UNIVERSIDADE FEDERAL DE SÃO CARLOS
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PROGRAMA DE PÓS-GRADUAÇÃO EM FISIOTERAPIA

DOCTORAL THESIS

Shoulder Impingement– Short-term effects of a thoracic spine manipulation and a systematic review of physical therapy strategies

Melina Nevoeiro Haik

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Thanks God for the health and strength to continue even when I thought I wasn't able anymore. To my husband Eduardo, for all the love and support day by day even when not completely understanding my absence from his side to accomplish this work. To my son Diogo, who is still living inside me, for being a good child, avoiding me to suffer from the huge symptoms of pregnancy and allowing me to be sitting and writing long hours in the past months. To my parents, Raquel and Nicolau, for the dedication of a lifetime to my wellness, always with enthusiasm and unconditional support during my entire carrier. For you all, thrust and encouragement were fuels to continue this journey.

To Paula for the supervision, teachings and dedication time during the past 11 years (ow!). Thanks for pulling me back to post-graduation studies and diving with me into the manual therapy scientific approach! It was a pleasure to be your first master and doctorate student.

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Contextualization

The present thesis is a continuation of my master investigation that started from a scientific cooperation between Dr. Paula Rezende Camargo and Dr. Francisco Alburquerque-Sendín (University of Salamanca, Spain) regarding manual therapy treatment for Shoulder Impingement Syndrome (SIS) and the effects of the therapy on shoulder pain and biomechanics. Considering our interest on shoulder complex research and my experience on Osteopathy, we designed the project to assess immediate and short-term effects of the spinal manipulation technique on pain, function and scapular kinematics and muscle activity in patients with SIS. The immediate effects on pain and scapular kinematics were presented in my master dissertation and published in the Journal of Orthopaedic & Sports Physical Therapy in 2014. The short-term effects of the technique on pain, function, scapular kinematics and muscle activity are presented in this thesis and the manuscript is submitted at Physical Therapy Journal.

Dr. Francisco Alburquerque-Sendín, as my co-advisor, was also interested in reviewing the efficacy of available physical therapy techniques for the treatment of SIS and suggested me to do this during the doctorate in an attempt to better understand the influence of manual therapy approach on this shoulder pathology. This was a huge systematic review that started about 20 months ago, and finally completed in the last month. Other people contributed to this review (Dr. Roberta F. C. Moreira and Elisa Dória Pires). The manuscript is also presented in this thesis and will be submitted to the British Journal of Sports Medicine. .

As part of the doctorate, in November 2014, I travelled to Australia for 6 months to develop another study related with SIS patients and manual therapy approach with Dr. Leanne Bisset and Dr. Kerrie Evans at Griffith University (Gold Coast). Using the emerging perspective for assessing central sensory processing in a clinical manner, we performed a single-arm clinical trial to assess conditioned pain modulation and temporal summation of pain in SIS patients before and after treatment with mobilization-with-movement. The aims were to determine the dominant pain modulation process in this population and the prognostic factors of those patients who are likely to respond to manual therapy. Moreover, we also assessed the reliability of conditioned pain modulation and temporal summation of pain assessments in healthy and SIS individuals. Data collection was finished in March 2015 and these studies are still in process of statistical analysis to be submitted to a physical therapy journal next year.

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Resumo

Introdução: A Síndrome do Impacto (SI) é uma causa comum de dor no ombro e inúmeras estratégias de tratamento estão disponíveis na clínica. Os efeitos da manipulação torácica e a eficácia de muitas técnicas de tratamento da SI ainda não estão claros na literatura.
Objetivos: Em um ensaio clínico, os objetivos foram avaliar os efeitos a curto-prazo de uma manipulação torácica na dor, função, cinematica scapular e atividade muscular em indivíduos portadores de SI. Em uma revisão sistemática, o objetivo foi sintetizar a atual evidência a respeito da efetividade da fisioterapia para melhorar a dor, função e amplitude de movimento nessa mesma população.
Métodos: No ensaio clínico, os participantes foram distribuídos aleatoriamente ao grupo manipulação (n=30) ou grupo *sham* (n=31) e receberam 2 sessões de intervenção durante 1 semana. Foram medidos dor e função do ombro (questionários DASH e WORC), cinematica e atividade muscular da escápula. Um avaliador cego coletou as variáveis no dia 1, dia 2-pré intervenção, dia 2 pós-intervenção e no dia 3. Na revisão sistemática, as buscas foram realizadas nas bases de dados Pubmed, Web of Science, CINAHL Cochrane, Embase, Lilacs, Ibecs e Scielo até abril de 2015. Foram incluídos ensaios clínicos randomizados controlados que investigaram o efeito de diferentes modalidades fisioterapêuticas no tratamento de pacientes com SI na dor, função e amplitude de movimento.
Resultados: No ensaio clínico, o grupo manipulação apresentou diminuição da dor (1.1 pontos) e uma tendência de melhora na função (5.0 pontos no WORC) comparado ao grupo *sham* após 2 intervenções. A rotação superior da scapula aumentou 4.0°, 5.3° e 3.3° no dia 2 pré-intervenção, dia 2 pós-intervenção e no dia 3, respectivamente durante a descida do braço. As mudanças na rotação interna e na inclinação da scapula não foram diferentes entre os grupos. Atividade do trapézio superior e trapézio inferior diminuiu no grupo manipulação e em ambos grupos, respectivamente. A atividade do serrátil anterior aumentou no grupo *sham*. Na revisão sistemática, 62 estudos controlados randomizados foram incluídos. A maioria dos estudos apresentou baixo risco de vies. Os exercícios terapêuticos apresentaram alta evidência de melhora no tratamento a curto, médio e longo prazo. Os exercícios proprioceptivos e a terapia manual associada com exercícios convencionais aumentam as melhoras a curto prazo. O laser de baixa intensidade, ultrassom, campo pulsado eletromagnético e o tape proporcionaram evidência moderada e alta de nenhum benefício ao tratamento. As terapias com ondas curtas, estimulação transcutânea eletromagnética, a terapia manual aplicada de forma isolada e a acupuntura apresentaram evidência limitada de benefícios.
Conclusão: A manipulação torácica parece proporcionar a curto prazo redução da dor no ombro, aumento da rotação superior da scapula e diminuição da atividade do trapézio superior facilitando a aplicação de outras terapias focadas no restabelecimento do movimento em pacientes com SI. Os exercícios terapêuticos devem ser utilizados como primeira opção para melhorar a dor, a função e a amplitude de movimento, e a associação dos exercícios com a terapia manual deve ser a melhor opção para acelerar a melhora dos sintomas. O laser de baixa intensidade, ultrassom, campo eletromagnético pulsado e o tape não proporcionam efeitos significativos à terapia, portanto, devem ser evitados. Mais estudos são necessaries para aperfeiçoar a evidência a respeito da terapia com ondas curtas, miofibrólise, estimulação elétrica transcutânea, acupuntura e terapia manual aplicada isoladamente no tratamento da SI.

Palavras-chave: Síndrome do impacto do ombro, manipulação espinhal, terapia manual , reabilitação

Abstract

Background: Shoulder impingement syndrome (SIS) is a common cause of shoulder pain complains and numerous treatment strategies are available in the clinic. Questions remain regarding the effects of Thoracic Spinal Manipulation (TSM) on SIS and concerning the efficacy of available techniques on the treatment of this population.
Objectives: In a clinical trial, the objective was to evaluate short-term effects of a TSM on pain, function, scapular kinematics and scapular muscle activity in individuals with SIS. In a systematic review, the objective was to summarize current evidence regarding effectiveness of physical therapy to improve pain, function and range of motion in this population.
Methods: In the clinical trial, participants were randomly allocated to TSM group (n=30) or *sham*-TSM group (n=31) and attended 2 intervention sessions over a 1-week period. Shoulder pain, shoulder function (DASH and WORC questionnaires), scapular kinematics and scapular muscle activity were measured. A blinded assessor evaluated the outcomes at day 1, day 2-pre, day 2-post and day 3. In the review, Pubmed, Web of Science, CINAHL Cochrane, Embase, Lilacs, Ibecs and Scielo databases were searched up to April 2015. Randomized controlled trials investigating different modalities of physical therapy in the treatment of patients with SIS on pain, function/disability or range of motion were included.
Results: In the clinical trial, TSM group improved pain (1.1 points) and tended to improve function (5.0 points on WORC) over the *sham*-TSM group after 2 intervention sessions. Scapular upward rotation increased 4.0°, 5.3° and 3.3° at day 2-pre, day 2-post and day 3, respectively, in the TSM group during lowering of the arm. Changes in scapular internal rotation and tilt were not different between groups. Upper and lower trapezius activity decreased in the TSM group and both groups, respectively, during elevation and lowering of the arm. Serratus anterior activity increased in the *sham*-TSM group. In the review, sixty-two RCTs were included. The majority had a low to moderate risk of bias. Exercise therapy provided high evidence of improvements to the treatment in the short, mid or long-term. Dynamic humeral centering, proprioceptive exercises and manual therapy associated with conventional exercises enhance the improvements in the short-term. Low-level laser, ultrasound, pulsed electromagnetic field and kinesio taping provided moderate and high evidence level towards no benefits to the treatment of SIS. Microwave diathermy, transcutaneous electrical nerve stimulation and isolated manual therapy or acupuncture provided limited evidence of benefits.
Conclusion: TSM may be worthy to achieve short-term reduction of shoulder pain, increase of scapular upward rotation and decrease of upper trapezius activity facilitating the application of other movement-based interventions in individuals with SIS. Exercise therapy should be used as the first choice to improve pain, function and range of motion, and the association of manual therapy should be the best choice to accelerate symptoms decrease and progress exercise therapy quickly. Low-level laser therapy, ultrasound, pulsed electromagnetic field and kinesio taping do not provide significant effects to the therapy and therefore could be avoided. More studies are necessary to improve evidence concerning effects of diacutaneous fibrolysis, microwave diathermy, transcutaneous electrical stimulation, acupuncture and isolated manual therapy techniques in the treatment of SIS.

Key-words: shoulder impingement syndrome, spinal manipulation, manual therapy, rehabilitation.

Introduction

Shoulder impingement syndrome (SIS) is a common cause of shoulder pain[82, 127] frequently associated with scapular motion alterations and scapulothoracic muscles misbalance[81, 106]. Although controversies exist regarding the direction of scapular motion alterations, decreased scapular upward rotation and posterior tilt and increased internal rotation are frequently described in individuals with SIS[82, 106]. Increased upper trapezius activity, decreased serratus anterior activity and delayed middle and lower trapezius onset during elevation and lowering of the arm have also been observed in this population[106].

There are numerous options of conservative interventions proposed for SIS, such as stretching and strengthening exercises[29, 31, 32, 77, 79], joint mobilization and manipulation[6, 9, 30, 60], scapular and proprioceptive training[7, 11, 85], taping[116, 117], acupuncture[66, 67] and many physical resources[46, 52, 54]. Thoracic spine manipulation (TSM) is one of the manual therapy techniques commonly used for the management of patients with shoulder dysfunctions based on regional interdependence between thoracic spine and shoulder complex. Regional interdependence concept involves mechanical[130] and neurophysiological[19] inter-relationships among seemingly unrelated regions, with relevant clinical applications[90].

Findings concerning TSM effects on shoulder pain are still contradictory. Some investigations have demonstrated improvements on pain and function following TSM[25, 98, 120] while others have shown no changes on pain, function, pressure pain threshold, or scapular kinematics after the intervention[60, 70, 109]. All these trials observed immediate or short-term effects of only one TSM session and those that demonstrated benefits were performed with no control group for comparison. On the other hand, recent systematic reviews pointed out a potential for benefit of shoulder conditions by treating the thoracic spine with repetitive sessions of manual therapy[73, 131]. Therefore, it is necessary to clarify clinical effectiveness of more than only one TSM session in the treatment of SIS in the short and long-term.

In respect of other physical therapy interventions, some systematic reviews have been shown evidence towards equal effectiveness of exercise therapy and surgery in the long-term, better efficacy of the exercises over no treatment, and better efficacy of combined treatment composed of exercise and other therapies over single interventions to improve pain and function[39, 42, 53, 73]. Some of these evidences were drawn from low to moderate quality level trials[39, 73, 74] and part of them was based on only 1 randomized-controlled trial[42]. Moreover, some of the reviews included trials in which patients were also diagnosed with calcareous tendinitis and rotator cuff rupture[42, 53], which represent different clinical presentations from SIS. Finally, in

the last review of all available treatment options the systematic search of trials was performed up to 2009[53]. Therefore, there is still need for recent and high quality level of evidence concerning the efficacy of exercise therapy and the combination of other therapies, and also regarding the effectiveness of other physical therapy resources.

According to the current scenario, the following work will present 2 studies involving physical therapy rehabilitation for SIS. In the first study, a randomized-controlled trial, the primary purpose was to investigate short-term effects of one TSM intervention on pain, function, scapular kinematics and scapular muscles activity in individuals with SIS. The secondary purpose of this study was to assess short-term effects of repeated TSM intervention on the same outcomes and population. In the second study, a systematic review of the literature was performed in order to summarize and analyze current evidence regarding effectiveness of physical therapy interventions to improve pain, function and range of motion in individuals diagnosed with SIS.

Study 1: Short-term effects of thoracic spine manipulation on shoulder impingement syndrome – A randomized controlled trial

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Abstract

Background. Thoracic spine manipulation (TSM) has been used in the management of patients with shoulder impingement syndrome (SIS). However, questions remain regarding the effects of this intervention on this population.

Objective. To investigate short-term effects of TSM on pain, function, scapular kinematics and scapular muscle activity in individuals with SIS.

Design. Double-blinded, randomized controlled trial.

Setting. Institutional laboratory.

Participants. Sixty-one patients with SIS.

Intervention. Participants were randomly allocated to TSM group (n=30) or *sham*-TSM group (n=31) and attended 2 intervention sessions over a 1-week period.

Measurements. Shoulder pain, shoulder function (DASH and WORC questionnaires), scapular kinematics and scapular muscle activity were measured. A blinded assessor evaluated the outcomes at day 1, day 2-pre, day 2-post and day 3.

Results. TSM group improved pain (1.1 points) over the *sham*-TSM group at day 3 (95% CI=-1.7 to -0.5). TSM group improved 2.9 points over the *sham*-TSM group (95% CI=-5.1 to -0.5) in DASH score at day 2-pre and 5.0 points (95% CI=-9.7;-0.3) in WORC score at day 2-post. Scapular upward rotation increased 4.0°, 5.3° and 3.3° at day 2-pre, day 2-post and day 3, respectively, in the TSM group during lowering of the arm. Changes in scapular internal rotation and tilt were not different between groups. Upper and lower trapezius activity decreased in the TSM group and both groups, respectively, during elevation and lowering of the arm. Serratus anterior activity increased in the *sham*-TSM group.

Conclusion. TSM may be worthy to achieve short-term reduction of shoulder pain, increase of scapular upward rotation and decrease of upper trapezius activity facilitating the application of other movement-based interventions in individuals with SIS.

Word count: 4,132 words

INTRODUCTION

Shoulder impingement syndrome (SIS) is a common cause of shoulder pain[82, 127] and is frequently associated with motion abnormalities[81]. Scapular orientation and control on the thorax play a critical role in normal shoulder function since it allows maximal joint congruency and a stable base for humeral motion[106]. Although controversies exist regarding the direction of scapular motion alterations, decreased scapular upward rotation and posterior tilt and increased internal rotation are frequently described in individuals with SIS[82, 106]. Abnormal scapulothoracic muscle activation has also been demonstrated in individuals with SIS. Increased upper trapezius activity, decreased serratus anterior activity and delayed middle and lower trapezius onset during elevation and lowering of the arm have been observed in this population[106].

Physical therapy treatment for SIS includes several evidence-based approaches such as strengthening and stretching exercises[13, 31, 32, 79, 86, 88], and manual therapy techniques[9, 18, 123, 133]. Thoracic spine manipulation (TSM) is one of the manual therapy techniques commonly used for the management of patients with shoulder dysfunctions based on regional interdependence between thoracic spine and shoulder complex. Regional interdependence concept involves mechanical[130] and neurophysiological[19] inter-relationships among seemingly unrelated regions, with relevant clinical applications[90].

Three investigations have demonstrated improvements in shoulder pain and function immediately following TSM in individuals with SIS[25, 98, 120]. However, it is difficult to draw conclusions due to the lack of control or comparison groups in the previous studies. Haik et al.[60] and Kardouni et al.[69] have recently used a *sham* group as comparator for the TSM group in SIS individuals and found no difference in changes between groups for shoulder pain and function, pressure pain threshold, and scapular kinematics during arm movement, after only one TSM intervention. Riley et al.[109] were the first group to investigate short-term effects of TSM in shoulder conditions in a randomized controlled trial using different type of verbal message and language for the patient regarding the treatment applied. They demonstrated that neither the type

of TSM nor the message conveyed to the patients had significant effect on pain and function improvement in patients with musculoskeletal shoulder symptoms after only one session. However, systematic reviews point out that there is potential for benefit of shoulder conditions by treating the thoracic spine with manual therapy[73, 131].

There is need for further research examining clinical effectiveness in the short- and long-term of more than only one session of TSM intervention in patients with shoulder conditions. The primary purpose of this study was to investigate short-term effects of one TSM intervention on pain, function, scapular kinematics and scapular muscle activity in individuals with SIS. The secondary purpose was to assess short-term follow-up effects of repeated TSM intervention. It is hypothesized that patients receiving TSM compared to *sham*-TSM would show: 1) decreased shoulder pain, 2) increased shoulder function, 3) increased scapular upward rotation and posterior tilt during arm movement, and 4) decreased upper trapezius activity and increased serratus anterior, lower and middle trapezius activity.

METHODS

Design overview

This was a double-blinded, randomized controlled trial with short-term follow-up after 2 sessions of TSM. Double-blinding design was achieved with the investigator responsible for data collection and the patient unaware of the sort of treatment applied by the therapist.

Setting and Participants

One-hundred eleven subjects with SIS were recruited by advertisement at local community, orthopedic clinics and university buildings. Inclusion criteria for patients with SIS are described elsewhere[60]: shoulder pain in the C5 or C6 dermatome region, 18-60 years of age, and 3 of the following 5 clinical signs of SIS: 1) positive Neer test[100], 2) positive Hawkins test[61], 3) positive Jobe test[65], 4) pain during active elevation in the scapular or sagittal plane, 5) pain or

weakness with resisted shoulder external rotation[93]. All subjects had to reach at least near 150° of arm elevation as determined by visual observation. Exclusion criteria for both groups were: signs of "red flags" for spinal manipulation (eg. fracture, osteoporosis, malignancy, infection, and active inflammatory process)[22], history of shoulder, cervical spine or thoracic spine fracture or surgery, signs of cervical nerve root involvement or central nervous system involvement, signs of complete rotator cuff tear or acute inflammation, adhesive capsulitis, glenohumeral instability (ie, positive apprehension, anterior drawer, or sulcus tests)[89], physical or manual therapy treatment within 6 months prior to the evaluation, analgesic pills within 1 month prior to the intervention, systemic illness, scoliosis, or pregnancy. All measurements and interventions were conducted at the Laboratory of Analysis and Intervention of the Shoulder Complex at the University. This study was approved by the university´s Institutional Review Board (number 465/2011) and is registered at www.clinicaltrials.gov (NCT02083796). All participants were provided verbal and written explanation of study procedures and signed an informed consent to participate.

Randomization and Intervention

Sixty-one individuals were allocated into one of the two groups: 1) TSM intervention (n=30); and 2) *sham*-TSM intervention (n=31). The website http://www.randomization.com was used to generate treatment assignments for the individuals and the intervention was revealed by a third assessor to the therapist only immediate before its execution. All individuals were blinded to treatment assignment and received general information about the purpose of the study to control the expectation and *sham* intervention effectiveness. An investigator blinded to group's assignment of each participant took all measurements and was not in the room during the application of the intervention. Individuals were asked not to talk about the intervention during the period of data collection.

Interventions were performed by a physical therapist with 4 years of experience in manual therapy. According to previous studies[25, 60, 69, 95], TSM or *sham*-TSM interventions were directed to the middle thoracic spine. The technique was applied twice in a period of 3-4 days apart. The administration of the TSM consisted of a high velocity, low-amplitude thrust applied at the end of available spinal motion after the patient exhaled. The individual was seated, foots in the ground, and arms crossed over the chest wall. The therapist was positioned behind the individual with the sternum over middle thoracic spine and the hands holding patient arms (Figure 1). If no cavitation was detected with the manipulation, the thrust was repeated up to 3 times.

During the *sham*-TSM intervention, the individual was in the same position and the therapist maintained manual contact through the range of motion during exhalation, but no manipulative thrust was delivered. *Sham*-TSM was previously reported as believable active treatment[92].

Figure 1. Subject and therapist positioning during both TSM and sham-TSM interventions.

