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Effectiveness of specific scapular therapeutic exercises in patients with shoulder pain: a systematic review with meta-analysis

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A R T I C L E I N F O

Keywords:
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Pain
Function
Kinematics
Muscular activity
Rehabilitation

Level of evidence: Level II; Systematic Review/Meta-Analysis

Background: Therapeutic exercise has been considered a useful tool to rehabilitate shoulder pain, namely through its influence on scapular dynamics. Accordingly, the effectiveness of scapular therapeutic exercise needs to be explored. The present study aims to evaluate the effectiveness of scapular therapeutic exercises in shoulder pain and to identify the most effective exercise type (focal or multi-joint) and ways of delivering them (as dose and progression).
Methods: Search was conducted at EMBASE, Cochrane Library, MEDLINE via PubMed, Web of Science, PEDro (Physiotherapy Evidence Database), and trial registration databases. The meta-analysis considered randomized controlled/crossover trials that compared the effect of scapular exercises against other types of intervention in the shoulder pain, shoulder function, scapular motion, and/or muscular activity. The risk of bias was assessed through the PEDro scale.
Results: From the 8318 records identified, 8 (high to low risk of bias– scoring from 4 to 8 on the PEDro scale) were included. The overall data, before sensitivity analysis, indicated that the scapular therapeutic exercises are: a) more effective than comparators in improving shoulder function (standardized mean difference [SMD] = 0.52 [95% CI: 0.05, 0.99], $P = .03$, $I^2 = 76\%$); and b) as effective as comparators in reducing shoulder pain (SMD = 0.32 [95% CI: −0.09, 0.73], $P = .13$, $I^2 = 70\%$). Subgroup analysis revealed that scapular exercises are more effective in improving shoulder function when the program duration is equal to or higher than 6 weeks (SMD = 0.43 [95% CI: 0.09, 0.76] $P = .01$, $I^2 = 21\%$) and/or when the maximum number of exercise repetitions per session is lower than 30 (SMD = 0.79 [95% CI: 0.15, 1.42], $P = .01$, $I^2 = 77\%$). Only 1 study considered scapular motion as an outcome measure, revealing therapeutic exercise effectiveness to improve scapular range of motion.
Conclusions: Intervention programs involving scapular therapeutic exercises are effective in improving shoulder function, presenting benefits when performed for 6 or more weeks and/or when used up to a maximum of 30 repetitions per exercise, per session.

Shoulder pain is the third most common musculoskeletal disorder in primary healthcare,[21,84] with a 66.7% lifetime prevalence.[42] Independent from its structural origin,[34,45,68,74] shoulder pain has been associated with adaptations in local and surrounding structures, namely in scapular positioning and motion[8,34,40,45,46,50,52,68,74,78,84] and muscular function.[15,27,29,41,45,50,60] This association is supported

Institutional review board approval was not required for this systematic review/meta-analysis.

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by the determinant role of the scapulothoracic joint in shoulder function.[15,27,32,45,50,68] According to our knowledge, at least ten systematic reviews have thoroughly explored the effectiveness of therapeutic exercise interventions in patients with shoulder pain.[1,7,9,17,23,50,63,70,72,18,83]

From the mentioned reviews, only two (both published in 2020) have explored the effectiveness of specific scapular therapeutic exercises.[50,63] Although these two reviews had reported exercise effectiveness in pain intensity, disability,[50,63] and glenohumeral positioning sense,[63] inconclusive findings have been reported for scapular position and motion.[50] Moreover, some limitations have been highlighted as: 1) the isolated effects of scapular exercises could not always be assessed once other intervention techniques were combined with the scapular exercises in the experimental group and not in the control group; 2) while one of the reviews have only included patients with subacromial impingement syndrome,[63] the other focused its interest in subjects with scapular dyskinesis, including and comparing both symptomatic or asymptomatic participants; and 3) both reviews only performed a qualitative analysis of the included studies. In turn, the other previous systematic reviews about global shoulder therapeutic exercises[1,7,17,23,70,72,18,83] have demonstrated the following: 1) effectiveness,[23,18] contradictory[1,7,72] and inconclusive[70] findings for shoulder pain; 2) effectiveness,[17,23,72] contradictory[1,7,18] and inconclusive findings[70] for shoulder function; 3) effectiveness for shoulder range of motion[23,72] and shoulder muscle strength[1,9]; 4) contradicting findings for quality of life,[7] muscle length and posture outcomes[18]; and 5) inconclusive results about scapular position/motion.[9] These conflicting results may be attributed to several factors, such as the inclusion of small sample-sized studies, high levels of observed heterogeneity, or the use of different comparators (between-groups vs. within-group comparisons). Given the mentioned facts, continued research about the effectiveness of therapeutic exercise in shoulder pain conditions, particularly the ones focusing on the scapular muscles, to reduce pain and/or restore shoulder function becomes relevant. The persistency[20,51] of these conditions and their impact on daily life activities,[38,42,53,56] psychological aspects,[44] quality of life, and socioeconomic component[20,44,73] highlight this need. Additionally, it is noteworthy that only two of the mentioned systematic reviews[50,63] consider 3D scapular kinematics as an outcome measure and none considered the scapular muscular activity. The inclusion of such parameters seems relevant, considering: a) the importance of scapular positioning and muscular activity for scapulohumeral rhythm[35,41,57,78]; and b) the adaptations found in these parameters during shoulder pain.[11,12,14,34,41,46,47,60,61,78,79] Moreover, to our knowledge, the previous systematic reviews did not consider in their analysis the type[7,9,50,64] and the ways of delivering[1,7,9,50,63,64] exercise which can contribute to the conflicting findings previously demonstrated.

