^b	Cohen's d^b
	Control group							
Pain at rest (0–10 cm VAS)	2.4±2.5	2.3±2.6	−2.6 to 3.2	0.705	4			
Pain during movement (0–10 cm VAS)	6.3±1.9	5.1±2.0	−0.48 to 1.6	0.111	19			
Hawkins (0–10 VNRS)	3.9±3.4	3.9±3.0	−3.15 to 2.6	0.815	0			
Empty can (0–10 VNRS)	3.8±3.6	3.0±2.8	−3.03 to 5.0	0.566	21			
Neer (0–10 VNRS)	5.1±3.6	6.0±2.1	−2.7 to 2.4	0.451	−18			
SDQ	50.9±11.9	48.7±11.3	−9.0 to 12.9	0.725	4			
Scapular upward rotation at rest SA (°)	−11.1±8.1	−9.6±4.6	−6.7 to 3.5	0.481	14			
Scapular upward rotation at 45° SA (°)	−4.9±5.4	−7.0±6.5	−4.1 to 8.4	0.434	−30			
Scapular upward rotation at 90° SA (°)	2.3±5.4	0.6±4.0	−1.1 to 4.6	0.193	−74			
Scapular upward rotation at 135° SA (°)	8.7±9.2	6.1±3.9	−2.8 to 8.0	0.287	−30			
Scapular upward rotation at end range SA (°)	14.4±9.6	10.6±11.3	−5.3 to 13.0	0.340	−26			
Acromial distance (relaxed) (cm/cm)	0.42±0.07	0.46±0.05	−0.07 to 0.01	0.082	−10			
Acromial Distance (retracted) (cm/cm)	0.34±0.07	0.32±0.06	−0.004 to 0.04	0.099	6			
Isometric strength (N)	62.9±20.75	74.11±34.28	−42.8 to 20.38	0.419	18			
Pectoralis Minor Index	8.9±1.2	9.2±0.5	−1.46 to 0.76	0.388	3			
	Experimental group							
Pain at rest (0–10 cm VAS)	2.8±2.8	1.3±1.5	−1.5 to 3.8	0.264	54		0.66	
Pain during movement (0–10 cm VAS)	5.7±2.6	3.0±1.9	0.3 to 3.9	0.004	47	1.19	0.046	1.04
Hawkins (0–10 VNRS)	5.0±1.8	2.9±2.2	1.5 to 4.5	0.017	42	1.04	0.083	
Empty can (0–10 VNRS)	4.2±2.9	1.9±2.0	0.6 to 3.6	0.003	55	0.92	0.475	
Neer (0–10 VNRS)	5.3±2.7	3.1±3.1	0.4 to 5.0	0.009	42	0.76	0.022	1.06
SDQ	55.9±14.6	35.0±14.0	4.2 to 35.6	0.006	37	0.93	0.025	0.73
Scapular upward rotation at rest SA (°)	−9.4±3.7	−9.6±2.6	−4.1 to 4.6	0.895	−2		0.522	
Scapular upward rotation at 45° SA (°)	−3.5±4.5	−5.0±4.1	−4.2 to 7.2	0.554	−43		0.858	
Scapular upward rotation at 90° SA (°)	4.9±7.0	1.4±3.0	−1.2 to 8.7	0.119	−71		0.467	
Scapular upward rotation at 135° SA (°)	12.5±9.0	9.0±5.4	−2.6 to 9.6	0.218	−28		0.792	
Scapular upward rotation at end range SA (°)	19.4±12.7	19.3±10.0	−6.5 to 6.7	0.965	−1		0.429	
Acromial distance (relaxed) (cm/cm)	0.42±0.06	0.40±0.05	−0.03 to 0.07	0.386	5		0.068	
Acromial distance (retracted) (cm/cm)	0.31±0.06	0.30±0.05	−0.04 to 0.06	0.703	3		0.755	
Isometric strength (N)	51.36±15.79	55.79±18.71	−20.71 to 11.88	0.542	9		0.624	
Pectoralis minor index	9.1±2.3	10.3±0.7	−15.2 to 12.8	0.472	13		0.375	