Outcomes and Follow-up

Pain, scapular kinematics and EMG data were collected during elevation and lowering of the arm in the sagittal plane at day 1 (baseline – before first intervention), day 2 pre-intervention (3-4 days after day 1), day 2 post-intervention (immediately after the second intervention), and at day 3 (follow-up at 3-4 days after the last intervention) (Figure 2). From baseline assessment to follow-up there was a 1-week interval. At the beginning of each day-session (day1, day 2 pre-intervention and day 3), individuals completed the DASH questionnaire and WORC index according to their conditions on the past weeks.

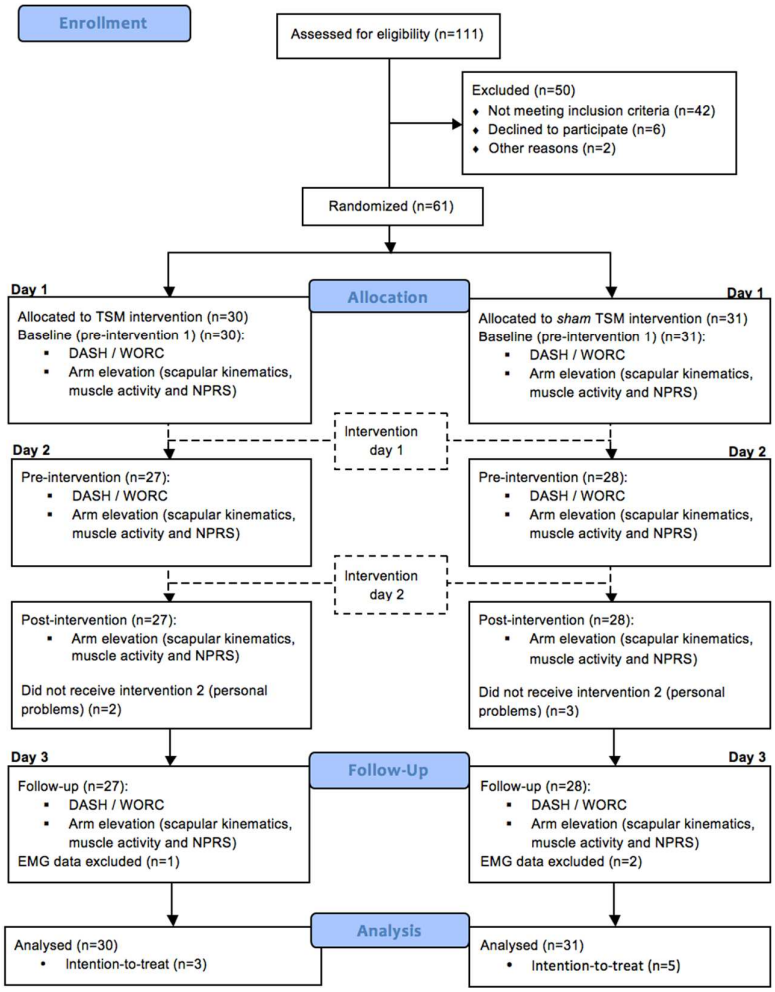

Figure 2. Flow diagram representing enrollment, allocation, follow-up, and analysis for manipulation and sham groups. Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; WORC, Western Ontario Rotator Cuff index; NPRS, Numeric Pain Rating Scale

Pain and function

Pain intensity was measured with the 11-point Numeric Pain Rating Scale (NPRS) where 0 is "no pain" and 10 is "the worst pain ever". The average of the 3 ratings during arm movement was used to represent each participant's level of pain. Numeric pain scales have been shown to be reliable and valid for subjects with shoulder pain[96]. Dworking et al.[43] considered the baseline score to calculate the minimal clinically important difference (MCID) as an improvement of 15% to 20% relative to baseline.

Disability of the Arm, Shoulder and Hand (DASH) questionnaire and Western Ontario Rotator Cuff Index (WORC) were used to assess shoulder pain and function. Both questionnaires are valid and reliable to assess function and health-related quality of life in subjects with upper-limb disorders[102] and rotator cuff disease[78]. DASH questionnaire scores range from 0 to 100 (0=best condition; 100=worst condition)[102]. MCID (90% confidence level) is 10.8 points for DASH questionnaire[48]. The WORC index is a self-reported questionnaire, which consists of 21 items in five domains: physical symptoms, sports and recreation, work, lifestyle, and emotions. Each item is scored on a 100-mm visual analog scale and summed to a total score of maximally 2,100, with a higher score indicating a reduced quality of life[78]. MCID (95% confidence level) is 19.3 points for total WORC score and the percent changes from baseline necessary for patient-related improvement is around 22%[44].

Scapular kinematics

For 3-D measurements, data capture and analysis were completed using Flock of Birds® (miniBird®) hardware (Ascension Technology Corporation, Burlington, VT) integrated with MotionMonitor™ software (Innovative Sports Training, Inc. Chicago, IL). The 3-D scapular tracking methodology used in the current investigation is described elsewhere[59, 60]. Individuals were instructed to perform 3 repetitions of full elevation and lowering of the arm in the sagittal plane (Figure 3). The procedure used has been shown to be reliable during elevation and lowering of the arm in asymptomatic individuals and individuals with SIS[59].

Previous studies have generally found that 2° to 5° of difference in scapular kinematics between those with and without SIS can be considered clinically relevant[80, 89]. Differences of 4° or greater in scapular kinematics were considered of clinical relevance in the present study.

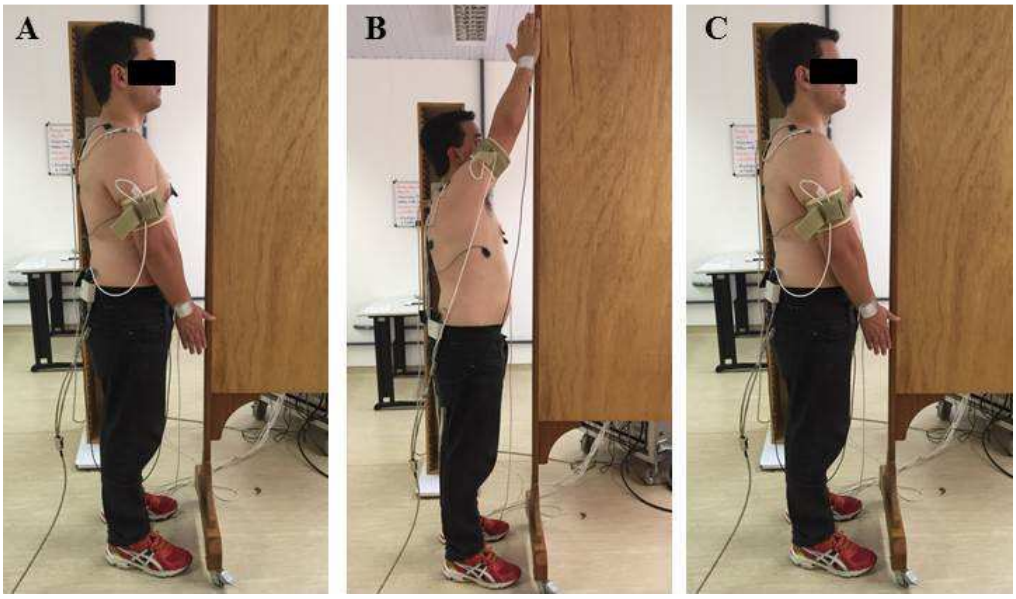

Figure 3. Data collection. (A) Start position of arm elevation, (B) maximal elevation, (C) final positiong of lowering of the arm.

Muscle activity

Activity of the upper trapezius (UT), lower trapezius (LT), middle trapezius (MD) and serratus anterior (SA) were collected at 2000 Hz/channel using Bagnoli-8 EMG System (DelSys, Boston, USA) during elevation and lowering of the arm. The EMG signal was recorded from each muscle with an active double-differential sensor (model #DE-3.1, DelSys, Boston, USA) made of pure silver (99.9%) with parallel bar geometry and 10 mm spacing between bars. The signal was pre-amplified using amplifier with input impedance of $<10^{15}$W in parallel, with 0.2 pF, voltage gain of 10, noise of 1.2 μV (RMS) and a common mode rejection ratio of 92 dB.

Electrodes on the UT[119], LT(44), MT(45) and SA(45) were positioned as previously described. Reference electrode was placed on distal ulna of the opposite wrist. To obtain maximal voluntary contraction (MVC) for normalization of each muscle, the individual performed two

trials of 3-second resisted isometric contraction for each muscle with 30-second interval between trials. For UT and SA, individuals were positioned and resistance was applied as described by Sousa et al.[118]. For MT and LT muscles, manual resistance was applied towards the floor on distal arm when the shoulder was horizontally abducted with external rotation with the individual in the prone position[45].

EMG signals were sampled in 2000 Hz, with gain of 1000 and filter band-pass of 20-450 Hz. The raw EMG data were full wave rectified, filtered with a 3rd order 60 Hz Butterworth notch filter, and smoothed using a root-mean-square (RMS) algorithm with a 500-ms moving window with Matlab software (Math Works, Inc., Massachusetts, USA) version 7.6.0. Data processing and reduction were done according to Sousa et al.[118]. Minimal detectable change inter-session for normalized mean UT, LT and SA EMG activity are 11.4, 3.9 and 10.3% during arm elevation, and 4.9, 3.2 and 7.6% during lowering of the arm, respectively[113].

Statistical Analysis

Sample size calculation was based on a significant level of 0.05, power of 0.80 to detect significant difference of 4° on scapular upward rotation and standard deviation of 4.5°[59]. Then, at least 21 participants with SIS were required in each group. Accounting for a withdraw rate of 15%, at least 26 participants were necessary.

Data were analyzed with SPSS Version 17.0 (SPSS Inc, Chicago, IL). Descriptive statistics for demographic data and all outcome measures were expressed as average and standard deviations. The Kolmogorov-Smirnov test was used to evaluate the distribution of data and all variables showed $p>0.05$.

A 2-factor analysis of variance was conducted for DASH, WORC, and NPRS data with group (TSM and *sham*-TSM) as between-subjects factor and time as within-subjects factor (3 levels of time for DASH and WORC, and 4 levels of time for NPRS). If no group x time interaction was observed main effect of time was analyzed.

Scapular kinematics and EMG data were analyzed using a 3-factor mixed model analyses of variance for elevation and lowering of the arm. Between-subjects factor group had 2 levels (TSM and *sham*-TSM), repeated-factor time had 4 levels (baseline, day 2 pre-intervention, day 2 post-intervention and follow-up), and repeated factor angle/interval had 4 levels for kinematics (30°, 60°, 90°, and 120°) and 3 levels for electromyography (30°-60°, 60°90°, and 90°-120°). If no interactions (group-by-time-by-angle, group-by-time, angle/interval-by-time) were observed, main effect of time was analyzed. Tukey and Sidak tests were used for post-hoc analysis when necessary. Significance level was 0.05 for all statistical analyses. An intention-to-treat analysis was performed using the expectation maximization method in SPSS to impute values for all missing data.

Finally, within- and between-group effect sizes for all variables were calculated using Cohen's d coefficient. An effect size smaller than 0.2 was considered small, between 0.3 and 0.7 moderate, and more than 0.8 large[35].

Role of the Funding Source

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RESULTS

Table 1 presents demographic data for both groups. Two subjects in the TSM group and 3 subjects in the *sham*-TSM group were lost to follow-up at days 2 and 3. EMG data from one subject in the TSM group and 2 subjects in the *sham*-TSM group were excluded because of noise in the signal. Intention-to-treat analysis was performed in 8/61 subjects (Figure 2). No subjects reported adverse effects.

Table 1. Demographic data

	TSM group (n=30)	***Sham*-TSM group (n=31)**
Age (years)	32.5 (12.0)	31.3 (11.0)
Sex	16 males / 14 females	22 males / 9 females
Mass (kg)	67.6 (14.5)	75.8 (12.4)
Height (m)	1.7 (0.1)	1.73 (0.1)
BMI (kg/m^2)	23.3 (3.2)	25.2 (3.2)
Involved shoulder	21 dominants / 9 non-dominants	19 dominants / 12 non-dominants
Duration of pain (months)	44.0 (86.3)	38.8 (59.7)

Data are mean (SD).

Pain and function

Table 2 brings results of pain for both groups. There was significant group-by-time interaction (p=0.04). Self-reported pain decreased for the TSM group at day 2 pre-intervention (21.2% of change) and day 2 post-intervention (27.3% of change) with moderate effect size compared to baseline. No differences were found for the *sham*-TSM group. Between-group comparison showed 33.3% of reduction in pain in the TSM group at follow-up with moderate effect size.

Table 3 shows the results for DASH and WORC questionnaires. There was no group-by-time interaction (p=0.14) for the DASH. However, main effect of time was significant (p<0.01) whereas score improved 2.5 points at day 2 pre-intervention and 4.7 points at day 2 post-intervention. Between-group analysis demonstrated improvement of 2.9 points (moderate effect) in the TSM group at day 2 pre-intervention.

For the WORC, there was no group-by-time interaction but main effect of time for physical symptoms (p=0.03), sports (p<0.01) and work (p<0.01) domains, as well as for total WORC score (p<0.01). Score improved 6.8 points on function related to sports (p=0.01), 7.4 on function related to work (p<0.01) and 5.2 on total function (p<0.01) at follow-up. Between-group comparison revealed improvement of 7.3 and 5.1 points in life style and emotion domains, respectively, at day 2 pre-intervention; 7.5 points in sports and work domains; and 5.0 in total WORC in the TSM group at follow-up, all with moderate effect of intervention. Total WORC improvement at follow-up occurred in 73.3% and 54.8% of participants in the TSM and *sham*-TSM groups, respectively.

Table 2. Pain at baseline, day 2 pre-intervention, day 2 post-intervention and at follow-up for subjects in both groups.

	Baseline	Day 2 pre-intervention	Day 2 post-intervention	Follow-up
TSM group	3.3 (2.4)	2.5 (2.4)	2.4 (2.5)	2.4 (2.1)
Sham-TSM group	2.7 (2.5)	2.4 (2.7)	2.4 (2.8)	2.9 (2.7)
Within-group change from baseline (95% CI) / within-group effect size				
TSM group	-	-0.7 (-1.3 to -0.1) / -0.33 (-0.8 to 0.2)*	-0.9 (-1.5 to -0.3) / -0.37 (-0.9 to 0.1)*	-0.9 (-1.5 to -0.2) / -0.39 (-0.9 to 0.1)
Sham-TSM group	-	-0.3 (-0.8 to 0.2) / -0.12 (-0.6 to 0.4)	-0.3 (-0.8 to 0.2) / -0.11 (-0.6 to 0.4)	0.2 (-0.4 to 0.8) / -0.08 (-0.4 to 0.6)
Between-group difference in change score (95% CI) / Between-group effect size				
	-	-0.4 (-1.0 to 0.1) / -0.3 (-0.8 to 0.2)	-0.6 (-1.1 to 0.0) / -0.4 (-0.9 to 0.1)	-1.1 (-1.7 to -0.5) / -0.6 (-1.1 to -0.1)

Data are expressed as mean (SD) unless stated otherwise; TSM: Thoracic Spinal Manipulation; 95% CI = 95% confidence interval.
Negative values represent pain decrease within-group or in favor to TSM group.
*significant change score ($p<0.05$) for within-group comparisons.

Table 3. Functional outcomes measures at baseline, day 2 pre-intervention, day 2 post-intervention and at follow-up for subjects in both groups.

Analysis/Measures	Baseline	Day 2 pre-intervention	Follow-up
Within-group difference from baseline (95% CI) / Within-group effect size (95% CI)†			
DASH			
TSM group		-3.9 (-6.3 to -1.6) / -0.3 (0.8 to -0.2)	-4.6 (-7.2 to -2.0) / -0.3 (-0.8 to 0.2)
Sham-TSM group		-1.0 (0.8 to -2.9) / -0.05 (-0.5 to 0.4)	-4.7 (-2.1 to -7.4) / -0.3 (-0.8 to 0.2)
WORC - Physical symptoms			
TSM group		-1.4 (-6.9 to 4.1) / 0.07 (-0.4 to 0.6)	-5.3 (-11.4 to 0.7) / 0.24 (-0.3 to 0.7)
Sham-TSM group		-3.4 (-7.2 to 0.4) / 0.13 (-0.4 to 0.6)	-4.2 (-9.1 to 0.8) / 0.16 (-0.3 to 0.6)
WORC – Sports / recreation			
TSM group		-4.4 (-9.5 to 0.8) / -0.2 (-0.7 to 0.3)	-10.6 (-17.6 to -3.5) / -0.4 (-1.0 to 0.1)
Sham-TSM group		-0.1 (-5.6 to 5.4) / 0.0 (-0.5 to 0.5)	-3.0 (-8.8 to 2.8) / 0.1 (-0.6 to 0.4)
WORC – Work			
TSM group		-4.5 (-10.8 to 1.7) / -0.2 (-0.7 to 0.3)	-11.2 (-16.9 to -5.6) / -0.5 (-1.0 to 0.0)
Sham-TSM group		-0.4 (-4.5 to 3.6) / -0.02 (-0.5 to 0.5)	-3.5 (-9.4 to 2.3) / -0.1 (-0.6 to 0.4)

WORC – Lifestyle		
TSM group	-6.2 (-13.4 to 0.9) / -0.3 (-0.8 to 0.2)	-6.3 (-13.8 to 1.2) / -0.3 (-0.8 to 0.2)
Sham-TSM group	1.1 (-4.1 to 6.2) / 0.0 (-0.5 to 0.5)	-1.1 (-5.6 to 3.4) / 0.0 (-0.5 to 0.5)
WORC – Emotions		
TSM group	-5.6 (-0.4 to -10.7) / -0.2 (-0.7 to 0.3)	-5.9 (-11.8 to -0.1) / -0.2 (-0.7 to 0.3)
Sham-TSM group	-0.5 (-6.0 to 5.0) / 0.0 (-0.5 to 0.5)	-0.3 (-5.4 to 4.9) / 0.0 (-0.5 to 0.5)
Total WORC		
TSM group	-4.1 (-8.8 to 0.6) / -0.2 (-0.7 to 0.3)	-7.7 (-2.6 to -12.8) / -0.4 (-0.9 to 0.1)
Sham-TSM group	-0.9 (-4.4 to 2.5) / 0.0 (-0.5 to 0.5)	-2.7 (-6.9 to 1.5) / -0.1 (-0.6 to 0.4)
Between-group difference in change score (95% CI) / Between-group effect size (95% CI) ‡		
DASH	-2.9 (-5.1 to -0.8) / -0.5 (-1.0 to 0.03)	0.1 (-2.5 to 2.8) / 0.01 (-0.5 to 0.5)
WORC – Physical symptoms	2.0 (-2.8 to 6.7) / 0.1 (-0.3 to 0.6)	-1.1 (-6.7 to 4.4) / -0.1 (-0.6 to 0.4)
WORC – Sports / recreation	-4.3 (-9.7 to 1.1) /-0.3 (-0.8 to 0.2)	-7.5 (-14.0; to-1.0) / -0.6 (-1.1 to -0.1)
WORC – Work	-4.1 (-9.4 to 1.2) / -0.3 (-0.8 to 0.2)	-7.7 (-13.5 to -1.9) / -0.6 (-1.1 to -0.1)
WORC – Lifestyle	-7.3 (-13.5 to -1.1) / -0.4 (-0.9 to 0.01)	-5.2 (-11.4 to 1.0) / -0.3 (-0.8 to 0.2)
WORC – Emotions	-5.1 (-10.5 to 0.3) / -0.3 (-0.8 to 0.2)	-5.6 (-11.2 to 0.1) / -0.4 (-0.9 to 0.1)
Total WORC	-3.2 (-7.4 to 1.1) / -0.3 (-0.8 to 0.2)	-5.0 (-9.7 to -0.3) / -0.5 (-1.0 to 0.0)

95% CI = 95% confidence interval; TSM: Thoracic Spinal Manipulation; DASH: Disability of the Arm, Shoulder and Hand questionnaire; WORC: Western Ontario Rotator Cuff Index.

† Negative values represent questionnaire score decrease and functional improvement within-group.

‡ Negative values represent questionnaire score decrease and functional improvement in favor to TSM group.

Scapular kinematics

Figure 4 illustrates scapular kinematics during elevation and lowering of the arm for both groups. Table 4 represents within- and between-group comparisons and effect size for scapular kinematics.

Elevation of the arm

For internal rotation and upward rotations, there was no group-by-time-by-angle interaction ($p=1.00$) neither were double interactions ($p>0.05$). Main effect of time was significant ($p<0.01$) for both rotations. Internal rotation decreased (mean change=2.2°; effect size=0.02; $p<0.01$) and upward rotation increased (mean change=2.6°; effect size=0.16; $p<0.01$) at day 2 pre-intervention. Upward rotation also increased at day 2 post-intervention (mean change=4.1°; effect size=0.25; $p<0.01$). Within-group analysis revealed that TSM group improved 4.9° of upward rotation at day 2 post-intervention with small effect size. Between-group comparisons revealed no significant differences for both rotations.