The present review aims to evaluate the effectiveness of scapular therapeutic exercises, performed alone or in addition to a baseline intervention, in shoulder pain conditions, considering outcomes such as shoulder pain, shoulder function, and scapular motor control-related variables. Secondarily, it aims to identify the exercise characteristics that could be associated with the effectiveness of scapular therapeutic exercises in patients with shoulder pain. Specifically, the exercise type (focal or multijoint exercises) and ways of delivering (total duration of intervention, weekly frequency, maximum number of exercise repetitions, and progression) were considered for analysis.

Materials and methods

This systematic review follows the guidelines of PRISMA[54,55] and was registered at PROSPERO (CRD42020215869).

Search strategy

A systematic search was performed in April 2023 in five main databases (EMBASE; Cochrane Library; MEDLINE via PubMed; Web of Science; PEDro), in the database of the World Health Organization (WHO ICTRP), and in the US National Institutes of Health (ClinicalTrials.gov). The search was limited to studies published after the year 2000. These criteria were used because most studies about scapula's role in the rehabilitation of shoulder pain[82] and about scapular clinical tests (positioning and influence in shoulder pain[29,31,62,77]) had already been published during the XXI century. The search strategy developed and adapted to each specific thesaurus (Supplementary Appendix A) was based on the most common terms related to “shoulder pain” and “therapeutic exercise”.

Selection of studies

After removing the duplicates using Endnote software, all titles and abstracts were independently assessed by two reviewers. For this process, a pre-established template considering the eligibility criteria of the present review with meta-analysis was used and compared after each reviewer completed all decisions. Then, a full-text review of the potentially eligible studies was made independently by the two reviewers. At the end of this independent process, decisions were compared, and the disagreements were resolved by discussion or by a third independent reviewer.

Randomized controlled trials, controlled clinical trials, and interventional prepost-design studies, published in English, French, Portuguese, or Spanish, were eligible if, in accordance with the PICO (patient, intervention, comparison, outcome) strategy, they considered: a) adults (≥18 year old) with shoulder pain, nonspecific or associated with a diagnosis (as rotator cuff tendinopathy or tear, impingement syndrome, bursitis, instability, adhesive capsulitis, and periarthritis)[59,18]; b) any type of therapeutic exercises that has focused exclusively on the scapular musculature and that was performed in any type of context, with or without supervision and with or without resistance [body weight (self or manual resistance) and/or elastic or weights resistance]; c) comparators as no intervention or other types of control; d) outcomes as pain and/or function (through standardised and validated self-reported questionnaire), scapular motion (through 3D-kinematic), and/or muscular activity level or ratios (through electromyography). Studies in which it was not possible to isolate the effects of scapular exercises in the experimental group were excluded. Other exclusion criteria were considered, namely, studies including animal or cadaveric samples; shoulder pain resulting from infection, neoplasm, surgery, fractures, or dislocation and/or associated with spinal pathology or dysfunction; and pain originated in other related areas as cervical or thoracic regions.

Data extraction

A standardised data extraction form was developed, piloted, and used to collect data for analysis. Two reviewers extracted the following data: study identification, participants' data, intervention description, outcomes of interest, assessment moments, and main results. Disagreements were resolved by mutual agreement or with a third reviewer. The template for intervention description and replication checklist was used to ensure the extraction of all the relevant details regarding included interventions (considering parameters such as exercise name; exercise aim/rationale; exercise provider; number of sessions, duration, intensity, and dose; tailoring or personalization or adaptation of the intervention to each participant; and modifications over the study). In the case of important missing data, the study's authors were contacted by mail.

Quality assessment

The study's methodological quality was assessed independently through the PEDro scale. The PEDro scale is a valid measure of the methodological quality of clinical trials,[48] assessing study internal and external validity as well as the suitability of statistical information to allow the interpretation of the results. Scores from 0–5 were considered high risk of bias (ROB)[10,66] and from 6–10, which satisfied at least 50% of the criteria,[6] as low ROB.[10,66]

Statistical analysis

A meta-analysis, using Review Manager 5.4 (The Cochrane Collaboration, London, United Kingdom), was performed to compare scapular therapeutic exercises against other types of control and to compare studies interventions according to scapular therapeutic exercise type and ways of delivering. Groups' mean, standard deviation, and final sample size were extracted from each study. The difference between groups was calculated considering the mean change in each group from the end of the intervention to the baseline, while the standard deviation (SD) change in each group was calculated using the formulae proposed by Higgins et al.[24] When these values were not provided, the SD was calculated by multiplying the standard error (SE) by the square root of the sample size.[24] Also, when one outcome was measured on a reverse scale (in which lower scores representing the worst condition), the mean values were multiplied by -1.[24] To guarantee that all data from the scales assessing shoulder function used the same score range (0-100), the following formulas were applied:

$$y = (\bar{x} - \min)/(\max - \min), \text{ and } SDy = SD/(\max - \min)$$

where y and SDy are the rescaled mean and SD, respectively, the $\bar{x}$ is the observed mean and max and min are the maximum and minimum numerical possible scores.