Analysis of variance for repeated measures was used

SDQ shoulder disability questionnaire, *SD* standard deviation, *VAS* visual analog scale, *SA* shoulder abduction, *IMPR* improvement, *CI* confidence interval

[a] Within group

[b] Between groups

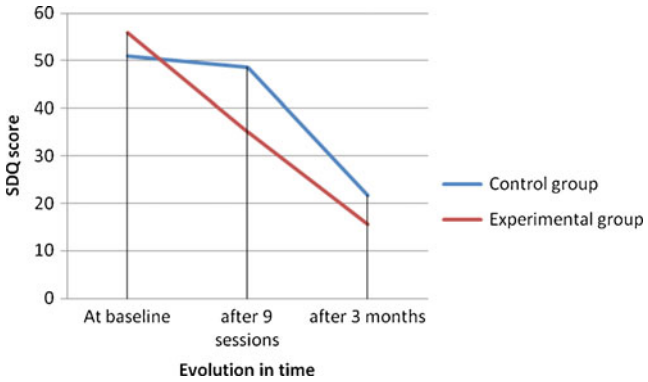

Fig. 11 Repeated measures ANOVA between the experimental group (scapular focused) and control group

Secondary outcomes

VNRS during impingement screening

There was a moderate effect (Cohen's d=0.76 in experimental group; p=0.022 between groups; Table 2) on the pain score during the Neer test in favor of the experimental protocol, in contrast to the effect in the control group. This effect was maintained after follow-up. Large improvements were noted in the experimental group when scoring the Hawkins and Empty can test. However, these effect sizes were not significant when comparing to the control group.

Visual analog scale

During movement, the effect size was larger (Cohen's d=1.19 in the experimental group) and there was a statistically significant difference between groups (p=0.046) in favor of the scapular-focused group.(Table 2) The scapular group demonstrated a moderate (Cohen's d of 0.67; p=0.26 within experimental group) improvement in self-experienced pain at rest whereas in the control group, almost no improvement was noted (Cohen's d of 0.04; p=0.71 within control group).

Scapular measurements

None of the scapular measurements (upward rotation, forward shoulder posture, strength, motor control, and pectoralis minor length) changed in response to the treatment (neither immediately following treatment nor at 3 months follow-up).

Discussion

The change in their ability to perform functional activities in daily life was measured with the SDQ. The SDQ focuses on how symptoms and complaints of patients with shoulder disorders affect their ability to perform daily activities. Since the improvement on the SDQ exceeds the 18.75 cutoff value for minimal clinically improvement [26], our findings suggest that the scapular-oriented approach showed clinically important beneficial effects on self-reported disability. Interestingly, the differences were maintained after 3 months follow-up. These improvements were accompanied by reduction in pain during movement and during the Neer impingement test. However, neither treatment protocols were able to change scapular positioning parameters in patients with shoulder impingement syndrome.

Our results support the findings of Lombardi et al. [57]. They assessed pain in patients with shoulder impingement syndrome who participated in muscle strengthening exercises. Patients in the experimental group showed an improvement from 4.2 to 2.4 cm on a 10-cm (VAS) regarding pain at rest and from 7.4 to 5.2 cm regarding pain during movement [47]. In our study, the improvement in pain during movement and during impingement screening in the experimental group was both statistically and clinically significant. The control group did not demonstrate such improvement. Therefore, we could suggest this improvement may have occurred as a result of its scapular focus. However, the applied test for motor control (KMRT) did not confirm an altered scapular motor control. In addition, the medial rotation test potentially lacks sensitivity for detecting this change. As the evaluation of scapular motor control could be of great importance, further study is warranted on the reliability and validity of this test. In addition, in order to evaluate scapular positioning in a clinical setting, there is a need for reliable and valid methods. However, although the method used in the present study has previously been shown to demonstrate satisfactory intraexaminer reproducibility in musicians [49] and in trapezius myalgia patients [58], validity of these tests is yet to be established. In addition, although it has been shown that subjects with short pectoralis minor muscle length demonstrate similar scapular kinematics as subjects with shoulder impingement syndrome. [25, 28, 31, 59], reliability is yet to be established.