For scapular tilt, there was no group-by-time-by-angle interaction ($p=1.00$) but group-by-time interaction was significant ($p=0.02$). Anterior tilt increased ($p<0.01$) after *sham* intervention at follow-up. Moderate between-group effect size was found towards the *sham*-TSM group.

Lowering of the arm

Manipulative intervention produced greater effects during lowering of the arm than during elevation. For internal and upward rotations, there was no group-by-time-by-angle interaction ($p=1.00$), but group-by-time interaction was significant ($p<0.05$). Internal rotation decreased ($p<0.01$) and upward rotation increased ($p<0.01$) at day 2 pre-intervention in the TSM group. Between-group comparison revealed greater internal rotation decrease in TSM group at day 2 pre- and post-intervention with moderate effect size.

TSM group also showed increased upward rotation ($p<0.01$) at day 2 post-intervention compared to baseline. At follow-up, upward rotation was still higher than baseline in the TSM

group ($p<0.01$). In the *sham*-TSM group, upward rotation increased ($p=0.01$) at day 2 post-intervention. Between-group changes were significant at follow-up whereas TSM group showed increased upward rotation.

For scapular tilt, there was no group-by-time-by-angle interaction ($p=0.98$), nor were double interactions ($p>0.05$) or main effect of time ($p=0.51$). Between-group comparisons revealed 2.2° of anterior tilt increase in the *sham*-TSM with moderate effect size.

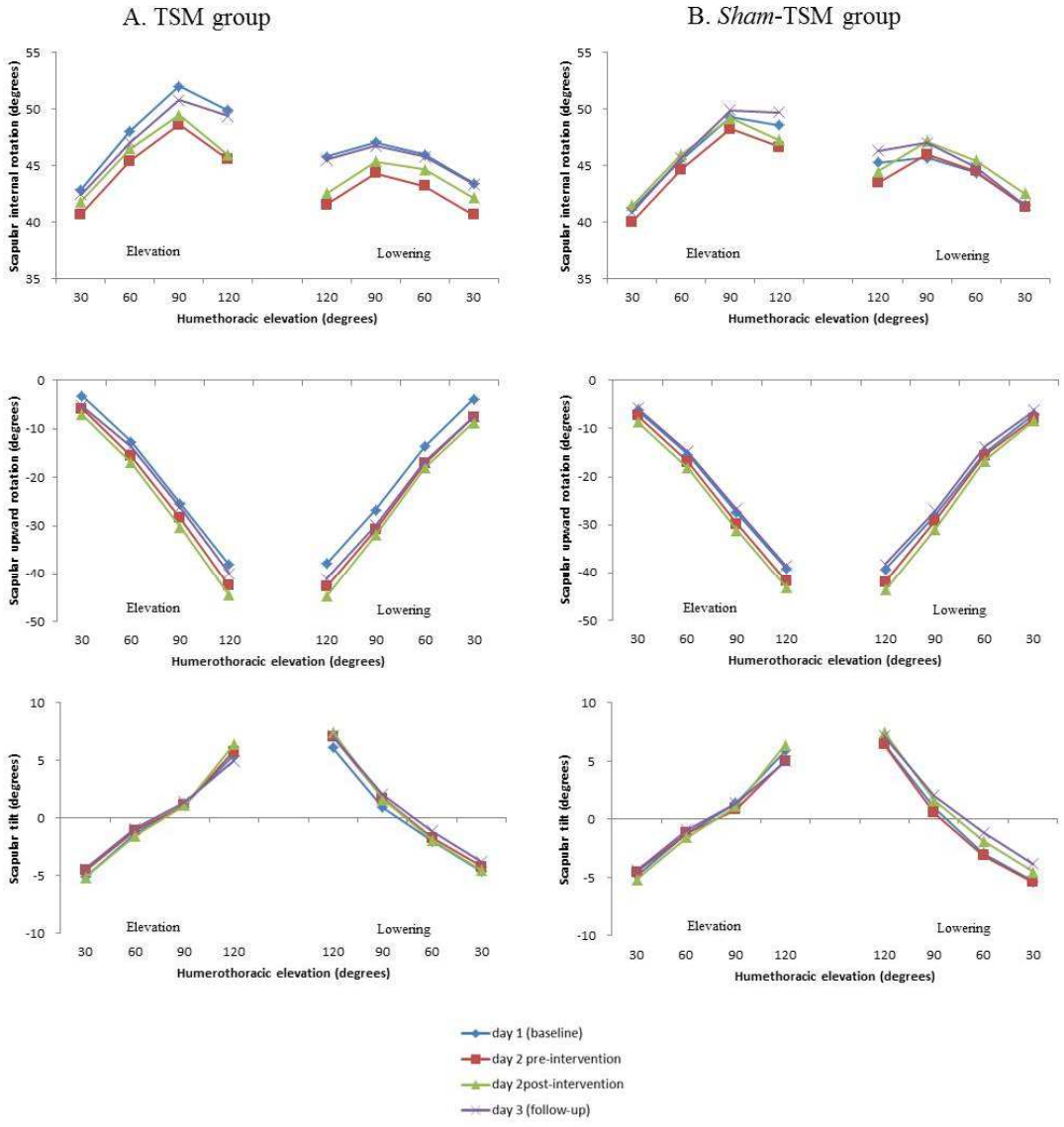

Figure 4. Data are mean ± SD for internal rotation, upward rotation and scapular tilt during elevation and lowering of the arm for TSM (A) and sham-TSM (B) groups.

Table 4. Within- and between-group change from baseline for scapular kinematics.

	Change score at day 2 pre-intervention from baseline†	Effect size (day 2 pre-intervention - baseline)‡	Change score at day 2 post-intervention from baseline†	Effect size (day 2 post-intervention - baseline)‡	Change score at follow-up from baseline†	Effect size (follow-up-baseline)‡
SCAPULAR INTERNAL ROTATION§						
Within group change score						
Elevation						
TSM group	-3.1 (-1.7 to -4.6)	-0.35 (-0.8 to 0.2)	-2.3 (-0.6 to -4.0)	-0.24 (-0.7 to 0.3)	-0.8 (0.3 to -1.8)	-0.11 (-0.6 to 0.4)
Sham-TSM group	-1.3 (0.2 to -2.7)	-0.13 (-0.6 to 0.4)	-0.2 (1.3 to -1.7)	-0.02 (-0.5 to 0.5)	0.4 (1.7 to -1.0)	0.03 (-0.8 to 0.8)
Lowering						
TSM group	-3.1 (-1.5 to -4.7)*	-0.40 (-0.9 to 0.1)	-1.9 (0.0 to -3.7)	-0.19 (-0.7 to 0.3)	-0.2 (0.9 to -1.3)	-0.03 (-0.5 to 0.5)
Sham-TSM group	-0.4 (1.2 to -1.9)	-0.04 (-0.5 to 0.5)	0.7 (2.3 to -0.9)	0.07 (-0.4 to 0.6)	0.7 (2.1 to -0.7)	0.07 (-0.4 to 0.6)
Between group change score						
Elevation	-1.9 (0.2 to -4.0)	-0.22 (-0.7 to 0.3)	-2.1 (0.1 to -4.4)	-0.23 (-0.7 to 0.3)	-1.1 (0.5 to -2.8)	-0.17 (-0.7 to 0.3)
Lowering	-2.7 (-0.6 to -5.0)	-0.30 (-0.8 to 0.2)	-2.6 (-0.1 to -5.0)	-0.26 (-0.8 to 0.2)	-0.9 (0.9 to -2.8)	-0.12 (-0.6 to 0.4)
SCAPULAR UPWARD ROTATION‖						
Within group change score						
Elevation						
TSM group	-3.2 (-1.7 to -4.7)	-0.16 (-0.7 to 0.3)	-4.9 (-3.2 to -6.5)	-0.24 (-0.7 to 0.3)	-1.5 (0.1 to -3.0)	-0.07 (-0,6 to 0.4)
Sham-TSM group	-1.9 (-0.6 to -3.2)	-0.13 (-0.6 to 0.4)	-3.2 (-1.8 to -4.7)	-0.22 (-0.7 to 0.3)	0.5 (1.8 to -0.8)	0.03 (-0.5 to 0.5)
Lowering						
TSM group	-4.0 (-2.5 to-5.5)*	-0.23 (-0.7 to 0.3)	-5.3 (-3.6 to -7.0)*	-0.31 (-0.8 to 0.2)	-3.3 (-1.7 to -4.8)*	-0.19 (-0.7 to 0.3)
Sham-TSM group	-1.3 (0.0 to -2.6)	-0.08 (-0.6 to 0.4)	-2.5 (-1.1 to -4.0)*	-0.16 (-0.7 to 0.3)	1.0 (2.2 to -0.2)	0.07 (-0.4 to 0.6)
Between group change score						
Elevation	-1.3 (0.6 to -3.3)	-0.17 (-0.7 to 0.3)	-1.6 (0.6 to -3.7)	-0.19 (-0.7 to 0.3)	-1.9 (0.1 to -4.0)	-0.24 (-0.7 to 0.3)
Lowering	-2.7 (-0.9 to -4.6)	-0.34 (-0.8 to 0.2)	-2.7 (-0.7 to -4.8)	-0.31 (-0.8 to 0.2)	-4.3 (-2.6 to -6.0)*	-0.24 (-0.7 to 0.3)

SCAPULAR TILT§						
Within group change score						
Elevation						
TSM group	0.3 (1.5 to -1.0)	0.03 (-0.5 to 0.5)	0.1 (1.5 to -1.2)	0.02 (-0.5 to 0.5)	0.2 (1.2 to -0.8)	0.02 (-0.5 to 0.5)
Sham-TSM group	-0.3 (1.0 to -1.5)	-0.03 (-0.5 to 0.5)	0.3 (1.5 to -0.9)	0.04 (-0.5 to 0.5)	-2.1 (-0.9 to -3.2)*	-0.25 (-0.7 to 0.2)
Lowering						
TSM group	0.6 (1.9 to -0.7)	0.07 (-0.4 to 0.6)	0.6 (1.9 to -0.8)	0.06 (-0.4 to 0.5)	0.9 (2.1 to -0.2	0.10 (-0.4 to 0.6)
Sham-TSM group	-0.2 (1.1 to -1.5)	-0.02 (-0.5 to 0.5)	0.3 (1.5 to -1.0	0.03 (-0.5 to 0.5)	-1.3 (-0.1 to -2.4)	-0.14 (-0.6 to 0.4)
Between groups change score						
Elevation	0.5 (2.3 to -1.2)	0.08 (-0.4 to 0.6)	-0.1 (1.7 to -1.9)	-0.03 (-0.5 to 0.5)	2.3 (3.8 to 0.8)	0.37 (-0.1 to 0.9)
Lowering	0.8 (2.2 to -0.5)	0.1 (-0.4 to 0.6)	0.3 (1.6 to -1.0)	0.04 (-0.5 to 0.5)	2.2 (3.3 to 1.1)	0.34 (-0.2 to 0.8)

TSM: Thoracic Spinal Manipulation

* Significant change in scapular kinematics ($p<0.05$) for within- or between-group comparisons.

†Values are mean of change in degrees (95% confidence interval).

‡Values are effect size (95% confidence interval).

§Negative values represent scapular internal rotation or posterior tilt decrease and the respective effect size.

‖Negative values represent scapular upward rotation increase and its effect size.

Muscle activity

Figure 5 presents muscle activity for UT, MT, LT and SA. Table 5 represents within- and between-group comparisons and effect size for muscle activity.

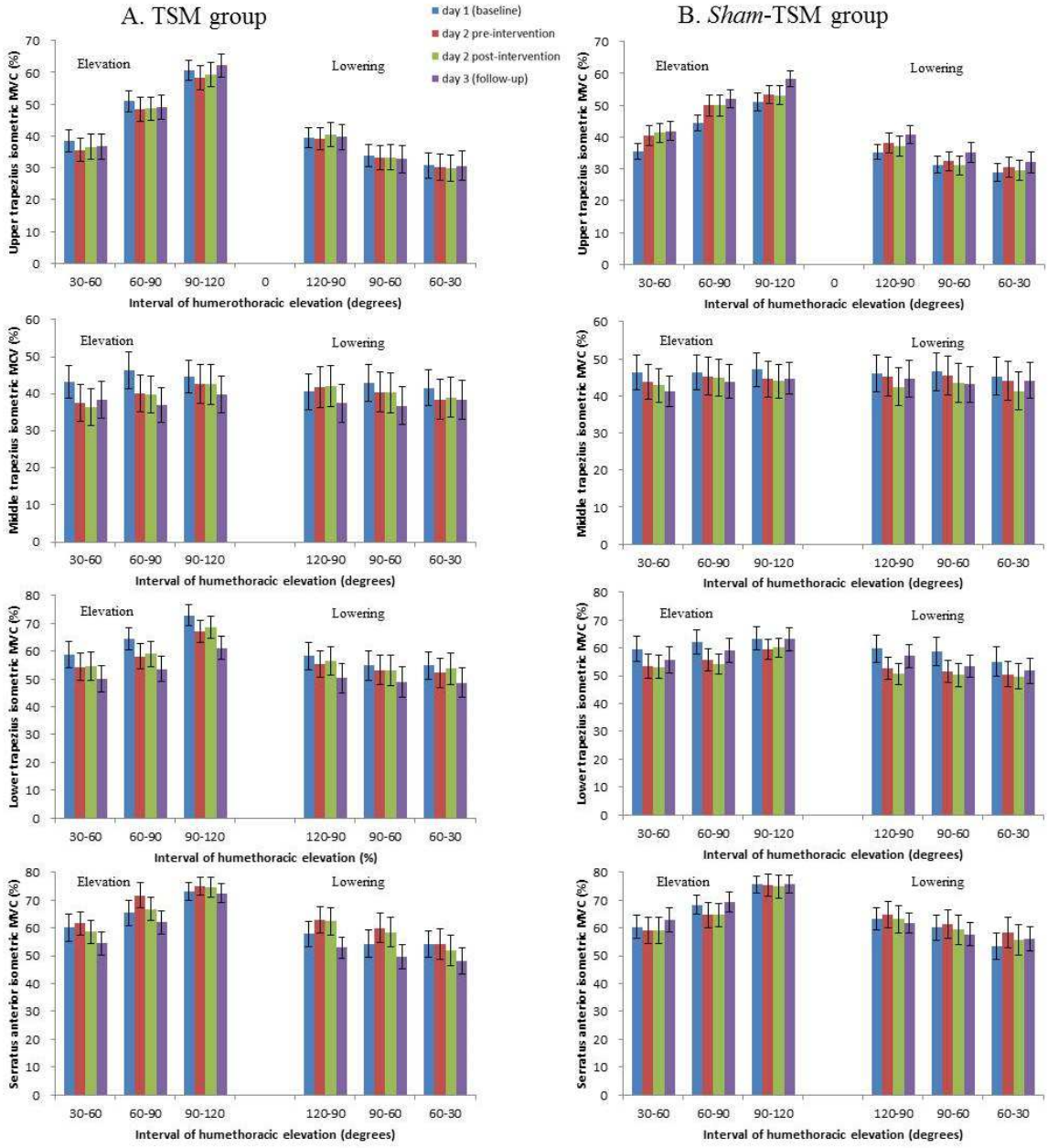

Figure 5. Data are mean percentage of MVC ± SD for upper, lower and medial trapezius and serratus anterior during elevation and lowering of the arm for TSM (A) and sham-TSM (B) groups.

Elevation of the arm

No group-by-time-by-interval interaction was found for all muscles. For UT, there was significant group-by-time interaction ($p<0.01$) with higher muscle activity in the *sham*-TSM group at day 2 pre-intervention ($p=0.01$), day 2 post-intervention ($p<0.01$) and follow-up ($p<0.01$). Between-group comparison showed moderate effect towards decrease in UT muscle activity in the TSM group at day 2 pre-intervention, day 2 post-intervention and follow-up.

For MT, there was no group-by-time interaction ($p=0.56$), but main effect of time was significant ($p<0.01$). Muscle activity decreased in average 4.9% (effect size=0.19, $p<0.01$) at follow-up from baseline. Between-group comparison revealed greater reduction of MT activity in the TSM group with small effect size.

For LT, there was significant group-by-time interaction ($p<0.01$). Muscle activity of both groups decreased at day 2 pre- and post-intervention ($p<0.05$). Muscle activity also decreased in the TSM group after follow-up ($p<0.01$). Between-group comparison showed greater reduction in the TSM group with moderate effect size.

For SA, there was significant group-by-time interaction ($p<0.01$), but pairwise comparisons of interest did not show any difference. Between-group comparison showed greater muscle activity increase at day 2 pre-intervention with moderate effect size in the TSM group. However, this difference was modified in favor to *sham*-TSM group at follow-up.

Lowering of the arm

No group-by-time-by-interval interaction was found for all muscles. For UT, there was no significant group-by-time interaction ($p=0.07$) nor was the main effect of time ($p=0.12$). Between-group differences showed moderate effect for decrease in UT muscle activity in the TSM group at follow-up.

For MT, there was no significant group-by-time interaction ($p=0.33$) nor was main effect of time ($p=0.12$). Between-group comparisons revealed no significant difference between groups and small effect size.

For LT, there was significant group-by-time interaction ($p<0.01$). Muscle activity decreased at day 2 pre-intervention ($p<0.01$) in both groups, and at day 2 post-intervention in the *sham*-TSM group ($p<0.01$). Between-group analysis showed greater decrease at day 2 post-intervention with moderate effect size in the *sham*-TSM group. This difference was not maintained at follow-up.

For SA, there was no significant group-by-time interaction ($p=0.07$). Main effect of time was significant ($p<0.01$), but pairwise comparisons did not show important changes for the comparisons of interest. Between-group analysis showed greater increase in the *sham*-TSM group at follow-up.

Table 5. Within- and between-group change from baseline for muscle activity.