The following criteria were established for meta-analysis: 1) in the case of cross-over designs,[49] only data obtained before the cross-over was considered; 2) considering shoulder pain assessment, only intensity reported in general (not associated with a specific condition) or during activity was considered. The effect size (<0.4, small effect; 0.4-0.7, moderate effect; >0.7, large effect, following Cohen's[16,24,67]) was calculated by using the between-group standardized mean difference (SMD) once several studies assessed the same outcomes with different scales,[24] with 95% confidence intervals. Calculations used the random-effects inverse variance model since some between-studies variation was expected.

The χ^2 test and the I^2 were used to assess statistical heterogeneity of effect estimates among studies (if <25%, low heterogeneity; if 25%-50% modest heterogeneity; and if >50%, large heterogeneity[58]). Subgroup analysis was performed when large heterogeneity was presented based on the comparator [other exercises (considering other muscles), or based on the selected exercise type and ways of delivering (total duration of intervention, weekly frequency, maximum number of exercise repetitions, and progression).

To evaluate the robustness of the findings and verify the influence of studies with high ROB, a leave-one-out method of sensitivity analysis was conducted.

Results

Study selection and characteristics

A total of 8314 records and 4 registers were found through the initial search. After removing 3024 duplicates and screening the title and abstract, 152 were analyzed by the full text. As depicted in Figure 1, eight studies met the eligibility criteria (7 randomized controlled trials[3-5,13,25,69,80] and 1 randomized crossover trial[49]). Excluded studies ($n = 144$) are listed in Supplementary Appendix B. The concordance between the two independent reviewers was substantial ($\kappa = 0.65$).

The included studies[3-5,13,25,49,69,80] considered a total of 346 participants of both genders, with shoulder pain conditions. Participants' mean age ranged from 33.4 ± 9.3[80] to 58.6 ± 11.3.[4] Intervention groups performed scapular therapeutic exercises, 2[3]-7[49,80] times a week, through a total duration varied from a single-hour session[4] to a 12-week program,[80] (Table I).

Quality of studies

The ROB ranged from 4 to 8 (Table II). Specifically, six studies presented high ROB,[4,5,13,49,69,80] and two presented low ROB.[3,25] All studies specified the eligibility criteria, were randomized, and reported both between-group differences along with point estimates and variability. Regarding the internal validity, different sources of potential bias were found, with lack of blinding of therapists[4,5,13,25,49,69,80] and assessors[3-5,13,25,49,69,80] as the most frequent ones.

Primary outcomes

Effectiveness of scapular therapeutic exercises on shoulder pain

Postintervention short-term assessment. The shoulder pain intensity was assessed by all the included studies, which compared the addition of scapular therapeutic exercises with other exercises,[3,5,25,49,69,80] with a multimodal intervention[13] or with electrophysical modalities.[4] The results of these two last studies,[4,13] were analyzed narratively. According to the overall results, the addition of scapular therapeutic exercises intervention was not significantly more effective than those interventions applied to the control groups, but the heterogeneity was found to be large (SMD = 0.32 [95% CI: −0.09, 0.73], $P = .13$, $I^2 = 70\%$, 323 patients total), Figure 2.

Subgroup analysis comparing scapular exercises with other exercise interventions was successfully conducted, and the combined data does not provide significant evidence for differences between both interventions regarding shoulder pain relief (SMD = 0.28 [95% CI: −0.20, 0.76], $P = .25$, $I^2 = 73\%$, 259 patients total), Figure 3. The comparison of scapular exercise with electrophysical modalities[4] and multimodal intervention[13] were each assessed in 1 study which precluded meta-analysis interpretation. However, the first one[4] does not show significant differences between groups while the second[13] reported a statistically significant decrease in shoulder pain (assessed by the visual analog scales score) in the experimental group after 6 weeks of intervention (6 times/week in a total of 30 sessions).

Considering the mentioned heterogeneity between studies as well as the high ROB identified in some studies, a sensitivity analysis was made. Despite the exclusion of a study with high ROB[69] from the subgroup of "other exercises" comparator leads to a reduction in heterogeneity (to $I^2 = 24\%$ overall and 0% subgroup), the results from the pooled analysis have not been changed.