Our results confirm the results of Roy et al. [32] who evaluated the effect of an intervention including shoulder control and strengthening exercises on function in patients with shoulder impingement syndrome. Their results provided preliminary evidence to support the use of shoulder control exercises to reduce pain and improve function of patients with shoulder impingement syndrome. Our present study was able to address some methodological issues in Roy's study [32]: the follow-up period was increased from 9 to 12 weeks, we treated 12 patients for scapular motor control instead of eight, and a blinded evaluator was used to assess outcomes, which improved the validity of our findings.

Excellent interrater and intrarater reliability have been reported with use of a hand-held dynamometer for assessment of shoulder strength in symptomatic subjects [60]. Although

both the control and intervention group were supposed to increase their muscle strength, no significant differences in isometric strength in the empty can position before and after treatment were found. Consequently, the favorable result of the experimental treatment protocol is unlikely to be due to increased muscle strength, especially not isometric strength. Some methodological issues should be addressed when using the hand-held dynamometer: when testing the arm strength by using a hand-held dynamometer, we often encountered problems with stability and tester strength. In addition, by rigidly mounting the dynamometer, we would be able to eliminate measurement variability due to variations in tester strength and stabilization, which has been reported as a limitation with use of the hand-held dynamometer. Although the hand-held dynamometer is widely used in clinical practice, a rigid mounted dynamometer allows the patient to perform a maximal effort without the clinician's ability to resist this effort affecting the strength measurement.

However, some study limitations remain. First, the secondary outcome measures were all clinical measures, not evaluated for intra-observer reliability prior to this study and often correlated to each other. Next, although this study proved sufficient power for the SDQ, the relative small sample may have minimized the potential to detect differences within some of the secondary outcome measures. The authors did not enroll the target number of patients predicted by their initial power analysis and elected to publish their results based on interim analysis. In addition, increasing the sample could have had a tempering effect on significance levels. In addition, accept for the 30-day inclusion criteria, there were no registrations of symptom duration. Likewise, no registration of their compliance with home exercises was done. Next, both treatment groups were treated by the same therapist. Although this approach augmented standardization, it is possible that the therapist believed one therapy was superior above the other. Finally, an important limitation of this study is the fact that the interventions in the scapular-focused group included both scapular mobilizations, stretching, and scapular motor control training. Therefore, it would be impossible to determine which part of the intervention led to the observed improvements.

Based on exclusion, the majority of this patient population is likely to present some kind of scapular dyskinesis. However, future effect studies targeting scapular repositioning and motor control should use aim at selecting patients on the basis of scapular dyskinesis. In addition, we used the Hawkins, Neer, and Jobe tests for diagnosing subacromial impingement syndrome. However, the accuracy of these tests indicate high sensitivity (e.g., useful at ruling out rotator cuff disorders), but less specificity (e.g., the exact structure at fault) [58]. One could suggest that other pathologies might have been the cause of symptom reproduction on testing. In fact, the experimental group reported with 11 % higher pain levels during the Hawkins test at baseline in contrast to the control group. Although no significant difference was noted between both groups at baseline, this difference could be the result of a possible difference in affected structure.

The intervention proposed in this study includes an exercise program, based mainly on scapular motor control principles, that provides improvement in shoulder disability and pain. Surprisingly, pain reduction and function improvement is apparent without measurable difference in scapular function. One can also argue that the measure used to quantify scapular rotations was not sensitive enough to capture changes that are relevant to function. When looking at individual data, changes of small magnitudes were observed following intervention for some subjects.

Additional study in patients with shoulder impingement syndrome should be performed to test the results of this randomized clinical trial. In addition, the effect of a scapular-focused treatment approach should be tested in other populations, such as overhead athletes or patients with other shoulder pathologies specifically selected for scapular dyskinesis. The addition of a third control group with no treatment could also strengthen the study design by controlling for natural recovery. In addition, duration of shoulder pain should be registered and consequently possible effects on outcome should be addressed.

In conclusion, a scapular-focused treatment approach showed promising clinical results in a group of patients with shoulder impingement syndrome. Our results suggest that a rehabilitation program that included motor control exercises, scapular mobilizations, and stretching is effective for reducing pain and disability for patients with shoulder impingement syndrome.

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Disclosures None

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