	Change score at day 2 pre-intervention from baseline†	Effect size (day 2 pre-intervention - baseline)‡	Change score at day 2 post-intervention from baseline†	Effect size (day 2 post-intervention - baseline)‡	Change score at follow-up from baseline†	Effect size (follow-up-baseline)‡
UPPER TRAPEZIUS						
Within group change score						
Elevation						
TSM group	-2.5 (-0.4 to -4.7)	-0.12 (-0.6 to 0.4)	-1.8 (0.5 to -4.1)	-0.08 (-0.6 to 0.4)	-0.7 (1.7 to -3.1)	-0.03 (-0.5 to 0.5)
Sham-TSM group	4.3 (7.4 to 1.1)*	0.25 (-0.2 to 0.7)	4.5 (7.6 to 1.4)*	0.27 (-0.2 to 0.7)	7.2 (10.6 to 3.7)*	0.44 (-0.06 to 0.9)
Lowering						
TSM group	-0.5 (1.4 to -2.4)	-0.02 (-0.5 to 0.5)	-0.1 (1.8 to -2.0)	-0.005 (-0.5 to 0.5)	-0.3 (1.4 to -1.9)	-0.01 (-0.5 to 0.5)
Sham-TSM group	-1.9 (4.9 to -1.1)	0.12 (-0.4 to 0.6)	0.9 (3.7 to -2.0)	0.05 (-0.5 to 0.5)	4.2 (7.8 to 0.6)	0.27 (-0.2 to 0.8)
Between group change score						
Elevation	-6.8 (-3.4 to -10.1)*	-0.51 (-1.0 to 0.0)	-6.3 (-2.9 to -9.6)	-0.47 (-1.0 to 0.0)	-7.9 (-4.2 to -11.6)	-0.54 (-1.0 to 0.0)
Lowering	-2.4 (0.2 to -5.1)	0.11 (-0.4 to 0.6)	-1.0 (1.6 to -3.5)	-0.08 (-0.6 to 0.4)	-4.5 (-1.3 to -7.7)	-0.32 (-0.8 to 0.2)
MIDDLE TRAPEZIUS						
Within group change score						
Elevation						
TSM group	-4.7 (-0.6 to -8.7)	-0.18 (-0.7 to 0.3)	-5.1 (-1.0 to -9.3)	-0.20 (-0.7 to 0.3)	-6.4 (-2.1 to -10.6)	-0.25 (-0.8 to 0.2)
Sham-TSM group	-2.1 (2.7 to -6.9)	-0.08 (-0.6 to 0.4)	-2.7 (1.8 to -7.2)	-0.11 (-0.6 to 0.4)	-3.3 (-0.4 to -6.3)	-0.14 (-0.6 to 0.4)
Lowering						
TSM group	-1.4 (2.4 to -5.3)	-0.05 (-0.6 to 0.4)	-1.2 (2.7 to -5.2)	-0.04 (-0.5 to 0.4)	-4.2 (-1.1 to -7.2)	-0.16 (-0.7 to 0.3)
Sham-TSM group	-1.0 (3.9 to -6.0)	-0.04 (-0.5 to 0.5)	-3.5 (1.1 to -8.1)	-0.13 (-0.6 to 0.4)	-2.0 (0.9 to -4.9)	-0.08 (-0.5 to 0.4)
Between groups change score						
Elevation	-2.5 (1.8 to -6.9)	-0.12 (-0.6 to 0.4)	-2.4 (1.7 to -6.6)	-0.11 (-0.6 to 0.4)	-3.0 (-0.1 to -5.9)	-0.18 (-0.7 to 0.3)
Lowering	-0.4 (4.0 to -4.8)	-0.02 (-0.5 to 0.5)	2.3 (6.4 to -1.9)	0.11 (-0.4 to 0.6)	-2.2 (0.5 to -4.9)	-0.15 (-0.7 to 0.3)

LOWER TRAPEZIUS						
Within group change score						
Elevation						
TSM group	-5.5 (-2.4 to -8.5)*	-0.23 (-0.7 to 0.3)	-4.6 (-1.4 to -7.8)*	-0.19 (-0.7 to 0.3)	-10.5 (-6.6 to -14.3)*	-0.45 (-0.9 to 0.07)
Sham-TSM group	-5.6 (-2.0 to -9.2)*	-0.25 (-0.7 to 0.3)	-5.9 (-2.8 to -9.0)*	-0.27 (-0.8 to 0.2)	-2.5 (2.1 to -7.0)	-0.10 (-0.6 to 0.4)
Lowering						
TSM group	-2.5 (1.0 to -5.9)	-0.09 (-0.6 to 0.4)	-1.5 (2.0 to -5.0)	-0.06 (-0.6 to 0.4)	-6.7 (-4.3 to -9.1)*	-0.24 (-0.7 to 0.3)
Sham-TSM group	-6.4 (-3.1 to -9.7)*	-0.24 (-0.7 to 0.2)	-7.7 (-4.9 to -10.4)*	-0.28 (-0.8 to 0.2)	-3.8 (-0.2 to -7.9)	-0.14 (-0.6 to 0.3)
Between group change score						
Elevation	0.1 (3.4 to -3.2)	0.01 (-0.5 to 0.5)	1.3 (4.2 to -1.5)	0.09 (-0.4 to 0.6)	-8.0 (-3.5 to -12.5)	-0.39 (-0.9 to 0.1)
Lowering	3.9 (6.9 to 0.9)	0.24 (-0.3 to 0.8)	6.2 (8.6 to 3.7)	0.41 (-0.1 to 0.9)	-2.9 (1.0 to -6.7)	-0.18 (-0.7 to 0.3)
SERRATUS ANTERIOR						
Within group change score						
Elevation						
TSM group	3.3 (6.3 to 0.3)	0.15 (-0.4 to 0.6)	0.5 (3.9 to -3.0)	0.02 (-0.5 to 0.5)	-3.3 (0.7 to -7.2)	-0.15 (-0.6 to 0.4)
Sham-TSM group	-1.8 (1.9 to -5.5)	-0.07 (-0.6 to 0.4)	-1.9 (1.6 to -5.5)	-0.08 (-0.6 to 0.4)	1.2 (5.7 to -3.2)	0.06 (-0.4 to 0.5)
Lowering						
TSM group	3.5 (6.9 to 0.2)	0.14 (-0.4 to 0.6)	2.1 (5.8 to -1.5)	0.08 (-0.4 to 0.6)	-5.2 (-2.0 to -8.4)	-0.21 (-0.7 to 0.3)
Sham-TSM group	2.6 (6.1 to -0.8)	0.10 (-0.4 to 0.6)	0.5 (3.8 to -2.7)	0.02 (-0.5 to 0.5)	-0.3 (3.3 to -2.7)	-0.01 (-0.5 to 0.5)
Between groups change score						
Elevation	5.1 (9.2 to 0.9)	0.31 (-0.2 to 0.8)	2.4 (6.6 to -1.9)	0.10 (-0.4 to 0.6)	-4.5 (0.6 to -9.6)*	-0.30 (-0.8 to 0.2)
Lowering	0.9 (5.1 to -3.2)	0.05 (-0.4 to 0.6)	1.6 (5.8 to -2.6)	0.10 (-0.4 to 0.6)	-4.9 (-0.8 to -9.0)*	-0.30 (-0.8 to 0.2)

TSM: Thoracic Spinal Manipulation

* significant change in muscle activity ($p<0.05$) for within- or between-group comparisons.

†Values are mean of change in percentage of MVC (95% confidence interval); negative values represent muscle activity decrease from baseline for within-group comparisons or greater muscle activity decrease in the TSM group for between-group comparisons.

‡Values are effect size (95% confidence interval); negative values represent effect of muscle activity decrease for comparison within-group or greater muscle activity decreasing effect in the TSM group for between-group comparisons.

DISCUSSION

This study demonstrated that, in the short-term, TSM may induce decrease in self-reported shoulder pain, increase in scapular upward rotation and decrease in UT activity mainly during lowering of the arm. Shoulder function showed a tendency towards improvement after TSM was delivered. All those improvements seem to be intensified with the repetition of the TSM intervention. To our knowledge, no previous studies have analyzed the short-term effects of TSM on scapular kinematics and muscle activity.

Pain and function

TSM seems to produce substantial decrease in self-reported shoulder pain during arm movement that can last up to 3 or 4 days after the intervention. Despite the low initial pain scores of the individuals, the percentage of changes within the TSM group and between groups was higher than the MCID established by Dworking et al.[43]. Moreover, 43.3% of individuals in the TSM group reached minimal clinically important percentage of change while only 22.6% of the individuals did in the *sham*-TSM group.

Previews investigations have reported no changes on self-reported shoulder pain after only one session of TSM when compared with *sham*-TSM in patients with SIS[60, 69]. On the other hand, Wassinger et al.[132] induced muscle soreness in the shoulder and demonstrated significant improvements in self-reported pain and pressure pain threshold in the short-term follow-up (24-48 hours) after a combination of cervical, cervicothoracic and thoracic spine manipulations. However, it is important to highlight that no control group was used for comparison. Recently, manipulative therapy in addition to usual exercises protocol[17, 123] has been demonstrated to improve pain and function in subjects with SIS while manual therapy applied with only mobilization techniques did not seem to induce better results than only exercise therapy[30, 37]. Therefore, it is reasonable to suggest that the thrust manipulative impulse applied repeated times over the joint induce hypoalgesia in individuals with SIS.

In the current study, improvements in function were observed for both groups as evaluated by the DASH and WORC questionnaires. Despite the moderate effect size, DASH score was not different between groups. However, TSM group showed greater improvements in the short-term for all domains of the WORC, except for physical symptoms. Moreover, the percentage of individuals who presented improvement greater than the MCID in total WORC scores was higher in the TSM group (53.3%) than in the *sham*-TSM group (29%). It is possible to suggest that TSM intervention brings potential relevant effects on function.

Clinical effects of manual therapy interventions are likely to involve potential multiple mechanisms. Hypoalgesia induced by TSM may be mediated by peripheral, spinal and supraspinal mechanisms that can influence supraspinal regions responsible for central pain processing[19]. Peripheral and central sensitizations were already described in individuals with shoulder pain[5, 24, 38, 110]. Central sensitization seems to influence pain complaints reported by 65 and 90% of the SIS patients[110]. The higher percentage of individuals presenting significant improvements in pain and function after the active TSM than after the *sham*-TSM contributes to reinforce the suggestion of spinal and supraspinal pain inhibition mechanisms induced by TSM and the suggestion that successful outcomes in manual therapy could depend on identifying individuals likely to respond rather than a specific lesion[38, 110].

Scapular kinematics

TSM seems to provoke more changes in scapular upward rotation than in internal rotation and tilt. The fact the last motions are more variable between subjects may explain the absence of important changes. Upward rotation increased during elevation and lowering of the arm after the second intervention. However, changes were only maintained in the follow-up during lowering of the arm. Although between-group comparison did not show differences, the percentage of individuals presenting clinical important upward rotation increase during arm elevation and

lowering of the arm was greater in the TSM group (40% and 53%, respectively) than in the *sham*-TSM group (22.5% and 22.5%, respectively).

The only two studies evaluating scapular kinematics changes after TSM found small and not relevant changes in upward rotation during arm movement [60, 98]; however these were immediate results followed only one TSM intervention.

Muscle activity

TSM group showed decreased activity of the UT after the intervention during elevation and lowering of the arm. There is evidence of increased UT and reduced SA activation in patients with SIS who have demonstrated reduced scapular upward rotation[75, 80]. Therefore, we believe that the TSM may have induced better balance between scapulothoracic muscles activity contributing to improve scapular upward rotation. Results of decreased LT and SA activation and no alteration in the MT after TSM did not explain observed scapular kinematics alterations. It seems that TSM intervention worsens recruitment of these muscles. Although LT and SA activity decreased in the TSM group, internal rotation and anterior tilt have not increased suggesting some compensatory mechanism with the alterations in upward rotation and UT activity.

A number of neurophysiological responses associated with TSM are also associated with non-specific effects such as placebo[87]. *Sham*-TSM technique used in this study was previously demonstrated by Michener et al.[92] to be an adequate *sham* comparator for TSM with similar expectations and believability as an active treatment. Therefore, possible effects from patient's expectation and therapist's manual contact with the patient skin surface were probably minimized in this investigation.

The current study presents some limitations. Screening examination of thoracic spine segments to identify specific spinal stiffness was not assessed. Addition of another control group such as placebo ultrasound or other placebo physical resource would be interesting as an attempt

to isolate placebo effect of the manual contact. Future studies should incorporate subgroup analysis based on spinal stiffness and/or central sensitization and also long-term follow-ups following repeated TSM interventions.

CONCLUSION

This study suggests that repeated TSM may be an appropriate intervention to improve pain, function, scapular upward rotation and UT activity in individuals with SIS. MT, LT and SA may be not beneficiated by TSM intervention.

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Study 2: Effectiveness of physical therapy approaches in Shoulder Impingement Syndrome treatment. A systematic review.

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Abstract

Aim: To summarize and analyze current evidence regarding effectiveness of physical therapy to improve pain, function and range of motion in individuals presenting clinical signs indicative for Shoulder Impingement Syndrome (SIS).

Design: Systematic review

Data sources: Pubmed, Web of Science, CINAHL Cochrane, Embase, Lilacs, Ibecs and Scielo databases searched up to April 2015.

Eligibility criteria for selecting studies: Randomized controlled trials investigating different modalities of physical therapy in the treatment of patients diagnosed with SIS on outcomes measures of pain, function/disability or range of motion. Low methodology quality trials were excluded.

Results: Sixty-two RCTs were included. The majority had a low to moderate risk of bias. Physical resources such as low-level laser, ultrasound and pulsed electromagnetic field do not provide beneficial effects on pain, function or range of motion outcomes in the treatment of SIS. Other physical resources like microwave diathermy and transcutaneous electrical nerve stimulation provided limited evidence for pain, function or range of motion improvements. Exercise therapy is as good as surgery intervention and better than no treatment or placebo treatment to decrease pain and restore function and range of motion in the short-, mid- and long-term. Dynamic humeral centering associated with conventional exercises provided greater improvements in the short-term than exercises alone. Associated with manual therapy, conventional exercises significantly enhance pain results in the short-term. Manual therapy used in isolation seems to improve pain, function and range of motion; however the evidence is still limited. Kinesio taping does not provide additional benefits on pain and function in the short-term. Effects of diacutaneous fibrolysis and acupuncture on SIS treatment are not well stablished yet.

Conclusions: Exercise therapy should be used as the first choice to improve pain, function and range of motion, and the association of manual therapy should be the best choice to accelerate symptoms decrease and progress exercise therapy quickly. Low-level laser therapy, pulsed electromagnetic field and kinesio taping do not provide significant effects to the therapy and therefore could be avoided. More studies are necessary to improve evidence concerning effects of diacutaneous fibrolysis, microwave diathermy, transcutaneous electrical stimulation and acupuncture in the treatment of SIS.

“What is already known and why this review needed to be done”

- Previous systematic reviews have incorporated moderate evidence towards the use of exercise therapy based on stretching and strengthening of the rotator cuff and scapular muscles in the treatment of SIS before recommending arthroscopy surgery.
- Evidence concerning efficacy of other therapies added to exercises or used alone is still controversial and limited.
- Last systematic reviews regarding effects of all available treatments for SIS were performed up to 2009 including other shoulder diagnoses beyond SIS; therefore it is important to update the evidence to 2015 in the specific population of SIS patients.

“What are the new findings”

- Exercise therapy based on stretching and strengthening of rotator cuff and scapular muscles is as effective as surgery intervention and the best conservative therapy to reduce pain, improve function and increase range of motion in inviduals with SIS in all stages of SIS treatment.
- Exercise therapy associated with manual therapy based on joint and soft-tissue mobilization or associated with dynamic humeral centering is more effective than exercises alone to reduce pain in SIS patients in the short-term.
- Low-level laser therapy and pulsed electromagnetic field are not better than their placebo treatment or than exercise therapy to improve pain or function in this population.

INTRODUCTION

Shoulder impingement syndrome (SIS) is the most frequently cause of shoulder pain and accounts for 44% to 60% of all complaints of shoulder pain[127]. SIS is characterized by pain and functional restrictions exacerbated during elevation of the arm or overhead activities[80]. It has been described as compression, entrapment, or mechanical irritation of the rotator cuff tendos and/or long head of the biceps tendon either beneath the coracoacromial arch (subacromial impingement)[100] or between the undersurface of the rotator cuff and the glenoid or glenoid labrum (internal impingement) when the arm is abducted and externally rotated[15, 63].

A great amount of factors have been associated to SIS such as alterations in glenohumeral and scapulothoracic kinematics[80, 125], degeneration and inflammation of the tendons or bursae, weakness or alterations in activity of the rotator cuff and scapular musculature[80, 82, 106], and capsular laxity or tightness[126]. Therefore there are numerous options of conservative interventions proposed for SIS, such as stretching and strengthening exercises[29, 31, 32, 77, 79], joint mobilization and manipulation[6, 9, 30, 60], scapular and proprioceptive training[7, 11, 85], taping[116, 117], acupuncture[66, 67] and many physical resources[46, 52, 54].

The last systematic review published about effectiveness of physical therapy in patients with SIS[53] showed effectiveness of hyperthermia compared to exercises or ultrasound in the short-term, better results for exercises therapy in the mid-term compared to placebo or controls, and highlighted the need for detailed description of the commonly used exercises protocol. However, the systematic search of trials was performed up to 2009. The review included two reviews with interventions for various shoulder pain complains and trials in which patients were also diagnosed with calcareous tendinitis which represents a different clinical presentation[55] from SIS.

In a recent systematic review with meta-analysis, Dong et al.[42] demonstrated the best treatment options among of all the available treatment strategies for SIS. However, most comparisons were performed based on only 1 randomized-controlled trial and included trials presenting patients diagnosed with calcareous tendinitis and rotator cuff tears, which again is a different clinic presentation that may occur as consequence of SIS, trauma or degenerative changes[49]. These facts have probably incorporated some bias to the results.

Other systematic reviews of physical therapy strategies for SIS[39, 73, 74] have included trials independently of the methodological quality and subjects with other shoulder pain causes as well. In one of the reviews[39], only 24% of the trials had a low risk of bias and, therefore, the conclusion was based on low to moderate quality of evidence. Moreover, none of them have

used the standard recommendation on how to analyze and synthesize the quality of the body of evidence.

According to the current scenario, it is necessary summarizing the high quality evidence of conservative SIS interventions to be used in this specific population. The present review aims to summarize and analyze current evidence regarding effectiveness of physical therapy to improve pain, function and range of motion in individuals presenting clinical signs of SIS. Therefore, randomized controlled clinical trials of all possible physical therapy intervention assessing the above outcomes for individuals diagnosed with SIS were included.

METHODS

The PRISMA statement was consulted prior to the start of this review and the checklist completed.

Selection criteria for including studies

Types of studies

Randomized controlled trials (RCTs) and quasi-RCTs that compared different modalities of physical therapy with each other, physical therapy with placebo treatment or physical therapy with other treatments, and used outcomes measures of pain, function/disability or range of motion were considered for inclusion in this review. Articles in English, Spanish and Portuguese were accepted.

Type of participants

Participants included in the review were restricted to patients (males or females aged 18 years or older) diagnosed with SIS through medical, imaging or clinical diagnosis using painful arc, Neer impingement test[100], Hawkins impingement test[61], Jobe test[65], pain with passive[63] or isometrically resisted[107, 123] shoulder external rotation.

Articles were excluded if they presented also other shoulder conditions (calcareous tendinitis, partial or full rotator cuff tears, adhesive capsulitis, osteoarthritis, unspecific shoulder/neck pain), addressed postoperative management, or were case series.

Types of intervention

All forms of active or passive physical therapy interventions were included. Experimental group could have been compared with no intervention, placebo or *sham* treatment, other physical therapy procedures, or even to surgical intervention or injection. The intervention could be the only treatment or an add-on treatment. If a combination of therapies was applied, the main

intervention and the co-interventions must have been clearly defined to assign the study to a specific intervention. If the main intervention was not defined or was unclear, it was assigned to the group of "combined therapy". Non-physiotherapeutic techniques such as surgery, injections, or extracorporeal shock wave therapy were excluded.

Treatments reported in studies were combined into 5 main clusters: (1)physical resources, (2)manual therapy, (3)kinesio taping, (4)exercises, and (5)acupuncture. Subsequently, distinctions were made according to the outcomes and comparison groups.

Types of outcome measures

A study was included if it used at least one of the primary outcome measures of interest: pain, function/disability, or range of motion.

The duration of the follow-up was defined as: immediately post-treatment (≤one day); short-term follow-up (one day to three months); mid-term follow-up (three months up to but not including one year); long-term follow-up (≥ one year).

Search methods for identification of studies

Electronic searches

The following databases were searched electronically: PubMed/MEDLINE, Embase, CINAHL, Lilacs, Cochrane, and Web of Science from their inception up to April 2015. A Cochrane highly sensitivity search strategy[50] was used, ie, all keywords were searched independently and then combined using relevant Boolean terms. We therefore used the following MeSH terms and key words: physiotherapy, physical therapy, physical therapy specialty, physical therapy modalities, musculoskeletal manipulations, exercise therapy, exercise movement technique, electric stimulation therapy, massage, manual therapy, mobilization, shoulder impingement syndrome, shoulder joint, shoulder pain, tendinopathy, rotator cuff.

Searching other resources

We also screened reference lists from retrieved full-text articles and systematic reviews for additional relevant publications.

Data collection and analysis

Selection of studies

All identified studies were initially judged for eligibility by title to exclude those clearly not related to our purpose. Then, abstracts of the selected articles were analyzed to determine whether studies met or not the inclusion criteria regarding design, participants and interventions. Full texts of the articles potentially relevant were retrieved for final assessment and the reference lists were screened for identification of additional relevant publication. Data collection was performed through a standardized form. Two independent reviewers (MNH and EDP) performed the selection process and a third reviewer (RFCM) was consulted for final consensus in case of disagreements.

Quality assessment

All studies were scored with the PEDro critical appraisal tool for experimental studies in physiotherapy (http://www.pedro.fhs.usyd.edu.au) based on Delphi list[129]. PEDro is a reliable tool[84] and contains 8 criteria for assessing internal validity of a study, and 2 criteria for assessing sufficiency of the statistical information displayed. Each criterion can be answered with "yes" or "no". Each item satisfied contributes with 1 point to final rating scale. Thus, the possible maximum score is 10 points. If a criterion was unclear even after discussion, no points were awarded.

Methodological assessment of indexed articles presenting PEDro score was maintained; methodological quality assessment of no indexed articles was performed independently by two independent reviewers (MNH and EDP) and inconsistencies of the rating were solved by a consensus with a third reviewer (RFCM). According to Maher et al.[84], due to the difficult of achieving certain conditions, such as the blinding of therapists or subjects in interventional studies, the maximum achievable score for this type of study would be 8 or 9 out of 10. Then, in order to improve the validity of the evidence and to draw conclusions based on moderate to high level evidence, only studies with a high methodological quality, defined as a minimum PEDro score of 5 were considered on final summary evidence[97, 105, 129].

Data extraction and management

Two independent reviewers (MNH and EDP) extracted data on trial methods, participants, settings, interventions, care providers, types of outcome measures, frequency of the intervention, duration of follow-up, loss to follow-up, outcomes measures and results using a standardized data extraction form adapted from Cochrane Collaboration model. Disagreements

were resolved through consensus. Missing data were either requested from the authors or calculated from mean change, graphical data, standard error or baseline standard deviation[64].