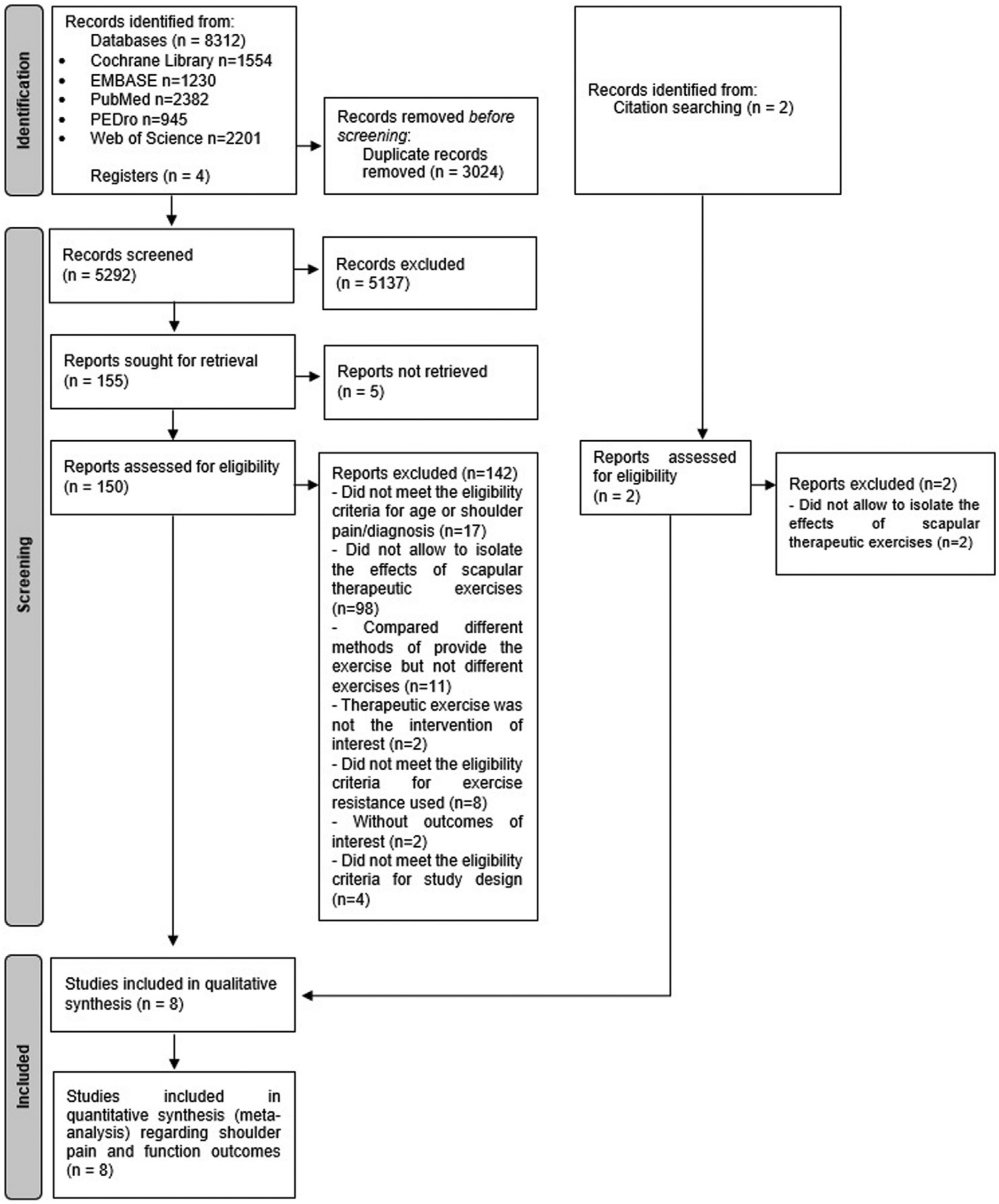

Figure 1 PRISMA 2020 flow diagram for literature search result.

Follow-up assessment. Two studies assessed the effects of scapular therapeutic exercise, namely against other exercises intervention[25] or a multimodal intervention,[13] several weeks after the completion of scapular therapeutic exercises' protocol. Both reported no differences between groups at a follow-up of 12[13] or 16[25] weeks after randomization.

Effectiveness of scapular therapeutic exercises on shoulder function

Postintervention short-term assessment. As in shoulder pain outcome, the effect of scapular therapeutic exercises on shoulder function was assessed against other exercises,[3,5,25,49,69,80] a multimodal intervention,[13] or electrophysical modalities.[4]

Considering the overall results, adding scapular therapeutic exercises to the experimental group intervention was significantly more effective than the control group interventions (SMD = 0.52 [95%CI: 0.05, 0.99], $P = .03$, $I^2 = 76\%$, 323 patients total) (Fig. 4). Despite the large heterogeneity, the results were associated with a moderate effect size.

In turn, the subgroups analysis shows that the addition of scapular exercise was as effective as the other exercises intervention (SMD = 0.54 [95%CI: −0.06, 1.14], $P = .08$, $I^2 = 82\%$, 259 patients total) Figure 5. Furthermore, the studies comparing scapular exercises with multimodal intervention[13] or electrophysical modalities[4] also reported no statistical significant differences between groups, regarding shoulder function.