The included outcome measures were categorized as follows: pain, including self-reported pain (when global pain score was not available pain at movement scores were used); function, including function measures with different questionnaires (Shoulder Pain and Disability Index - SPADI, Disabilities of the Arm, Shoulder and Hand – DASH score, Western Ontario Rotator Cuff – WORC index, Shoulder Disability Questionnaire – SDQ, Constant-Murley Shoulder – CMS score, or University of California at Los Angeles – UCLA score); and range of motion (flexion, abduction or total range of motion including available range for all shoulder motions).

Data synthesis and analysis

Outcome measures are presented separately. Due to the clinical or measured heterogeneity in the outcome of the primary studies, it was not possible to perform a meta-analysis. To compare treatment's effect the effect size (ES) of each intervention was calculated with 95% confidence interval for continuous outcomes in each comparison group, considering the values before and after intervention. Treatment effects were further classified as small (<0.20), moderate (between 0.21 and 0.79) and large (>0.80), according to Cohen's criteria[35].

Quality of the body of evidence was determined using the GRADE (Grading of Recommendations, Assessment, Development and Evaluation) approach which analyses the following domains: trial design limitations due to risk of bias (utilizing the PEDro score), inconsistency of results, indirectness, imprecision of results and publication bias[50]. Ultimately, the quality of evidence for each outcome was presented on a rating system with four categories: high, moderate, low or very low evidence, according to GRADE guideline[56].

RESULTS

Description of studies

The literature review included titles published until April 2015. Sixty-two studies fulfilled the criteria for inclusion. Of these, 3 studies[26, 51, 57] were follow-ups of the initial studies. A flow-chart of the search process with main reasons for exclusion is shown in Figure 1.

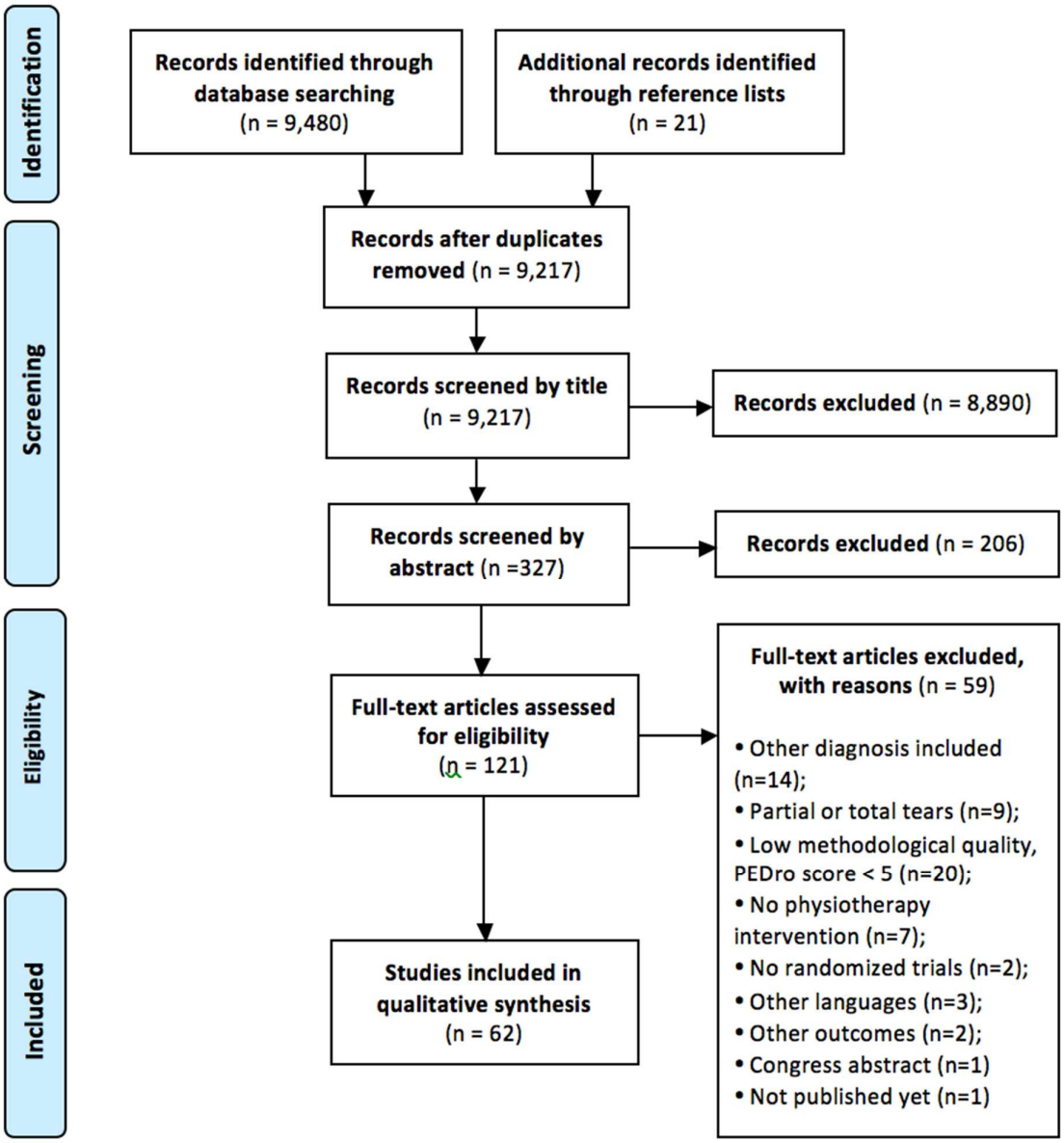

Figure 1. PRISMA 2009 flow diagram for literature search results.

Quality assessment

Among 62 included studies, 6 were not indexed in the PEDro database and their quality was evaluated by consensus of two reviewers (MNH and EDP), using the PEDro scale. Mean PEDro score obtained for the studies was 6.9 (range 5-10), demonstrating a high level of quality among studies. Scores of each one of the included studies are shown in Table 1.

Table 1. Scoring of methodological quality of included studies

Study	1. Random allocation	2. Concealed allocation	3. Baseline compara-bility	4. Blinding subjects	5. Blinding therapists	6. Blinding assessors	7. Outcome data > 85%	8. Intention-to-treat	9. Between-group results	10. Point measures / measures variability	PEDro score
Abrisham et al, 2011	1	1	1	1	0	1	1	1	1	1	9
Aktas et al, 2007	1	0	1	1	1	1	1	0	1	1	8
Akyol et al, 2012	1	1	1	1	0	1	1	0	1	1	8
Atkinson et al, 2009.	1	1	1	0	0	0	1	0	1	1	6
Bae et al, 2011	1	0	1	0	0	0	1	0	1	1	5
Bal et al, 2009	1	1	1	1	1	1	1	0	1	1	9
Bang and Deyle, 2000.	1	0	1	0	0	1	1	0	1	1	6
Barra-López et al, 2013	1	0	1	0	0	1	0	1	1	1	6
Baskurt et al, 2011	1	0	1	0	0	0	1	0	1	1	5
Beaudreuil et al, 2011	1	1	1	1	0	1	1	1	1	1	9
Beaudreuil et al, 2013	1	1	1	1	0	1	1	0	1	1	8
Bennel et al, 2010	1	1	1	1	0	1	1	1	1	1	9
Binder et al, 1984.	1	0	0	1	0	1	1	0	1	0	5
Brox et al, 1993	1	0	1	0	0	1	1	1	1	1	7
Brox et al, 1999	1	0	1	0	0	1	0	1	1	1	6
Calis et al, 2011	1	1	1	0	0	0	0	0	1	1	5
Chard et al, 1988	1	0	1	1	0	1	1	0	1	0	6
Cheng and Hung, 2007	1	0	1	0	0	0	1	0	1	1	5
Conroy and Hayes, 1998.	1	0	1	0	0	1	1	0	1	1	6
Cook et al, 2014	1	0	1	0	0	0	1	0	1	1	5
Dickens et al, 2005.	1	1	1	0	0	1	1	1	1	1	8
Dogan et al, 2010	1	1	1	1	0	1	1	1	1	1	9
Eslamian et al, 2012.	1	1	1	1	0	1	0	0	1	1	7
Eyigor et al, 2010	1	0	1	0	0	1	1	0	1	1	6
Galace de Freitas et al, 2013	1	1	1	1	0	1	1	1	1	1	9
Galace de Freitas et al, 2014	1	1	1	1	0	1	1	1	1	1	9
Giombini et al, 2006.	1	0	1	0	0	1	1	1	1	1	7
Haahr and Andersen, 2006.	1	1	0	0	0	0	1	1	1	1	6

Haahr et al, 2005.	1	1	1	0	0	0	1	1	1	1	7
Haik et al, 2014.	1	0	1	1	0	0	1	0	1	1	6
Heredia0Rizo et al, 2013.	1	1	1	0	0	1	1	0	1	1	7
Johansson et al, 2005.	1	1	1	0	0	1	1	1	1	1	8
Johansson et al, 2011	1	1	1	0	0	1	0	1	1	1	7
Kachingwe et al, 2008.	1	0	0	0	0	1	1	0	1	1	5
Kaya et al, 2011	0	0	1	0	0	1	1	0	1	1	5
Kleinhenz et al, 1999	1	1	1	1	0	1	1	1	1	1	9
Kromer et al, 2013.	1	1	1	0	0	0	1	1	1	1	7
Kromer et al., 2014	1	1	1	0	0	0	1	1	1	1	7
Littlewood et al, 2014	1	1	1	0	0	0	1	0	1	1	6
Lombardi et al, 2008.	1	1	1	0	0	1	1	1	1	1	8
Ludewig and Borstad, 2003.	1	1	0	0	0	0	1	1	1	1	6
Maenhout et al, 2013.	1	0	1	0	0	0	1	1	1	1	6
Martins and Marziale, 2012.	1	0	1	0	0	1	1	0	1	1	6
Marzetti et al, 2014.	1	1	1	0	0	0	1	1	1	1	7
Melchiorre et al, 2013.	0	0	1	0	0	1	1	0	1	1	5
Miller and Osmotherly, 2009	1	1	0	0	0	1	0	1	1	1	6
Nakra et al, 2013.	1	0	1	0	0	0	1	0	1	1	5
Nykanen et al, 1995.	1	0	1	1	1	1	1	0	1	1	8
Osteras et al, 2010	1	1	1	0	0	0	1	1	1	1	7
Otadi et al, 2012.	1	1	1	1	0	1	1	0	1	1	8
Rhon et al, 2014.	1	1	1	0	0	1	1	1	1	1	8
Santamato et al, 2005.	1	1	1	0	0	1	1	1	1	1	8
Saunders, 1995.	1	0	1	1	1	1	1	1	1	1	9
Shakeri et al, 2013.	1	0	0	1	0	1	1	1	1	1	7
Simsek et al, 2013.	1	0	0	0	0	1	1	0	1	1	5
Struyf et al, 2012.	1	0	1	0	0	1	1	1	1	1	7
Szczurko et al, 2009		1	1	0	0	1	1	1	1	1	8
Thelen et al, 2008.	1	1	1	1	0	1	1	1	1	1	9
Vecchio et al, 1993	1	0	1	1	1	1	1	0	1	1	8
Winters et al, 1997	1	0	0	0	0	1	0	1	1	1	5
Yavuz et al, 2014.	1	1	1	0	0	1	1	1	1	1	7
Yeldan et al, 2009.	1	0	1	1	0	1	1	0	1	1	7

The most critical criteria to be satisfied were blinding therapist (91.9%), blinding subjects (64.5%), concealed allocation (46.8%) and intention-to-treat analysis (46.8%). Different specific methods to generate the random allocation sequence were used such as computer randomization, random number tables and randomization cards. Only 2 studies[71, 91] have used less appropriated randomization methods such as allocation based on the order of admittance in the rehabilitation program. In 8 studies patients were not compared at baseline, 7 studies lost more than 15% of the patients who were initially allocated to the groups during follow-up and 2 studies did not report point measures and measurements of variability for at least one key outcome (Figure 2).

According to GRADE quality assessment of the evidence high methodological quality, good directness and low publication bias were achieved among comparison groups of interventions. Consistency and precision of the evidence were the most difficult criteria to be reached among the groups of interventions.

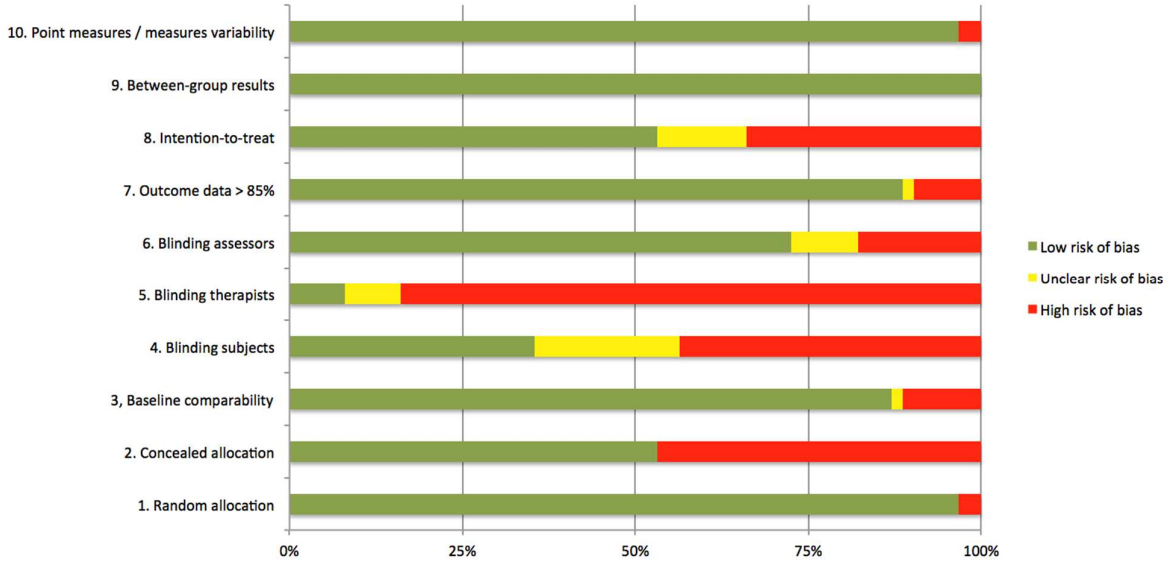

Figure 2. Risk of bias: judgements about each risk of bias item presented as percentages across all included studies.

Characteristics of the included studies

The appendix shows the characteristics of the included studies and a summary of the results in relation to pain, function and range of motion outcomes. For the interpretation of the results, outcomes of interest were categorized as follows. Studies in which the experimental group demonstrated statistically significant result compared to the control group or moderate/high ES of the change compared with control group were considered as positive results. Investigations that showed no significant result after the intervention, those in which a

significant reduction occurred in both groups or those in which ES of the change was equal in both groups were classified as non-effect. Results were not considered if they were described by the authors as positive based on trends or positive interpretations and were not accompanied by numerical values of the outcome.

Effectiveness of Interventions

Included studies investigated physical resources (n=11 for laser therapy[2, 8, 28, 41, 46, 104, 111, 112, 128, 134, 135], n=5 for pulsed electromagnetic field[3, 21, 33, 51, 52], n=5 for ultrasound[28, 54, 101, 111, 134], n=2 for microwave therapy[4, 54], and n=1 for Transcutaneous Electrical Nerve Stimulation[47]), exercise therapy (n=20)[7, 11, 12, 14, 26, 27, 34, 57, 58, 68, 76, 77, 79, 83, 85, 86, 103, 121], manual therapy (n=13)[6, 9, 10, 16, 36, 37, 40, 60, 62, 68, 73, 91, 99, 108, 133], kinesio tapping (n=5)[71, 94, 116, 117, 124], and acupuncture (n=4)[66, 67, 72, 122]. GRADE analysis and synthesis of evidence for each group comparison are presented on Tables 2, 3, 4 and 5. Results for each comparison group using physical resource are presented on Table 2. Findings for each comparison group using exercise therapy and manual therapy are presented on Tables 3 and 4, respectively. Table 5 summarizes the results for kinesio taping. Groups of comparison with only one trial were not added to GRADE analysis since it provides limited evidence for the result. Then, these groups of comparisons were not added on tables but only described along the text.

Comparison group's findings are presented in the following order: intervention versus placebo intervention, intervention associated with usual intervention versus usual intervention (exercise therapy or usual physical therapy), and intervention versus another intervention.

Effects of physical resources (Table 2)

Laser therapy versus placebo: For laser therapy, 6 studies compared a laser protocol with a placebo laser protocol of 6 to 16 sessions with follow-up of 2 to 8 weeks[2, 41, 46, 112, 128, 135]. Six of them measured pain, 4 measured function, and 4 measured range of motion. Direction of the results was contradictory in the short-term with 3 studies demonstrating significant pain decrease after laser therapy[2, 46, 112] and 3 demonstrating that both interventions reduce shoulder pain[41, 128, 135]. Contradictory findings seem to be due to the amount of energy applied in each point of laser application. Overall, high dosage of energy seems to contribute to pain decrease outcomes; however the evidence was moderate towards no beneficial effect of laser therapy in pain decrease. High evidence was demonstrated towards no effects of laser therapy over placebo laser therapy to increase function and abduction range of motion. Both interventions provide significant improvements on these outcomes. There is moderate evidence concerning no effect of laser therapy compared with placebo laser in flexion and external rotation range of motion.

Adding laser therapy versus only exercises: Three studies added laser therapy to an exercise protocol of 3 to 12 weeks[8, 28, 104] and moderate evidence was shown towards no additional benefit of laser therapy to reduce pain or improve function. In the short-term, the exercise protocol with or without laser therapy has improved pain and function outcomes.

Laser versus ultrasound: When comparing laser with ultrasound associated with exercises in a follow-up of 2 to 3 weeks, two studies[28, 134] provided moderate evidence regarding no better benefit of one or the other physical resource in reducing pain and improving function. Both modalities when associated with exercises produced significant improvements on these variables. Only 1 study compared 10 sessions of laser and ultrasound therapies in isolation[111] in the follow-up of 2 weeks and significant better effect of low laser therapy was seen compared with ultrasound to reduce pain and improve function.

Ultrasound versus placebo: Two studies investigated effects of ultrasound compared with placebo ultrasound[54, 101]. Moderate evidence was provided for no additional effect of ultrasound over placebo ultrasound on pain and function.

Pulsed electromagnetic field (PEMF) versus placebo: Five studies compared PEMF with placebo or low dosage of PEMF[3, 21, 33, 51, 52] and there is high evidence of no greater effect of PEMF on pain reduction and moderate evidence of no greater effect of PEMF on function improvement.

Microwave diathermy versus placebo: Two studies investigated effects of the therapy compared with placebo treatment[4, 54]. There is low evidence for improvements on pain and function using microwave diathermy compared with placebo treatment due to large effect in both groups, sparse participants, and statistical and clinical heterogeneity between trials.

Transcutaneous electrical nerve stimulation (TENS) versus injection: Only one study[47] compared conventional TENS with intra-articular corticosteroid injection in a follow-up of 3 weeks. Fifteen sessions of TENS or one intra-articular corticosteroid injection improved pain, function and range of motion when associated with an exercise therapy protocol. Therefore, there is limited evidence for the effectiveness of TENS compared with corticosteroid injection.

Table 2. Overview of GRADE results for group comparisons concerning intervention with physical resources.

Outcomes	Intervention and comparison intervention	Trials	Effect size for intervention group	No of Participants (studies)	Quality of the evidence (GRADE)	Result
Pain						
	Laser x placebo laser	Abrisham et al., 2011 Dogan et al., 2010 Eslamian et al., 2012 Sauders, 1995 Vecchio et al., 1993 Yeldan et al., 2009	From 1.22 to 5.63	301 (6 studies)	⊕⊕⊕□ **moderate**[2] due to indirectness	No additional benefit from laser therapy
	Laser associated with exercises x exercises	Bal et al., 2009 Calis et al., 2011 Otadi et al., 2012	From 0.93 to 0.95	117 (3 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No additional benefit from laser therapy
	Laser associated with exercises x ultrasound associated with exercises	Calis et al., 2011 Yavuz et al., 2014	From 0.95 to 1.28	67 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No additional benefit from laser or ultrasound therapy
	PEMF x placebo PEMF	Aktas et al., 2007 Binder et al., 1984 Galace de Freitas et al., 2013 Galace de Freitas et al., 2014 Chard et al., 1988	From 0.91 to 2.11	230 (5 studies)	⊕⊕⊕⊕ **high**	No difference between groups
	Ultrasound x placebo ultrasound	Giombini et al., 2006 Nykanen et al., 1995	From 0.55 to 1.12	95 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
	Microwave diathermy x placebo diathermy	Giombini et al., 2006 Akyol et al., 2012	From 3.40 to 5.52	65 (2 studies)	⊕□□□ **very low**[1,2,3] due to inconsistency, indirectness, imprecision	No difference between groups
Function						
	Laser x placebo laser	Dogan et al., 2010 Eslamian et al., 2012 Vecchio et al., 1993 Yeldan et al., 2009	From 0.77 to 2.26	197 (4 studies)	⊕⊕⊕⊕ **high**	No difference between groups
	Laser associated with exercises x exercises	Bal et al., 2009 Calis et al., 2011 Otadi et al., 2012	From 0.53 to 2.15	117 (3 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No additional benefit from laser therapy
	Laser associated with exercises x ultrasound associated with exercises	Calis et al., 2011 Yavuz et al., 2011	From 0.53 to 1.98	67 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No additional benefit from laser or ultrasound therapy

PEMF x placebo PEMF	Aktas et al., 2007 Galace de Freitas et al., 2013 Galace de Freitas et al., 2014	From 0.81 to 1.74	197 (3 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
Ultrasound x placebo ultrasound	Giombini et al., 2006 Nykanen et al., 1995	From 0.36 to 0.60	95 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
Microwave diathermy x placebo diathermy	Giombini et al., 2006 Akyol et al., 2012	From 4.79 to 20.00	65 (2 studies)	⊕□□□ **very low**[1,2,3] due to inconsistency, indirectness, imprecision	No difference between groups
Range of motion, flexion					
Laser x placebo laser	Abrisham et al., 2011 Dogan et al., 2010 Yeldan et al., 2009	From 0.44 to 7.00	192 (3 studies)	⊕⊕⊕□ **moderate**[1] due to inconsistency	No difference between groups
Range of motion, abduction					
Laser x placebo laser	Abrisham et al., 2011 Dogan et al., 2010 Eslamian et al., 2012 Yeldan et al., 2009	From 0.57 to 6.11	242 (4 studies)	⊕⊕⊕⊕ **high**	No difference between groups
Range of motion, external rotation					
Laser x placebo laser	Abrisham et al., 2011 Dogan et al., 2010 Eslamian et al., 2012 Yeldan et al., 2009	From 0.09 to 4.09	242 (4 studies)	⊕⊕□□ **low**[1] due to inconsistency	No difference between groups

[1]Inconsistency: there was statistical or effect size heterogeneity between trials.
[2]Indirectness: there was clinical heterogeneity between trials.
[3]Imprecision: there was sparse data with less than 200 participants for the comparison.
[4]Publication bias: there were two comparisons from the same research group.
[5]Large effect: a quality point was added when more than 75% of the trials presented large effect (between 0.21 and 0.79) for the experimental group and not for the comparison group.

Effects of exercise therapy (Table 3)

Exercise versus placebo or no treatment: Five studies[26, 27, 68, 77, 79] investigated effects of exercise therapy compared with no treatment or placebo treatment in the follow-up of 6 weeks to 2-8 years. There was high evidence that exercises aimed to restore scapular and shoulder motions are more effective than placebo or no treatment concerning pain reduction and function improvement in the short-, mid- and long-term. For range of motion outcome, the evidence is moderate that these exercises are better than placebo or no treatment.

Exercises versus arthroscopy surgery: Two studies[27, 58] investigated mid-term effects of supervised exercises compared with arthroscopy surgery in individuals with SIS in pain, function and range of motion. For all these outcomes, there is moderate evidence that 2 to 6 months of supervised exercises were as efficious as the arthroscopy surgery after 6 or 12 months. Other two studies with longer follow-up of these patients[26, 57] provided moderate evidence that benefits in pain and function observed in those interventions were maintained after 2 to 8 years.

Scapular training versus usual physical therapy: Three studies[7, 11, 121] investigated effectiveness of scapular focused training compared with usual physical therapy using shoulder stretch, strengthening and electrotherapy to improve pain, function and/or range of motion outcomes in the follow-up of 1.5 to 3 months. Low evidence was demonstrated towards greater benefits of one therapy over the other to improve pain and function outcomes since 3 to 6 weeks of both interventions showed moderate effect size of the improvement. Both interventions seem to improve range of motion and low evidence was demonstrated concerning greater increase in flexion and abduction range of motion with scapular focused training or usual physical therapy.

Dynamic humeral centering exercises versus conventional exercises: Two studies[12, 14] compared dynamic humeral centering exercises with conventional exercises in the follow-up of 3 and 6 months. In the short- and mid-term, there was moderate evidence that exercises associated with dynamic humeral centering are more effective than conventional exercises alone to improve pain and function. However, only one study investigated the effects in the follow-up of 12 months and limited evidence was provided concerning long-lasting effects of the dynamic humeral centering therapy on pain and function[14] and range of motion[12].

Proprioceptive training versus usual physical therapy: Three studies[85, 91, 99] investigated effects of adding a proprioceptive training to the usual physical therapy protocol with shoulder stretches and strengthening in pain, function and/or range of motion outcomes in the follow-up of 2 to 6 weeks. There is low evidence for no difference in pain results between interventions and there is moderate evidence that adding proprioceptive training on exercises protocol is more

effective than conventional exercises to improve function in the short-term follow-up. Only one study investigated range of motion[91]; however between-group comparison was not performed.

Eccentric training versus usual physical therapy: Maenhout et al.[83] investigated the effect of adding eccentric training to usual physical therapy in the follow-up of 12 weeks. There is limited evidence that eccentric training did not result in less pain or better shoulder function than traditional rotator cuff training after 12 weeks.

Self-managed loaded exercise versus usual physical therapy: One study[76] compared a self-managed loaded exercise program to usual physical therapy treatment in the follow-up of 3 months. There is limited evidence that self-managed loaded exercise is equivalent of usual clinical physical therapy treatment.

High dosage versus low dosage of exercises: Osteras et al.[103] investigated effects of high dosage exercise therapy compared with a low dosage of exercise therapy in the short-, mid- and long-term follow-up. There is limited evidence that the high dosage exercise protocol is more effective to reduce pain and improve function 12 weeks, 3 and 6 months after the treatment.

Workplace-based versus clinical-based rehabilitation: One study[34] compared a workplace-based rehabilitation program with a clinical-based rehabilitation in the follow-up of 1 month. There is limited evidence that workplace-based exercises are more effective to improve function in patients with rotator cuff tendinopathy than the clinical based program.

Table 3. Overview of GRADE results for group comparisons using exercise therapy.

Outcomes	Intervention and comparison intervention	Trials	Effect size for intervention group	No of Participants (studies)	Quality of the evidence (GRADE)	Result
Pain						
	Exercises x arthroscopy surgery	Brox et al., 1993 Haahr et al., 2005	Mean of 9.50 lower	159 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
	Scapular and shoulder exercises x no treatment or placebo treatment	Brox et al., 1993 Brox et al., 1997 Kachingwe et al., 2008 Lombardi et al., 2008 Ludewig and Borstad, 2003	From 0.40 to 1.47 lower	222 (5 studies)	⊕⊕⊕⊕ **high**[5] due to large effect	Pain decrease in the experimental group
	Scapular training x usual physiotherapy	Baskurt et al., 2011 Struyf et al., 2012	From 1.20 to 3.58 lower	62 (2 studies)	⊕⊕□□ **low**[1,3] due to inconsistency, imprecision	No difference between groups; large effect for both
	Dynamic humeral centering x exercise	Beaudreuil et al., 2011 Marzetti et al., 2014	Mean of 1.61 lower	118 (2 studies)	⊕⊕⊕□ **moderate**[2,3,5] due to indirectness, imprecision, large effect	Pain decrease in the experimental group
	Proprioceptive neuromuscular facilitation x usual physiotherapy	Martins and Marziale, 2012 Melchiorre et al., 2013	Not estimable	56 (2 studies)	⊕⊕□□ **low**[1,3] due to inconsistency, imprecision	No difference between groups
Pain, long-term						
	Exercises x arthroscopy surgery	Brox et al., 1999 Haahr and Andersen, 2006	Not estimable	152 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
Function						
	Exercises x arthroscopy surgery	Brox et al., 1993 Haahr et al., 2005	Mean of 9.20 higher	159 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
	Scapular and shoulder exercises x no treatment or placebo treatment	Brox et al., 1993 Brox et al., 1997 Kachingwe et al., 2008 Lombardi et al., 2008 Ludewig and Borstad, 2003	From 0.59 to 1.16 higher	222 (5 studies)	⊕⊕⊕⊕ **high**[5] due to large effect	Function improvement in the experimental group

	Scapular training x usual physiotherapy	Bae et al., 2011 Baskurt et al., 2011 Struyf et al., 2012	From 1.46 to 4.26 higher	97 (3 studies)	⊕⊕□□ **low**[2,3] due to imprecision, indirectness	No difference between groups; large effect for both
	Dynamic humeral centering x exercise	Beaudreuil et al., 2013 Marzetti et al., 2014	Mean effect was 1.51 higher	118 (2 studies)	⊕⊕⊕□ **moderate**[2,3,5] due to indirectness, imprecision, large effect	Function improvement in the experimental group
	Proprioceptive neuromuscular facilitation x usual physiotherapy	Martins and Marziale, 2012 Nakra et al., 2013	From 1.57 to 3.16 higher	46 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	Function improvement in the experimental group
Function, long-term						
	Exercises x arthroscopy surgery	Brox et al., 1999 Haahr and Andersen, 2006	Not estimable	152 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
Range of motion, total						
	Exercises x arthroscopy surgery	Brox et al., 1993 Haahr et al., 2005	Mean of 8.58 higher	159 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
	Scapular and shoulder exercises x no treatment or placebo treatment	Brox et al., 1993 Brox et al., 1997 Lombardi et al., 2008	Mean of 0.76 lower	140 (3 studies)	⊕⊕⊕□ **moderate** [3,4,5] due to imprecision, publication bias, large effect	Range of motion improvement in the experimental group
Range of motion, flexion						
	Scapular training x usual physiotherapy	Bae et al., 2011 Baskurt et al., 2011	From 1.45 to 1.88 higher	75 (2 studies)	⊕□□□ **very low**[1,2,3] due to inconsistency, imprecision, indirectness	No difference between groups; large effect for both
Range of motion, abduction						
	Scapular training x usual physiotherapy	Bae et al., 2011 Baskurt et al., 2011	From 0.70 to 2.13 higher	75 (2 studies)	⊕□□□ **very low**[1,2,3] due to inconsistency, imprecision, indirectness	No difference between groups; moderate effect for both

[1]Inconsistency: there was statistical or effect size heterogeneity between trials.
[2]Indirectness: there was clinical heterogeneity between trials.
[3]Imprecision: there was sparse data with less than 200 participants for the comparison.
[4]Publication bias: there were two comparisons from the same research group.
[5]Large effect: a quality point was added when more than 75% of the trials presented large effect (between 0.21 and 0.79) for the experimental group and not for the comparison group.

Effects of manual therapy techniques (Table 4)

Manipulation versus sham-manipulation: Two studies[6, 60] compared thrust manipulation with *sham* manipulation in a short-term follow-up. Low evidence was provided regarding benefits of thrust manipulation in reducing shoulder pain due to sparse participants and clinical and statistical heterogeneity between trials. One study showed no benefits immediately after only one session of thoracic spine manipulation[60] while the other trial demonstrated that 6 sessions of shoulder joint manipulations significantly reduce pain and improve range of motion after 2 weeks[6].

Mobilizations associated with exercises versus only exercises: Five studies[9, 36, 37, 68, 73] compared exercises with or without manual mobilizations of shoulder girdle, cervical and thoracic spine in the follow-up of 3 to 8 weeks. High evidence was demonstrated for pain reduction after 6 to 10 sessions of mobilization associated with exercises when compared with only exercises in the short-term. Concerning function improvement, 4 of them [9, 37, 68, 73] investigated this outcome and moderate evidence was found towards no additional benefit of adding manual therapy to exercise therapy in the short-term. However, all the studies showed large effect of both therapies. Considering range of motion, only 2 studies[36, 68] evaluated these outcomes. There was low evidence for range of motion increase with adding mobilizations, due to sparse participants and some statistical and clinical heterogeneity between trials.

Manual therapy versus injection: When compared with corticosteroid injection, manual therapy treatment results of pain decrease did not differ from those of the injection. Findings of two studies provided low evidence that 6 sessions of manual therapy treatment are as effective as corticosteroid injection in reducing pain in individuals with SIS after 11 weeks[108, 133]. One study revealed that manual therapy is as effective as corticosteroid injection to improve function after 3 weeks of treatment even in a follow-up of 1 year[108].

Manual therapy versus exercises: When comparing manual therapy with exercises, only one study investigated pain as an outcome[133] and another study investigated function and range of motion as outcomes[62]. Any of them revealed greater effectiveness of one therapy over the other one concerning pain reduction, functional improvement or range of motion increase. Both therapies demonstrated significant improvements after 2 to 3 weeks of treatment but due to the presence of only one study for each outcome this result was not incorporated to GRADE analysis, and therefore the evidence for the comparison is still limited.

Table 4. Overview of GRADE results for group comparisons with manual therapy techniques.

Outcomes	Intervention and comparison intervention	Trials	Effect size for intervention group	No of Participants (studies)	Quality of the evidence (GRADE)	Result
Pain						
	Manipulation x placebo (sham or placebo therapy)	Atkinson et al., 2008 Haik et al., 2014	From 0.31 to 1.23 lower	140 (2 studies)	⊕⊕□□ **low**[2,3] due to indirectness, imprecision	No difference between groups
	Mobilization associated with exercises x exercises	Bang and Deyle, 2000 Conroy and Hayes, 1998 Cook et al., 2014 Kachingwe, 2008 Kromer et al., 2013	From 1.15 to 1.99 lower	264 (5 studies)	⊕⊕⊕⊕ **high**[5] due to large effect	Pain decrease in the experimental group
	Combined therapy (manual therapy, exercises, scapular control) x placebo or no treatment	Bennel et al., 2010 Kachingwe et al., 2008	From 0.89 to 1.7 lower	152 (2 studies; 3 comparisons)	⊕⊕⊕□ **moderate**[3,4,5] due to imprecision, publication bias, large effect	Pain decrease in the experimental group
	Manual therapy x corticosteroid injection	Rhon et al., 2014 Winters et al., 1997	From 0.32 to 2.96 lower	183 (2 studies)	⊕⊕□□ **low**[1,3] due to inconsistency, imprecision	No difference between groups
Function						
	Mobilization associated with exercises x exercises	Bang and Deyle, 2000 Cook et al., 2014 Kachingwe, 2008 Kromer et al., 2013	From 0.93 to 2.1 higher	250 (4 studies)	⊕⊕⊕□ **moderate**[2] due to indirectness	No difference between groups
	Combined therapy (manual therapy, exercises, scapular control) x placebo or no treatment	Bennel et al., 2010 Kachingwe et al., 2008	From 0.85 to 1.3 higher	152 (2 studies; 3 comparisons)	⊕⊕⊕□ **moderate**[3,4,5] due to imprecision, publication bias, large effect	Functional improvement in the experimental group
Function, long term						
	Combined therapy (manual therapy, exercises, scapular control) x placebo or no treatment	Bennel et al., 2010 Dickens et al., 2005	From 0.67 to 1.19 higher	205 (2 studies)	⊕⊕⊕⊕ **high**[5] due to large effect	Functional improvement in the experimental group
Range of motion, total						

	Combined therapy (manual therapy, exercises, scapular control) x placebo or no treatment	Kachingwe et al., 2008	From 2.49 lower to 4.28 higher	32 (1 study, 2 comparisons)	⊕⊕□□ **low**[3,5] due to imprecision, publication bias	No difference between groups
Range of motion, flexion						
	Mobilization associated with exercises x exercises	Conroy and Hayes, 1998 Kachingwe, 2008	From 2.49 lower to 4.28 higher	48 (2 studies)	⊕⊕□□ **low**[2,3] due to imprecision, indirectness	No difference between groups
Range of motion, abduction						
	Mobilization associated with exercises x exercises	Conroy and Hayes, 1998 Kachingwe, 2008	From 0.16 to 4.53 higher	48 (2 studies)	⊕⊕□□ **low**[2,3] due to imprecision, indirectness	No difference between groups

[1]Inconsistency: there was statistical or effect size heterogeneity between trials.
[2]Indirectness: there was clinical heterogeneity between trials.
[3]Imprecision: there was sparse data with less than 200 participants for the comparison.
[4]Publication bias: there were two comparisons from the same research group.
[5]Large effect: a quality point was added when more than 75% of the trials presented large effect (between 0.21 and 0.79) for the experimental group and not for the comparison group.

Combined therapy versus placebo or no treatment: Two studies[16, 68] compared combined therapy using manual therapy techniques, exercises and scapular training with placebo or no treatment in the follow-up of 6 to 22 weeks. In the short-term, high evidence was demonstrated towards pain decrease after combined therapy when compared with placebo or no treatment. This was due to the large effect size observed in the experimental group and not in the control group, although no statistical differences were observed between interventions. Concerning function outcome, moderate evidence was demonstrated towards functional improvements after combined therapy when compared with no treatment in the short-term and high evidence was demonstrated towards functional improvements in the long-term follow-up. Only one study[68] evaluated range of motion outcome in two comparisons using different manual therapy techniques and exercises *versus* placebo treatment. Imprecision and publication bias contributed to low evidence towards no effect of the therapy.

Diacutaneous fibrolysis versus placebo or exercises: Only one trial compared diacutaneous fibrolysis with placebo diacutaneous fibrolysis or supervised exercises[10] then limited evidence was provided concerning the results. In the short-term of 3 weeks, supervised exercises associated with diacutaneous fibrolysis were more effective to improve function than supervised exercises alone. However, in the mid-term of 3 months both interventions were effective in improving function. Regarding pain and range of motion outcomes, supervised exercises alone, associated with diacutaneous fibrolysis or with placebo diacutaneous fibrolysis demonstrated the same effectiveness to reduce pain and increase range of motion in the short- or mid-term.

Effects of kinesio taping (Table 5)

Taping versus placebo taping: Three studies[116, 117, 124] investigated the effect of kinesio taping compared with placebo taping on pain, function and/or range of motion. There is moderate evidence towards no additional benefits of kinesio taping compared with placebo taping to improve shouder pain, function or range of motion.

Taping associated with usual physical therapy versus usual physical therapy: Two studies[71, 94] investigated effects of kinesio taping associated with usual physical therapy based on exercises and electrotherapy compared to usual physical therapy alone in the follow-up of 2 to 6 weeks. There is moderate evidence towards no additional benefits of kinesio taping to improve shoulder pain and function in the short-term. Regarding range of motion improvement, there is limited evidence for the above comparison since only one study has measured this outcome[94].

Table 5. Overview of GRADE results for group comparisons using kinesio taping.

Outcomes	Intervention and Comparison intervention	Trials	Effect size for intervention group	No of Participants (studies)	Quality of the evidence (GRADE)	Results
Pain						
	Taping + usual physiotherapy x usual physiotherapy	Kaya et al., 2011 Miller and Osmotherly, 2009	Not estimable	82 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
	Taping x placebo tapping	Shakeri et al., 2013 Simsek et al., 2013 Thelen et al., 2008	From 1.15 to 1.46 lower	110 (3 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
Function						
	Taping + usual physiotherapy x usual physiotherapy	Kaya et al., 2011 Miller and Osmotherly, 2009	Not estimable	82 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
	Taping x placebo tapping	Simsek et al., 2013 Thelen et al., 2008	From 1.13 to 1.38 higher	80 (2 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
Range of motion, flexion						
	Taping x placebo tapping	Shakeri et al., 2013 Simsek et al., 2013 Thelen et al., 2008	From 0.81 to 3.46 higher	110 (3 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups
Range of motion, abduction						
	Taping x placebo tapping	Shakeri et al., 2013 Simsek et al., 2013 Thelen et al., 2008	From 1 to 4.22 higher	110 (3 studies)	⊕⊕⊕□ **moderate**[3] due to imprecision	No difference between groups

[3]Imprecision: there was sparse data with less than 200 participants for the comparison.

Effects of acupuncture

Acupuncture versus placebo needling: Kleinhenz et al.[72] evaluated 52 subjects with SIS receiving acupuncture as active treatment or placebo-needling as control treatment. Effectiveness of needling procedure to improve shoulder function was demonstrated in the follow-up of 4 months. Due to the sparse number of subjects, the study provides limited evidence concerning the effectiveness of this therapy.

Acupuncture associated with home exercise versus corticosteroid injection: One study[66] investigated the effect of acupuncture and exercise therapy compared with injection of corticosteroid in 123 subjects with SIS. In a follow-up of 12 months, they demonstrated that acupuncture associated with exercises therapy is equivalent to corticosteroid injection to improve pain and function since both groups significantly improved in this outcome. However, this study provides limited evidence concerning the above comparison.

Acupuncture versus ultrasound: One study[67] compared acupuncture treatment with ultrasound treatment in 85 subjects in the follow-up of 12 months. There is limited evidence that 5 weeks of treatment with acupuncture is more effective than ultrasound to improve shoulder function after treatment and in 1-year follow-up.

Acupuncture versus physical exercise: Szczurk et al.[122] compared naturopathic treatment with usual physiotherapy exercises in the follow-up of 12 weeks. There is limited evidence that acupuncture applied during 30 minutes once a week is more effective than usual physiotherapy to reduce pain and improve function in 12 weeks of treatment.