Considering the sensitivity analysis, although the maintenance of high heterogeneity, the exclusion of Celik[13] or Turgut et al[80] studies (high ROB), leads to different overall results ($P \geq .05$, indicating no significant differences between groups).

Table I
Overview of the included studies with respect to participants data, intervention, outcomes of interest and results.

Author, year, study design, country	Participants: Diagnosis (location); n total* (by groups), age (mean ± SD) and gender	Comparison	Intervention: Exercises (position); sets/ repetitions; progression; frequency (total length) – total number of sessions	Outcomes and assessment moments	Results
Akguller et al,[3] 2022, RCT, Turkey	Unilateral subacromial impingement syndrome for at least 3 mo (D or nD sides) N = 36 (16 EG, 16 CG); y: 47.56 ± 10.79 (EG), 47.37 ± 12.63 (CG); gender: 27F, 5M	Standard exercise program: rotator cuff strengthening exercises (3 sets of 10 reps - with elastic band), scapula setting exercise, and posture exercises	Same as comparison, with additionally scapular PNF techniques: **I.** "Anterior elevation"-"posterior depression" and "anterior depression"-"posterior elevation" patterns of the scapula (side-lying - with rhythmic initiation and repeated stretch technique) 5-10 reps (20" rest between reps) Progressed by reps and added techniques 2 × week (6 weeks) – 12 sessions, applied by a physiotherapist	Pain (VAS – at rest, at night and during activity); Shoulder function (DASH) Pre & Post	Significant differences between groups on shoulder function, at 6 weeks (*P* = .026) No significant differences between groups on pain, at 6 weeks (*P* > .05)
Balci et al,[4] 2016, RCT, Turkey	Unilateral adhesive capsulitis of stage II and pain for at least 3 mo (D or nD sides) N = 53 (18 EG, 17 CG); y: 56.7 ± 7.7 (EG), 58.6 ± 11.3 (CG); gender: 25F, 10M	Hot pack (20 min), conventional TENS (20 min, at a frequency of 100 Hz, a pulse duration of 60 μsn), US (3 min, at 1 MHz US head and 1.5 W/cm^2 dosage)	EG - same as control group, with additionally scapular PNF: **I.** "anterior elevation" –"posterior depression" and "posterior elevation" –"anterior depression" scapula patterns (side-lying - rhythmic initiation and repeated contractions) 20 reps (20" rest between reps) - 1 h session, applied by a trained therapist	Pain (VAS – during activity); Function (SST) Pre & Post	No significant differences between groups on pain (*P* > .05) and shoulder function (*P* > .05)
Başkurt et al,[5] 2011, RCT, Turkey	Unilateral shoulder impingement of Neer stages I and II (ND) N = 40 (20 EG, 20 CG); y: 51.5 ± 8.4 (EG), 51.3 ± 11.6 (CG); gender: 27F, 13M	Standardized flexibility (internal rotation and capsule stretching, forward flexion and abduction range of motion), strengthening (infraspinatus, deltoid, subscapularis and supraspinatus) and Codman exercises	Same as comparison, but with additionally scapular stabilization: **I.** Scapular clock exercise, **II.** Standing weight shift, **III.** Wall push up, **IV**. Wall slide exercises (upright) + **V**. scapular PNF exercises (side-lying) + **VI.** Double arm balancing and scapular depression (ND) 3 sets until 10 reps Progressed by reps and stronger elastic band (according to pain and fatigue) 3 × week (6 weeks) – 18 sessions, under physiotherapist supervision	Pain (VAS – at rest and during activity); Physical symptoms and Function (WORC) Pre & Post	No significant differences between groups on pain (*P* > .05) and shoulder function (*P* > .05), at 6 weeks
Çelik, 2010,[13] RCT, Turkey	Primary or secondary adhesive capsulitis (D or nD sides) N = 29 (15 EG, 14 CG); y: ≈ 49.6 (EG), ≈ 54.8 (CG); gender: 22F, 7M	Passive or active assistive manual stretching, PNF and phase I gliding exercises, Pulley exercises, TENS (20', 5 weeks), Cold pack (15'), nonsteroidal anti-	Same as comparison, with additionally scapulothoracic strengthening and mobilization exercises: **I.** Scapular retraction with exercise band, **II.** Extension with exercise	Pain (VAS - in general); Shoulder Function (modified Constant score) Pre & Post plus follow-up	Significant differences between groups on pain, at 6 weeks (*P* = .05) No significant differences between groups on pain, at 12 weeks (*P* > .05), and on

(*continued on next page*)

Table I (*continued*)

Author, year, study design, country	Participants: Diagnosis (location); n total[*] (by groups), age (mean ± SD) and gender	Comparison	Intervention: Exercises (position); sets/ repetitions; progression; frequency (total length) – total number of sessions	Outcomes and assessment moments	Results
		inflammatory drugs (5 weeks), home exercises (self-stick, posterior and inferior capsule stretching, flexion, scapular elevation, internal and external rotation - 20 reps, 2 × day, additionally)	band, **III.** Scapular adduction and elevation, **IV.** Wall and table push-up, **V.** Scapular stabilization with ball and scapular abduction (upright) + **VI**. Floor push-up, **VII.** Extension and scapular adduction (prone) + **VIII.** Push-up (sitting) 2 sets of 15 reps Progressed by increased frequency and intensity (according to pain and muscle strength) 5 × week (6 weeks) – 30 sessions, led by physiotherapists at minimum pain level Note: Treatment planned accordingly the clinical phase of each patient		shoulder function, at 6 and 12 weeks ($P < .05$)
Hotta et al,[25] 2020, RCT, Brazil	Subacromial pain syndrome, with history of shoulder pain for more than one week (D or nD sides) N = 60 (26 EG, 27 CG); y: 51 ± 8 (EG), 47 ± 10 (CG); gender: 42F, 18M	Periscapular strength: side-lying external rotation with abduction at 0°; prone horizontal abduction with external rotation from 90° to 135°; scapular punch; knee push; full can; diagonal D1	Same as comparison, with additionally scapular stabilization exercise: **I.** Towel slide, **II.** Scapular clock, **III.** Protraction/retraction in front of a mirror (upright) + **IV.** Scapular PNF (side-lying) + **V.** Modified inferior glide, **VI.** Scapular orientation exercise (sitting) 3 sets until 15 reps (1' rest between reps) Progressed (weekly based) by reps (10, 12 or 15) and load from 60% of 1-RM to 80% of the new 1-RM. Knee push-up progress to push-up plus (feet flat on the floor and to feet on the supports) 50', 3 × week (8 weeks) – 24 sessions, conducted by physical therapists	Pain (NRS – during activity); Shoulder Functional Performance (SPADI) Pre & Post plus follow-up	No significant differences between groups on pain and shoulder function, at 8 and 16 weeks ($P > .05$)
Mulligan et al,[49] 2016, Randomized Crossover trial, USA	Subacromial impingement syndrome (Neer stage I/ II), with a primary pain complaint in shoulder and/or upper arm (D or nD sides) N = 50 (21 EG, 22 CG); y: 50.8 ± 11.1 (EG), 49.4 ± 10.6 (CG); gender: 26F, 14M	Standardized physical therapy [education, postural advice, manual therapy of upper quarter, flexibility, range of motion exercises and, possibly, corticosteroid injection] and additional rotator cuff exercises [upright: external rotation (arm in rest position); 0-30° short arc military press (progressed to long arc scapular plane elevation); internal	Standardized physical therapy (5 sessions) as comparison, but with additionally scapular stabilization exercise: **I.** Shoulder protraction punch (supine) + **II.** Wide grip rows at shoulder level, **III.** Shoulder extension/ scapular depression and retraction from an overhead position, **IV.** Shoulder retraction with both shoulders in external rotation with the elbows at the side	Pain (NRS – during activity); Physical symptoms and Function (ASES) Pre & Post	No significant differences between groups on pain and shoulder function, at 4 weeks ($P > .5$)

Table I (*continued*)

Author, year, study design, country	Participants: Diagnosis (location); n total* (by groups), age (mean ± SD) and gender	Comparison	Intervention: Exercises (position); sets/ repetitions; progression; frequency (total length) – total number of sessions	Outcomes and assessment moments	Results
		rotation; horizontal abduction].	(upright) 3 sets of 20 repetitions Progressed by increasing theraband resistance (if exercise performed correctly and easy) 3 × day, 7 × week (4 weeks, home) – 28 sessions. Only standardized physical therapy was provided by a physical therapist		
Shah et al,[69] 2014, RCT, India	Shoulder impingement syndrome (ND) N = 60 (30 EG, 30 CG); y: 46.9 (EG), 47.0 (CG); gender: 29F, 31M	Strength [shoulder flexors, extensors, external rotators, adductors and horizontal adductors (side-lying)]; stretch (pectoralis major, levator scapulae and cross-chest); wand and pendulum exercises 3 sets of 8 reps	Same as comparison, with additionally scapular stability exercise: **I.** Scapular clock, **II.** Towel sliding, **III.** Lawnmower, **IV.** Wall push up (upright) + **V.** Horizontal abduction, **VI.** Press up plus exercise (prone) + **VII.** Scapular PNF with alternative weight shifting (side-lying) 3 sets of 8 reps ND 1 × day, 6 × week (4 weeks) – 24 sessions, treated at physiotherapy	Pain (VAS - in general); Shoulder Functional Performance (SPADI) Pre & Post	Significant differences between groups on pain and shoulder function, at 6 weeks ($P < .05$)
Turgut et al,[80] 2017, RCT, Turkey	Subacromial impingement, with unilateral shoulder pain lasting more than 6 weeks, with type 1 or type 2 scapular dyskinesis (D or nD sides) N = 36 (15 EG, 15 CG); y: 33.4 ± 9.3 (EG), 39.5 ± 8.2(CG); gender: 14F, 16M	Rotator cuff strengthening resisted shoulder internal or external rotation at 0° abduction, full can and self-stretching of posterior shoulder and pectoralis minor (upright); Stretching: levator scapulae and latissimus dorsi stretching (3 sets of 5 reps, sitting)	Same as comparison, with additionally scapular stabilization exercises: **I.** Wall slides with squat, **II.** Wall push-ups plus ipsilateral leg extension, **III.** Lawnmower with diagonal squat, **IV.** Resisted scapular retraction with contralateral 1-leg squat, **V.** Robbery with squat (upright) 3 sets until 20 reps (strengthening) Strength exercises progressed by reps (10, 15 or 20 given movement quality, presence of pain, and fatigue) and then by heavier resistance ban [3]d 7 × week (12 weeks), weekly monitored exercise program – 84 sessions	Pain (VAS – at rest, at night and during activity); Shoulder Functional Performance (SPADI); 3D scapular and humeral kinematic (electromagnetic tracking system) Pre & Post	Significant differences between groups on external rotation, posterior tilt, and upward rotation, at 12 weeks ($P < .05$) No significant differences between groups on pain and shoulder function, at 12 weeks ($P > .05$)