DISCUSSION

This systematic review summarized the effectiveness of different physical therapy interventions in the treatment of SIS. Sixty-two RCTs were included, with low to moderate risk of bias. According to our best-evidence synthesis, rehabilitation based on stretching and strengthening exercises is as effective as arthroscopy surgery in all phases of the treatment and manual therapy added to exercises is worthy to achieve better results with these patients. Kinesio taping and physical resources such as laser, ultrasound or pulsed electromagnetic field do not add significant contribution to the rehabilitation. The greatest tendency of the results was towards moderate evidence for pain decrease or functional improvements with conservative interventions. Few studies evaluated shoulder range of motion.

Most of the included trials had high methodological quality based on PEDro scale. This fact incorporates significant internal validity and minimal methodological quality limitation based on GRADE analysis. A high level of directness among population, intervention and

outcome measures was also present in the included studies. Although SIS diagnosis is still controversial, studies were included only if all subjects have had clinically or imaging diagnosed SIS and no signs of rotator cuff tendon rupture, calcareous tendinitis, frozen shoulder or other shoulder pathologies, which contributed to maintain directness in the comparisons. Quality of evidence was mostly downgraded to moderate due to imprecision of the comparison groups. Inconsistency and inderectiness among trials were both mostly responsible for downgrading some of the evidence to low or very low quality level.

Exercises and Manual therapy effectiveness

Among the 5 clusters of physical therapy treatments for SIS found in the literature (physical resources, exercises, manual therapy, kinesio taping and acupuncture), exercises and manual therapy are those which demontrated more efficacy to improve pain, function and range of motion outcomes.

Moderate evidence was found towards the same effectiveness with rehabilitation exercises and arthroscopy surgery to reduce pain, improve function and increase range of motion in the short-, mid-, and long-term for patients with SIS. These results are in agreement with those from Kromer et al.[73] suggesting that patients should not undergo surgery before having been treated conservatively with exercise therapy based on restoration of balance, flexibility and strength of the rotator cuff and scapular muscles. Moreover, rehabilitation with exercises involves easy application, low costs, and low risks to the patient since it consists of a non-invasive treatment. Surgery should be handled with care and its indication needs to be better stablished.

Exercise therapy was also strongtly recommended instead of no treatment or placebo treatment in order to improve pain, function and range of motion what reinforces previous recommendations based on moderate evidence[53]. Concerning types of exercises used in the treatment, there were some interesting findings. There was moderate evidence in favor of adding dynamic humeral centering exercises to exercise treatment when compared with conventional exercises alone to improve pain and function in the short- and mid-term. However, for long-term follow-up the evidence was still limited. Dynamic humeral centering approach aims to retrain and restore consciousness and motor control during normal movements of the arm[13, 86]. Proprioceptive exercises added to conventional exercises are more effective than only exercises and could help to improve shoulder function in the short-term. When adding a specific scapular training to exercise therapy, low evidence was found in favor of one or the other program to improve pain and function. Nevertheless, it is important to emphasize that other outcomes as muscle strength and scapular dyskinesia were not included in this review but consist part of the

objectives aimed to achieve with the exercise intervention. It is important to highlight that some studies did not provide much details regarding the programs for strengthening other than reporting target muscles involved in the treatment[58, 68] while others were more specific in describing the exercise programs[7, 77, 79, 121]. Therefore, consistent comparisons and conclusions about specific types of exercises are difficult to be stablished.

Different manual therapy techniques were used including mobilization-with-movement, shoulder girdle, thoracic and cervical joint mobilizations, soft-tissue mobilizations and neural mobilizations. In addition to the exercises, there was high evidence that manual therapy provides additional benefits to shoulder pain decrease in the short-term and, therefore, could be used to accelerate symptoms decrease in order to progress exercise therapy quickly. A preview systematic review[53] and a recent systematic review and meta-analysis[39] found limited and low-level evidence, respectively, that manual therapy either used alone or in conjuction with other interventions significantly reduces pain in individuals with rotator cuff tendinopathy. However, the authors did not rule out the possibility of a small but clinically relevant effect of this therapy[39]. Two of the included studies in the more recent review were excluded from ours due to low quality level[20, 114], and one due to the presence of individuals with parcial rotator cuff rupture[115]. Moreover, we have incuded another clinical trial not published at that moment which have strengthened our findings.

When manual therapy is applied alone and compared with exercise or corticosteroid injection this review corroborates with previous results[39] and suggests that there is limited evidence in favor of one over the other therapy to improve pain, function or range of motion since only one study evaluated each one of the mentioned outcomes and comparisons.

Diacutaneous fibrolysis seems to add some functional improvements to exercise therapy in the short-term but not in the mid-term neither regarding pain or range of motion. However, there was only one trial investigating this manual therapy technique limiting the evidence synthesis to only a trend toward benefit, as found by Dong et al.[42]

Physical resources effectiveness

Although the great quantity of studies investigating the effect of laser therapy, results are conficting regarding its efficacy to reduce pain. Variability in the protocol and different equipments used to apply laser have contributed to differences in the level of energy applied in each trial, and therefore may justify divergences between results. It seems that the amount of energy directly contributes to pain decrease since 3 studies using higher total energy revealed effectiveness of the therapy on pain reduction. In a systematic review of low-level laser therapy on acute pain, Bjordal et al[23] support this suggestion. However, our conclusion was guided by

GRADE analysis, in which less than 75% of trials did not show additional benefits of laser over placebo laser in the treatment of SIS. Moderate evidence was also observed towards no additional benefits from laser therapy to improve function and range of motion. A recent systematic review of all treatments for SIS[42] also provided the same conclusion and did not recommend laser therapy to this population. When adding laser or ultrasound to the exercise therapy, no additional benefits were observed in order to decrease pain or improve function in the short-term.

Pulsed electromagnetic field and ultrasound were not more effective than their placebo application to improve shoulder pain and function and should not be included as part of the treatment based on moderate and high evidence. Previous review[42] found only a trend toward a benefit from these physical resources but the authors have included fewer trials than we did in the present review.

Microwave diathermy and TENS also do not seem to be beneficial in SIS treatment but the evidence is still low due to sparse participants and few studies.

Kinesio taping effectiveness

Regarding kinesio taping application in the SIS, it seems that kinesio taping does not produce additional benefits over usual physical therapy or placebo taping to reduce pain, improve function or increase range of motion based on moderate evidence from 5 studies. Kinesio taping is a widespread technique commonly used in rehabilitation protocols but its effectiveness seems not be related with quantitative measures. In the athletic shoulder, similar results were found following kinesio taping application where Zanca et al.[136] did not find changes in scapular kinematics in throwers after taping, and Aaserth et al.[1] showed that joint position sense was impaired after taping in healthy athletes.

Acupunture effectiveness

There is very limited evidence concerning effectiveness of acupuncture to improve pain and function in comparison with placebo needling, usual physical therapy or corticosteroid injection. Only one study evaluated each one of the mentioned outcomes or comparisons which makes difficult to stablish some conclusion.

Strengths of the review

One of the strengths of this review involves the inclusion criteria of primary studies, what provided homogeneity among patient population and high quality level among trials. Moreover, the comprehensive search and the best-practice guidelines for review were followed as set down

by the Cochrane and PRISMA recommendations. These facts have contributed to improve clinical recommendations for the treatment of patients with signs of SIS.

Previews systematic reviews[42, 53] showed moderate evidence on the effectiveness of exercise therapy. This review strengthens clinical recommendations for the use of exercise therapy as the first choice to improve shoulder pain, function and range of motion over surgery or no treatment. Moreover, this review also provides high-level of evidence to recommend exercise therapy associated with joint and soft-tissue manual mobilizations in the shoulder girdle, thoracic and cervical spine as the best choice of treatment in the short- and long-term to reduce pain and improve function in patients with SIS. Therefore, these results also strength previous suggestions of some clinical benefit from manual therapy approach in SIS[39, 53].

Limitations

There was large number of comparison groups in order to guarantee clinical homogeneity between most of them. Tools and methods for measuring selected outcomes were also homogeneous between trials, except for function assessment. However, even facing different questionnaires to measure function among trials, the similarity between questionnaires was considered before downgrading a quality point for directness domain. Publication bias was present in only two comparison groups: combined therapy versus placebo/no treatment and scapular and shoulder exercises versus placebo/no treatment. Therefore, 2 out of 5 GRADE criteria were more difficult to be fulfilled among comparison groups of interventions: consistency and precision. Most of consistency problems between trials were observed in statistical results and most of precision deficit were due to sparse number of participants to draw some conclusion.

Future research

Future studies should provide more information allowing the evidence synthesis regarding the kind of exercise that is better indicated to improve specific movement alterations in the SIS patients. There is still need for more results regarding the effects of manual therapy techniques used in isolation and compared with exercise therapy to treat this population. Moreover, future research should investigate what kind of patients are more likely to benefit from manual therapy techniques or exercise interventions in order to improve rehabilitation programs of SIS patients. There is still need for studies using specific dosage of laser therapy with high energy to better understand real benefits of this therapy on pain reduction. Finally, there is also need for more evidence concerning effectiveness of diacutaneous fibrolysis, microwave diathermy, TENS and acupuncture in the treatment of SIS.

CONCLUSION

According to the strength of the body evidence, exercise therapy aimed to restore muscle flexibility and strength of shoulder and scapular muscles associated with manual joint and soft-tissue mobilizations should be the first choice of treatment to reduce pain and improve function in patients with SIS before recommending arthroscopy surgery. Dynamic humeral centering and proprioceptive training incorporated to exercise therapy are also important to improve motor control in the short- and mid-term of the treatment. Future studies are necessary to better understand the specific effects of manual therapy techniques used in isolation to enhance clinical recommendations for this population. Also, future research should address evidence of what kind of exercise is better indicated to specific movement alterations and which patient better respond to specific manual therapy techniques in this population.

There is evidence to not recommend the use of kinesio taping in isolation or associated with exercise in order to improve pain or function. Low-level laser therapy seems not be relevant to pain decrease although more investigation could compare different energy dosages to support this evidence. And finally, more studies are necessary to conclude about efficacy of diacutaneous fibrolysis, microwave diathermy, TENS and acupuncture in the treatment of SIS.

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APPENDIX - Characteristics of all included trials in Study 2

			Parameters			*Between-groups comparison**		
Trial	***Patients***	***Intervention***	***Session frequency and duration***	***Treatment duration***	***Outcome measures***	***Pain***	***Function***	***ROM***
Abrisham et al, 2011	N=80 (30M and 50W) Age: >18 Symptoms duration: NR	G1: supervised exercise + LLLT. Laser: 890nm wavelength, 2-4J/cm^2, 3 points G2: supervised exercise + placebo LLLT G1 and G2: pendulum, stretching, strengthening, mobilizations	5 sessions per week	2 weeks	Pain (VAS) ROM (goniometer) Assessments: baseline and 2 weeks	G1 x G2: positive effect	-	G1 x G2: positive effect
Aktas et al, 2007	N=46 (10M and 30W) Age: NR Symptoms duration: mean 4.8 months.	G1: PEMF + usual physiotherapy. PEMF: 50HZ, 30G intensity G2: sham PEMF G1 and G2: Usual physiotherapy – pendulum, cold pack, patient education	Usual physiotherapy: 5 sessions per week PEMF: 25 minutes a day	3 weeks	Pain (VAS) Function (CMS) Assessments: baseline, 3 weeks	G1 x G2: non-effect	G1 x G2: non-effect	-
Akyol et al, 2012	N=40 (10M and 30W) Age: 21-78 Symptoms duration: >3 months (mean 10.5 months)	G1: Therapeutic microwave diathermy + supervised exercise. Curadar 409, 2,450MHz, 100W G2: sham microwave diathermy + supervised exercise G1 and G2: Supervised exercise – AROM, stretching, strengthening (rotator cuff, scapular muscles)	Microwave diathermy: 20 minutes, 5x per week Exercises: 30 minutes, 5x per week	3 weeks	Pain (VAS) ROM (goniometer) Function (SPADI) Assessments: baseline, 3 weeks, 1 month.	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: non-effect
Atkinson et al, 2009.	N=60 (17M and 43W) Age: 18-76 Symptoms duration: NR	G1: Shoulder joint manipulation G2: shoulder sham manipulation	6 sessions	2 weeks	Pain ROM Assessments: baseline, 3rd visit and 6th visit.	G1 x G2: positive effect	-	G1 x G2: positive effect

Bae et al, 2011	N=55 (12M and 23W) Age: 49.1 Symptoms duration: NR	G1: motor control and strengthening (scapular and shoulder muscles) + usual physiotherapy G2: usual physiotherapy G1 and G2: usual physiotherapy - hot pack, TENS, ultrasound	G1: 75 minutes, 3x per week G2: 45 minutes, 3x per week	4 weeks	Function (SPADI) ROM (goniometer) Assessments: baseline, 4 weeks.	-	G1 x G2: positive effect	G1 x G2: positive effect
Bal et al, 2009	N=44 (12M and 28W) Age: 18-70 Symptoms duration: 1.5-6 months	G1: Laser therapy + home exercise program Laser: Ga-As, 904nm wavelength, 16J/cm^2, 5 points, 27 power, 5500Hz G2: home exercise program G1 and G2: pendulum, stretching, strengthening, scapular stabilization and hot pack	Laser: 5 sessions per week Exercises: NR	12 weeks	Pain (VAS) Function (SPADI) Assessments: baseline, 2 and 12 weeks	G1 x G2: non-effect	G1 x G2: non-effect	-
Bang and Deyle, 2000.	N=52 (30M and 22W) Age: 24-65 Symptoms duration: 1-12 months	G1: Supervised exercise + Manual therapy (joint mobilization and soft tissue techniques for shoulder girdle, cervical and upper thoracic spine and costotransverse joints) G2: Supervised exercise G1 and G2: 2 stretching and 6 strengthening exercises	30 minutes, 2x per week	3-4 weeks	Pain (VAS) Function (Owestry Low Back Disability Questionnaire) Assessments: baseline, 6 weeks, 2 months.	G1 x G2: positive effect	G1 x G2: positive effect	-
Barra-López et al, 2013	N=120 (45M and 75W) Age: 31-83 Symptoms duration: mean 18.8 months	G1: supervised exercise + diacutaneous fibrolysis G2: supervised exercise + placebo diacutaneous fibrolysis G2: Supervised exercise G1, G2 and G3: supervised exercise – therapeutic exercises, analgesic electrotherapy and cryotherapy	Exercises: 5 sessions per week Diacutaneous fibrolysis: 2 sessions per week	3 weeks	Pain (VAS) Function (CMS) ROM (goniometer) Assessments: baseline, 3 weeks, 3 months.	G1 x G2 x G3: non-effect	G1 x G3: positive effect for G1 at 3 weeks; non-effect at 3 months G1 x G2: non-effect	G1 x G2 x G3: non-effect

Baskurt et al, 2011	N=40 (13M and 27W) Age: 24-71 Symptoms duration: mean 10.1 months	G1: supervised exercise G2: supervised exercise + scapular stabilization (FNP and scapular exercises) G1 and G2: supervised exercise – pendulum, AROM, stretching, and strengthening	3 sessions per week	6 weeks	Pain (VAS) ROM (goniometer) Function (WORC) Assessments: baseline and 6 weeks	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: non-effect
Beaudreuil et al, 2011 and 2013	N=70 (47M and 22W) Age: 34-79 Symptoms duration: 1-360 months	G1: dynamic humeral centering program + home exercises (co-contraction exercises) G2: passive and active mobilizations of the shoulder + home exercises (pendulum and AROM)	30 minutes, 2 or 3 sessions per week	6 months	Pain (CMS) Function (CMS) Assessments: baseline, 3 and 12 months.	G1 x G2: positive effect at 3 months; non-effect at 12 months	G1 x G2: non-effect	G1 x G2: positive effect at 3 months; non-effect at 12 months
Bennel et al, 2010	N=120 (64M and 56W) Age: >18 Symptoms duration: 6-54 months	G1: combined therapy (shoulder, thoracic and cervical spine joint mobilization, scapular training, taping) + home exercises + patient education G2: placebo intervention (sham ultrasound and non-therapeutic gel)	35-40 minutes, 10 sessions.	G1: 10 weeks + 12 weeks home exercises G2: 10 weeks	Pain (NPRS) Function (SPADI) Assessments: baseline, 11 and 22 weeks.	G1 x G2: non-effect	G1 x G2: non-effect	-
Binder et al, 1984.	N=29 (21M and 8W) Age: NR Symptoms duration: 3-24 months	G1: PEMF G2: PEMF + sham PEMF G1 and G2: PEMF – 50 turns of copper wire, 73Hz pulse.	1h a day	G1: active for 8 weeks. G2: active for 4 weeks, dummy for 4 weeks.	Pain (VAS) ROM (goniometer) Assessments: baseline, fortnightly (1-8 weeks) and monthly (8-16 weeks).	G1 x G2: non-effect		G1 x G2: non-effect
Brox et al, 1993 and 1999	N=125 (66M and 59W) Age: 18-66 Symptoms duration: >3 months	G1: Arthroscopic surgery and supervised exercise (n=45) G2: Supervised exercise (n=50) G3: Placebo laser (n=30) G1 and G2: supervised exercise aimed at	G1: surgery + 20 sessions G2: 30 sessions G3: 12 sessions.	3 to 6 months.	Pain (Neer shoulder score) Function (Neer shoulder score) ROM (Neer score) Assessments: baseline, 3 months, 6	G1 x G2: non-effect G1 x G3: positive effect G2 x G3:	G1 x G2: non-effect G1 x G3: positive effect G2 x G3:	G1 x G2: non-effect G1 x G3: positive effect G2 x G3:

		normalizing dysfunctional movement patterns, stretching, and strengthening of the rotator cuff and scapular muscles / patient education			months.	positive effect	positive effect	positive effect
Calis et al, 2011	N=52 (17M and 35W) Age: 18-65 Symptoms duration: 1-24 months	G1: supervised exercise + hot pack + ultrasound (1.5W/cm^2 power, 3 MHz frequency) (n=21) G2: supervised exercise + hot pack + laser (Ga-As, 904nm wavelength, 6mW power, 1 J/cm^2, 16 Hz frequency) (n=15) G3: supervised exercise + hot pack (n=16) G1, G2 and G3: supervised exercise – pendulum, PROM, stretching and strengthening	5 sessions per week Ultrasound: 5 minutes Laser: 2 minutes Hot pack: 20 minutes	3 weeks	Pain (VAS) Function (CMS) ROM Assessments: baseline and 3 weeks	G1 x G2 x G1: non-effect	G1 x G2 x G1: non-effect	G1 x G2 x G1: non-effect
Chard et al, 1988	N=49 (25M and 18W) Age:>18 (mean 51.5) Symptoms duration: >3 months (mean 14.4 months)	G1: PEMF G2: PEMF + sham PEMF G1 and G2: PEMF – 380 us pulse duration, 72Hz frequency	G1: 8h per day G2: 2h per day	8 weeks	Pain (3-points pain scale) ROM (goniometer) Assessments: baseline, 2, 4, 6 and 8 weeks.	G1 x G2: non-effect	-	G1 x G2: non-effect
Cheng and Hung, 2007	N=103 (72M and 22W) Age: mean 32 Symptoms duration: >3 months	G1: workplace-based work hardening training – biomechanics and ergonomic education, stretching, strengthening, scapular control exercises and job-specific activities (n=46) G2: Clinic-based work hardening training – AROM, strength exercises and endurance training (n=48)	3 sessions per week	4 weeks	Pain and function (SPADI) Assessments: Baseline and 4 weeks.	-	G1 x G2: positive effect	-
Conroy and Hayes, 1998.	N=14 (8M and 6W) Age: mean 52.9 Symptoms duration: NR	G1: Supervised exercise + joint mobilizations (n=7) G2: Supervised exercise (n=7) G1 and G2: hot packs, AROM, stretching, strengthening, soft tissue mobilizations,	G1: 45-60 minutes, 3 sessions per week G2: 60-75 minutes, 3 sessions per week	3 weeks	Pain (VAS) ROM (goniometer) Assessments: baseline, 3 weeks.	G1 x G2: positive effect	-	G1 x G2: non-effect

		patient education						
Cook et al, 2014	N=74 (37M and 31W) Age: > 18 (mean 52.6) Symptoms duration: mean 3 months.	G1: Shoulder treatment + neck mobilization G2: shoulder treatment. Groups 1 and 2: shoulder treatment – stretching, strengthening, and restoration of normative movement	Determined by the therapist or patient	Average of 56 +/- 55 days.	Pain (VAS) Function (DASH) Assessments: baseline, 2 days, and at the discharge.	G1 x G2: non-effect	G1 x G2: non-effect	-
Dickens et al, 2005.	N=85 (48M and 37W) Age: 27-68 Symptoms duration: NR	G1: supervised exercise (rotator cuff, scapular muscles) + joint mobilization (shoulder girdle, thoracic and cervical spine) + postural advice + home exercises G2: no treatment (wait and see)	1 or 2 supervised sessions per week; twice a day at home	6 months	Pain and function (CMS) Assessments: baseline, 6 months.	G1 x G2: positive effect	G1 x G2: positive effect	-
Dogan et al, 2010	N=52 (19M and 33W) Age: mean 53.6 Symptoms duration: mean 13.5 months.	G1: laser (Ga-As-Al, 850nm wavelength, 15-20J, 5-6 points) + cold pack + exercise G2: placebo laser + cold pack + exercise. G1 and G2: exercise – ROM, stretching, strengthening	5 sessions per week: Cold pack: 10 minutes Laser: 5-6 minutes Exercise: once a day	3 weeks	Pain (VAS) Function (SPADI) ROM (goniometer) Assessments: baseline and after treatment	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: non-effect
Eslamian et al, 2012.	N=50 (24M and 26W) Age: NR Symptoms duration: NR	G1: laser therapy (Ga-As-Al, 476 wavelengthening, 5J, up to 10 points) G2: placebo laser G1 and G2: hot pack + Ultrasound (1MHz, 1.5-2W/$cm^{2,}$) + TENS (100Hz, 10-30mA intensity, 50us pulse) + exercise (ROM, stretching, strengthening	3 sessions per week: Hot pack: 20 minutes Ultrasound: 5 minutes TENS: 20 minutes Laser: 5 minutes Exercise: once a day	3 weeks	Pain (VAS) Function (SDQ) ROM (goniometer) Assessments: baseline and 3 weeks.	G1 x G2: positive effect	G1 x G2: positive effect	G1 x G2: non-effect
Eyigor et al, 2010	N=40 (11M and 29W) Age: 18-80 Symptoms duration: >3 months (mean 8.8 months)	G1: corticosteroid injection (acromioclavicular joint) + exercise G2: TENS (100Hz, 15mA intensity, 150 us) + exercise G1 and G2: Exercise – pendulum, AROM, and strengthening	Injection: once TENS: 5 sessions per week Exercise: 5 sessions per week	3 weeks	Pain (VAS) ROM (goniometer) Function (SDQ) Assessments: baseline, 1, 4 and 12 weeks	G1 x G2: positive effect	G1 x G2: positive effect	G1 x G2: non-effect