ASES, American Shoulder and Elbow Surgeons shoulder score; *CG*, control group; *D*, dominant side; *DASH*, Disabilities of the Arm, Shoulder, and Hand Questionnaire; *EG*, experimental group; *F*, female; *M*, male; *nDS*, non-dominant side; *ND*, not defined; *NRS*, numeric rating scale; *Pre&post*, pre and postintervention; *PNF*, proprioceptive neuromuscular facilitation; *RCT*, randomized controlled trial; *reps*, repetitions; *SPADI*, shoulder pain and disability index; *SST*, simple shoulder test; *US*, ultrasound therapy; *VAS*, visual analog scale; *WORC*, western Ontario rotator cuff index; *Y*, years old; *D1*, diagonal pattern of flexion, horizontal adduction and external rotation; *TENS*, transcutaneous electrical nerve stimulation.

*Total sample size (n), not considering dropouts.

Table II
PEDro scores resulting from the quality assessment of the included studies.

Study	Eligibility criteria	Random allocation	Concealed allocation	Groups similar at baseline	Blind subject	Blind therapist	Blind assessor	Follow-up (<15% dropouts)	Intention-to-treat analysis	Between-group comparison	Point measures and variability	PEDro score	Risk of bias
Akguller et al[3]	1	1	1	1	1	1	0	1	0	1	1	8	L
Balci et al[4]	1	1	0	0	0	0	0	1	0	1	1	4	H
Başkurt et al[5]	1	1	0	1	0	0	0	1	0	1	1	5	H
Çelik[13]	1	1	0	1	0	0	0	1	0	1	1	5	H
Hotta et al[25]	1	1	1	1	1	0	0	1	1	1	1	8	L
Mulligan et al[49]	1	1	0	1	0	0	0	0	1	1	1	5	H
Shah et al[69]	1	1	0	0	0	0	0	1	0	1	1	4	H
Turgut et al[80]	1	1	0	1	0	0	0	0	0	1	1	4	H

H, high; *L*, low; *PEDro*, Physiotherapy Evidence Database.

Follow-up assessment. The comparison of scapular therapeutic exercise with a multimodal intervention[13] or other exercises,[25] at a time point after the completion of intervention protocols revealed no differences between groups at 12[13] or 16[25] weeks after randomization.

Secondary outcomes

Effectiveness of scapular therapeutic exercises on scapular motion (3D kinematics), muscular activity level, and/or muscular ratios (electromyographic data)

Turgut et al,[80] a high ROB study, was the only one that assessed scapular 3D kinematics (at different humerothoracic elevation angles – 30°, 60°, 90°, and 120°). The study found significant differences between groups, indicating that the addition of multijoint scapular stabilization exercises (performed 7 times per week in a total of 84 sessions) was more effective than an intervention based on other exercises (stretching and rotator cuff strengthening) immediately after 12 weeks of intervention. Such results were expressed in the experimental group as a scapula more: a) externally rotated, an increase of 7.4-10.11°– considering all humerothoracic elevation angles; b) upwardly rotated, increased of 4.96° or 5.83° – considering humerothoracic 30° elevation and 60° lowering, respectively); and c) posteriorly tilted, an increase of 3.14-6.78° (at 12 weeks) – considering all humerothoracic elevation angles, except 120° elevation.

None of the 8 included studies[3-5,13,25,49,69,80] reported data about muscular activity level or muscular ratios.

Exercise type and ways of delivering

Effectiveness of scapular therapeutic exercises considering their type and ways of delivering

The subgroup analysis, regarding exercise type and ways of delivery, was performed to identify the parameters that could be associated with higher exercise effectiveness. So, we tried to add knowledge by comparing exercise type (focal scapular exercises – when the exercise only involved movement and/or activation of the scapular structures; against multijoint exercises – exercises direct to scapula that included trunk or lower limb movements[30,79] in addition to shoulder and scapular components) and ways of delivering, namely, considering exercise dose [total duration of the intervention (the duration of all the intervention protocol); weekly frequency; the maximum number of exercise repetitions (which includes the total number of repetitions done combining all the sets performed)] and progression (given the relevance of improving and/or modifying the exercises during the course of the intervention).