Galace de Freitas et al, 2013 and 2014.	N=56 (20M and 36W) Age: 35-67 Symptoms duration: >3 months (mean 21.6 months)	G1: PEMF (50Hz, 20mT field strength) + exercise G2: placebo PEMF + exercise G1 and G2: exercise – pendulum, AROM, and strengthening for rotator cuff and scapular muscles	PEMF: 30 minutes, 3 sessions per week Exercise: 4 sessions per week	PEMF: 3 weeks Exercises: 6 weeks	Pain (VAS) Function (CMS) Assessments: baseline, 3 and 9 weeks, and 3 months	G1 x G2: non-effect	G1 x G2: non-effect	-
Giombini et al, 2006.	N=37 (29M and 8W) Age: 19-43 Symptoms duration: 3-6 months	G1: hyperthermia (434MHz, 50-70W power) G2: Ultrasound (1MHz, 2 W/cm^2) G3: exercise – pendulum and stretching	3 sessions per week: Hyperthermia: 30 minutes Ultrasound: 15 minutes Exercises: twice a day, 5 minutes	4 weeks	Pain (VAS) Function (CMS) Assessments: baseline, 4 weeks and 10 weeks	G1 x G2 x G3: positive effect for G1	G1 x G2 x G3: non-effect	-
Haahr and Andersen, 2005 and 2006.	N=90 (41M and 58W) Age: 18-55 Symptoms duration: 6-36 months	G1: hot pack, cold pack or soft tissue treatment + strengthening exercise (rotator cuff and scapular muscles) G2: subacromial arthroscopy (bursectomy and partial resection of acromion and coracoacromial ligament) + AROM and strengthening (rotator cuff)	60 minutes, 2-3 sessions per week	6 weeks	Pain (VAS) Function (CMS) ROM (CMS) Assessments: baseline, 3, 6 and 12 months, and 4-8 years.	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: non-effect
Haik et al, 2014.	N=52 (32M and 18W) Age: mean 31.7 Symptoms duration: 45.8 months	G1: thoracic spine manipulation G2: sham thoracic spine manipulation	1 session	-	Pain (NPRS) Assessments: baseline and immediately after.	G1 x G2: non-effect		
Heredia-Rizo et al, 2013.	N=22 (13M and 9W) Age: 43-79 Symptoms duration: NR	G1: electrotherapy + joint mobilization (shoulder girdle, cervical and thoracic spine) G2: electrotherapy + exercise (pendulum, AROM, proprioceptive exercise) Groups 1 and 2: electrotherapy - infrared + TENS (80Hz, 150ms) + ultrasound (1.5W/cm^2, 3 MHz, pulsating mode)	Infrared: 15 minutes TENS: 30 minutes Ultrasound: 5 minutes Joint mobilization: 40 minutes	3 weeks	Function (DASH) ROM (goniometer) Assessments: baseline and 3 weeks.	G1 x G2: non-effect	-	G1 x G2: non-effect

Johansson et al, 2005.	N=85 (26M and 59W) Age: 30-65 Symptoms duration: >2 months	G1: acupuncture (5 points, needle nº 8, 30mm diameter) + home exercise. G2: ultrasound (1MHz, 1W/cm^2) + home exercise. G1 and G2: home exercise – AROM and rotator cuff strengthening	Acupuncture: 30 minutes, 2 sessions per week Ultrasound: 10 minutes, 2 sessions per week Home exercises: 3 to 5 sessions per week	5 weeks	Pain and function (CMS) Assessments: baseline, 5 weeks, 3, 6 and 12 months.	-	G1 x G2: positive effect	-
Johansson et al, 2011	N=123 (38M and 53W) Age: 30-65 Symptoms duration: >2 months	G1: acupuncture (5 points, needle nº 8, 30mm diameter) + home exercise (AROM, rotator cuff strengthening) G2: corticosteroid injection	Acupuncture: 2 sessions per week Injection: 1 or 2 sessions	5 weeks	Pain and function (AL score) Assessments: baseline, 6 weeks, 3, 6 and 12 months	-	G1 xG2: non-effect	-
Kachingwe et al, 2008.	N=36 (17M and 16W) Age: 18-74 Symptoms duration: mean 36 months	G1: supervised exercise + glenohumeral joint mobilization G2: supervised exercise + glenohumeral MWM G3: supervised exercise G4: patient education + home exercise without any input from the physiotherapy G1, G2 and G3: supervised exercise – posterior shoulder stretching, postural correction, rotator cuff strengthening and scapular stabilization	Joint mobilization: 3 sets of 30 seconds MWM: 3 sets of 10 repetitions Exercise: 1 session per week with supervision, daily at home	6 weeks	Pain (VAS) Function (SPADI) ROM (goniometer) Assessments: baseline and 6 weeks	G1 x G2 x G3 x G4: non-effect (greater percentage of reduction in G1 and G2)	G1 x G2 x G3 x G4: non-effect (greater percentage of reduction in G1 and G2)	G1 x G2 x G3 x G4: non-effect (greater percentage of reduction in G1 and G2)
Kaya et al, 2011	N=60 Age: 18-70 Symptoms duration: mean 6.7 months	G1: kinesio taping (supraspinatus, deltoids, teres minor) + usual physiotherapy G2: usual physiotherapy G1 and G2: usual physiotherapy - hot pack + ultrasound (1MHz, 1 W/cm^2) + TENS + home exercise (isometric exercise, ROM,	Daily: Hot pack: 20 minutes Ultrasound: 5 minutes TENS: 20 minutes	2 weeks	Pain (VAS) Function (DASH) Assessments: baseline, 1 and 2 weeks	G1 x G2: positive effect at 1 week; non-effect at 2 weeks	G1 x G2: non-effect	-

		stretching, strengthening for rotator cuff and scapular muscles)	Exercise: twice a day					
Kleinhenz et al, 1999	N=52 (31M and 21W) Age: 18-50 Symptoms duration: 1-156 months	G1: acupuncture G2: placebo-needling	12 points, 20 minutes, 2 session per week	4 weeks	Pain and function (CMS) Assessments: baseline, 4 weeks and 4 months	-	G1 x G2: positive effect	-
Kromer et al, 2013 and 2014.	N=90 (44M and 46W) Age: 18-75 Symptoms duration: >1 month (mean 8.5 months)	G1: Individually adapted exercise + individualized manual therapy (shoulder girdle, cervical and upper thoracic spine) G2: Individually adapted exercise only G1 and G2: Individually adapted exercise: rotator cuff, shoulder and scapular muscles, scapular training, neck, thoracic spine and core program	2 sessions per week G1: 20-30 minutes G2: 15-20 minutes	5 weeks Home exercise: additional 7 weeks	Pain (VNRS) Function (SPADI) Assessments: baseline, 5 and 12 weeks.	G1 x G2: non-effect	G1 x G2: non-effect	-
Littlewood et al, 2014	N=24 (12M and 12W) Age: 44-79 Symptoms duration: 3-168 months	G1: self-managed exercises (resisted exercise focusing skill acquisition and self-monitoring) G2: usual physiotherapy (patient education, stretching, manual therapy, acupuncture, electrotherapy, corticosteroid injection)	G1: 10-15 repetitions, twice a day G2: NR	G1: 3.9 sessions G2: 7.6 sessions	Pain and function (SPADI) Assessments: baseline and 3 months	-	G1 x G2: non-effect	-
Lombardi et al, 2008.	N=60 Age: mean 55.5 Symptoms duration: >2 months (mean 13.8 months)	G1: Supervised exercise (rotator cuff, flexors, and extensors) G2: control group (wait and see)	2 sessions per week	8 weeks	Pain (VAS) Function (DASH) ROM (goniometer) Assessments: baseline and 8 weeks	G1 x G2: positive effect	G1 x G2: positive effect	G1 x G2: positive effect
Ludewig and Borstad, 2003.	N=67 (67M) Age: mean 49 Symptoms duration: NR	G1: home exercise (stretching, strengthening for serratus anterior and rotator cuff) G2: control group (no treatment).	Every-day	10 weeks	Pain and function (SRQ and SPADI) Assessments: baseline and 10 weeks	G1 x G2: positive effect	G1 x G2: positive effect	-

Maenhout et al, 2013.	N=61 (25M and 36W) Age: > 18 (mean 39.8) Symptoms duration: > 3 months	G1: rotator cuff strengthening + heavy load eccentric exercise for shoulder abductors G2: traditional exercise. Groups 1 and 2: traditional exercise for rotator cuff	Every day	12 weeks	Pain and function (SPADI) Assessments: baseline, 6 and 12 weeks.	-	G1 x G2: non-effect	-
Martins and Marziale, 2012.	N=16 (2M and 14W) Age: >30 Symptoms duration: >6 months	G1: Supervised exercise + proprioception G2: supervised exercise G1 and G2: supervised exercise – pendulum, stretching, strengthening for rotator cuff and scapular muscles	2 sessions per week	6 weeks	Pain (VAS) Function (WORC) Assessments: baseline and 6 weeks.	G1 x G2: non-effect	G1 x G2: positive effect	-
Marzetti et al, 2014.	N=48 (21M and 27W) Age: >18 Symptoms duration: >3 months (mean 62.1 months)	G1: Neurocognitive Therapeutic Exercise (motor control and dynamic humeral centering) G2: supervised exercise - pendulum, stretching, and strengthening for rotator cuff and scapular muscles	3 sessions per week	5 weeks	Pain (VAS) Function (DASH) Assessments: baseline, 5, 12 and 24 weeks.	G1 x G2: positive effect	G1 x G2: positive effect	-
Melchiorre et al, 2013.	N=60 (36M and 24W) Age: 34-86 Symptoms duration: > 6 months	G1: Muscle shortening manoeuvre (n=20) G2: scapular mobilization (n=20) G3: simple traction of the shoulder (n=20)	G1: 10 minutes, once G2: 20 minutes, 10 sessions G3: 10 minutes, once	G2: 4 weeks	Pain (VAS) ROM (goniometer) Assessments: baseline, after treatment and 30 days after the treatment	There was no comparison between groups		
Miller and Osmotherly, 2009	N=22 (10M and 12W) Age: 18-70 Symptoms duration: 1.5-16 months	G1: kinesiotaping (scapular winging correction) + usual physiotherapy G2: usual physiotherapy G1 and G2: usual physiotherapy – mobilization, stretching, strengthening for rotator cuff and scapular muscles	3 sessions per week	2 weeks	Pain (VAS) Function (SPADI) ROM (inclinometer) Assessments: baseline, 2 and 6 weeks.	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: non-effect

Nakra et al, 2013.	N=30 (15M and 15W) Age: 43-85 Symptoms duration: NR	G1: usual physiotherapy + proprioceptive neuromuscular facilitation G2: usual physiotherapy G1 and G2: usual physiotherapy – cold pack, stretching, strengthening (rotator cuff, deltoids and scapular muscles)	3 sessions per week	3 weeks	Function (SPADI) Assessments: baseline, 3rd, 6th and 9th sessions.	-	G1 x G2: positive effect	-
Nykanen et al, 1995.	N=73 (62M and 11W) Age: 37-81 Symptoms duration: > 2 months	G1: ultrasound (1mHz, 1 W/cm^2, 2ms pulse duration) + neck and shoulder massage and stretching G2: placebo ultrasound + neck and shoulder massage and stretching	10 minutes, 10-12 sessions	3-4 weeks	Pain (pain-index) Function (ADL-index) ROM (goniometer) Assessments: baseline, 4 weeks, 4 and 12 months.	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: non-effect
Osteras et al, 2010	N=61 Age: 18-60 Symptoms duration: >3 months (mean 40.2 months)	G1: high dosage exercise for AROM and strengthening G2: low dosage exercise for AROM and strengthening	3 sessions per week	12 weeks	Pain (VAS) Function (SRQ) Assessments: baseline, 3, 6, 9, and 12 months.	G1 x G2: positive effect	G1 x G2: positive effect	-
Otadi et al, 2012.	N=44 (44W) Age: NR Symptoms duration: NR	G1: laser (Ga-As-Al, 830nm wavelength, 30nW power, 1J/cm^2). + ultrasound + exercise G2: ultrasound + exercise G1 and G2: ultrasound (1MHz, 1W/cm^2, pulsed) + supervised and home exercises (pendulum, AROM, strengthening for rotator cuff and scapular muscles)	3 sessions per week	3 weeks	Pain (VAS) Function (CMS) Assessments: baseline, 3 and 12 weeks	G1 x G2: positive effect	G1 x G2: positive effect	-
Rhon et al, 2014.	N=104 (67M and 37W) Age: 18-65 Symptoms duration:	G1: joint and soft tissue mobilizations, stretching, exercises to shoulder girdle and thoracic spine G2: Corticosteroid injection	G1: 30 minutes, 2 sessions per week G2: 1-3 injections	G1: 3 weeks	Pain (NPRS) Function (SPADI) Assessments: baseline, 1, 3 and 6 months, and 1 year.	G1 x G2: non-effect	G1 x G2: non-effect	-

	mean 5.7 months							
Santamato et al, 2005.	N=70 (28M and 42W) Age: 35-69 Symptoms duration: 1-42 months	G1: high-intensity laser therapy (Ga-Al, 1,064nm wavelength, 1kW power) G2: ultrasound (1MHz, 2 W/cm^2, continuous)	5 sessions per week	2 weeks	Pain (VAS) Function (CMS) ROM (goniometer) Assessments: baseline and 2 weeks	G1 x G2: positive effect	G1 x G2: positive effect	-
Saunders, 1995.	N=24 (12M and 12W) Age: 37-64 Symptoms duration: 1-10 months	G1: laser (820nm wavelength, 4.4J, 2 points) G2: placebo laser	180 seconds, 3 sessions per week	3 weeks	Pain (Huskisson's horizontal pain analogue scale) Assessments: baseline and 3 weeks.	G1 x G2: positive effect	-	-
Shakeri et al, 2013.	N=30 (15M and 15W) Age: mean 46.5 Symptoms duration: >0.2 months (mean 8.4 months)	G1: kinesio taping (50 a 75% stretched) G2: placebo taping.	2 sessions	1 week	Pain (VAS) ROM Assessments: baseline, 4th day and 1 week	G1 x G2: non-effect	-	G1 x G2: non-effect
Simsek et al, 2013.	N=38 (13M and 25W) Age: 18-69 Symptoms duration: >1 month	G1: kinesio taping (50 a 75% stretched) + supervised and home exercise G2: placebo taping + supervised and home exercise G1 and G2: supervised and home exercise – strengthening for rotator cuff and scapular muscles	Tapping: 3-days application, 4 sessions Exercises: once a day, 7 sessions per week	2 weeks	Pain (VAS) Function (DASH) ROM (goniometer) Assessments: baseline, 5th and 12th day	G1 x G2: positive effect	G1 x G2: positive effect	G1 x G2: positive effect
Struyf et al, 2012.	N=22 (10M and 12W) Age: >18 (mean 45.8 months) Symptoms duration: >1 month	G1: scapular training (scapular mobilization, stretching, scapular motor control training) G2: Strengthening (flexors, extensors, and rotator cuff) + glenoumeral joint and soft tissue mobilizations + ultrasound (100Hz,	30 minutes, 2-3 sessions per week	3 weeks	Pain (VAS and Neer score) Function (SDQ) Assessments: baseline, 3 weeks, and 3 months.	G1 x G2: positive effect	G1 x G2: positive effect at 3 weeks; non-effect at 3 months	-

		2W/cm^2, 5 minutes)						
Szczurko et al, 2009	N=89 (35M and 50W) Age: 18-65 Symptoms duration: >1.5 months	G1: dietary counseling + acupuncture + natural tablets G2: supervised exercise (AROM, strengthening and joint therapy)	30 minutes, 1 session per week	12 weeks	Pain (VAS) Function (SPADI) Assessments: baseline, 4, 8 and 12 weeks	G1 x G2: positive effect	G1 x G2: positive effect	-
Thelen et al, 2008.	N=42 (36M and 6W) Age: 18-24 Symptoms duration: 0.2-1 month	G1: kinesio taping (50 a 75% stretched) G2: sham taping	2 sessions	6 days	Pain (VAS) Function (SPADI) ROM (goniometer) Assessments: baseline, immediately after, 3rd and 6th days	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: positive effect at 3rd day; non-effect at 6th day
Vecchio et al, 1993	N=35 (10M and 25W) Age: 17-77 Symptoms duration: 4-48 months	G1: laser (839nm wavelength, 3J) + home exercise G2: placebo laser + home exercise G1 and G2: home exercise - pendulum and AROM	10 minutes, 2 sessions per week	8 weeks	Pain (VAS) Function (functional limitation of daily activities scale) ROM (goniometer) Assessments: baseline, 2, 4 and 8 weeks	G1 x G2: non-effect	G1 x G2: non-effect	-
Winters et al, 1997	N=172 (87M and 111W) Age: NR Symptoms duration: >1 month	G1: mobilization and manipulation (shoulder girdle, cervical and thoracic spine, ribs) (n=28) G2: usual physiotherapy (massage, physical applications and exercise) (n=29) G3: corticosteroid injection	G1: 1 session per week G2: 2 sessions per week G3: 1-3 injections	G1 and G2: 6 weeks G3: 2 weeks	Pain (VAS) Assessments: baseline, 2, 6, and 11 weeks	G1 x G2 x G3: non-effect	-	-
Yavuz et al, 2014.	N=31 (19M and 14W) Age: 30-65 Symptoms duration:	G1: laser (Ga-As-Al, 850nm wavelength, 100mV, 3 J/cm^2) + hot pack + exercise G2: ultrasound (1MHz, + hot pack + exercise + ultrasound 2 W/cm^2, continuous)	Hot pack: 10 minutes Laser: 5 minutes Ultrasound: 5 minutes Exercise: once a day	2 weeks.	Pain (VAS) Function (SPADI) Assessments: baseline, 1 and 3	G1 x G2: non-effect	G1 x G2: non-effect	-

	>1 month (mean 6.5 months) G1 and G2: exercise – AROM, stretching and strengthening				months			
Yeldan et al, 2009.	N=67 (13M and 47W) Age: NR Symptoms duration: NR	G1: Laser (Ga-As, 904 wavelength, 5-7000Hz, 3J, 3 points) + supervised exercise + cold pack G2: placebo laser G1 and G2: supervised exercise - AROM, stretching and strengthening (flexors, extensors, rotator cuff)	Daily: Laser: 8 minutes Exercise: 15-30 minutes Cold pack: 1 minute	3 weeks	Pain (VAS) Function (DASH, CMS and SDQ) ROM (goniometer) Assessments: baseline and 3 weeks	G1 x G2: non-effect	G1 x G2: non-effect	G1 x G2: non-effect