More specifically, statistical results pointed the addition of scapular therapeutic exercises, in comparison with control groups' interventions, as more effective to improvement shoulder function when the following conditions were observed: a) the total duration of the intervention was at least of 6 weeks (SMD = 0.43 [95% CI: 0.09, 0.76], $P = .01$, $I^2 = 21\%$, 185 patients total) – supported by a moderate effect size and a low heterogeneity, Figure 6; b) the maximum number of each exercise repetitions, per sessions, was not higher than 30 repetitions (SMD = 0.79 [95% CI: 0.15, 1.42], $P = .01$, $I^2 = 77\%$, 196 patients total) – supported by a large effect size although the large heterogeneity, Figure 7. No other results were found considering exercise type or other ways of delivering (Supplementary Appendix C, Figures C1-C3).

The sensitivity analysis, considering shoulder function outcome, revealed that when the study of Celik[13] was excluded from the subgroups' analysis regarding intervention total duration and maximum number of exercise repetition factors, the heterogeneity

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Akguller 2022	4.25	2.339	16	3.75	1.56	16	11.9%	0.25 [-0.45, 0.94]
Balci 2016	1.91	3.823	18	2.33	3.011	17	12.3%	-0.12 [-0.78, 0.54]
Baskurt 2011	5.05	1.994	20	5.05	2.036	20	12.8%	0.00 [-0.62, 0.62]
Celik 2010	7.2	2.871	15	4.5	1.972	14	10.9%	1.06 [0.27, 1.84]
Hotta 2020	2.6	4.2	27	1.9	3.805	27	13.8%	0.17 [-0.36, 0.71]
Mulligan 2016	1.2	3.705	21	2.05	2.475	22	13.0%	-0.27 [-0.87, 0.33]
Shah 2014	4.77	0.973	30	3.52	0.837	30	13.5%	1.36 [0.79, 1.92]
Turgut 2017	4.46	2.503	15	4.06	3.243	15	11.7%	0.13 [-0.58, 0.85]
Total (95% CI)			**162**			**161**	**100.0%**	**0.32 [-0.09, 0.73]**

Heterogeneity: Tau² = 0.25; Chi² = 23.35, df = 7 (P = 0.001); I² = 70%
Test for overall effect: Z = 1.51 (P = 0.13)

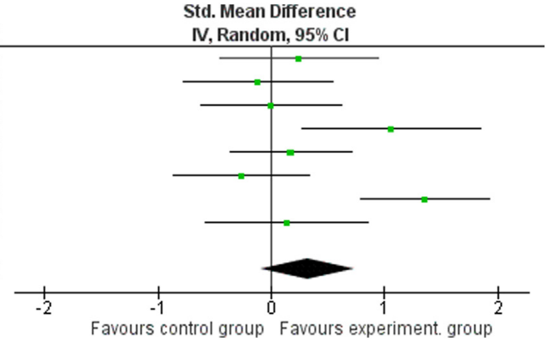

Figure 2 Forest plot of the meta-analysis overall comparison of scapular therapeutic exercise against other types of control, regarding shoulder pain outcome at postintervention short-term assessment. *SD*, standard deviation; *CI*, confidence interval.

level was maintained, but the results pointed to similarity between groups ($P > .05$).

Considering shoulder pain outcome, the results agreed with the overall data, not allowing any recommendations regarding other exercise parameters (Supplementary Appendix C, Figures C4-C8). Despite the mentioned, the sensitivity analysis revealed that the exclusion of the study from Mulligan et al[49] leads to significant results favoring the scapular therapeutic exercises group if the exercises were performed more than 3 times a week ($P = .02$), but maintaining the large heterogeneity ($I^2 = 72\%$). For the remaining factors, the results were consistent and robust enough to be maintained.

Discussion

Scapular adaptations, regardless its direction, the outcome[40,65,74,78] and the high scapular kinematics' variability,[63] have been reported in shoulder pain conditions.[4,41,74,78] Thus, several studies have included scapular exercises in their intervention protocols with the aim to restore scapular motor control and, consequently, to decrease shoulder symptomatology and improve shoulder function.[50,63] With this in mind, the present meta-analysis aimed to investigate the effectiveness of scapular therapeutic exercises against other types of interventions. In terms of shoulder function, the obtained results provide evidence on the effectiveness of adding scapular therapeutic exercises. Also, the present meta-analysis aimed to identify the most effective exercise type and ways of delivering it. When considering shoulder function, it appears that performing scapular therapeutic exercises for a total duration of 6 weeks or more, along with a maximum number of each exercise repetitions (across all sets performed) not exceeding 30, yields greater benefits.

Effectiveness of scapular therapeutic exercises on primary outcomes (pain and shoulder function)

Based on 8 studies, the addition of scapular therapeutic exercises to shoulder pain rehabilitation shows an overall superior effectiveness in improving shoulder function when compared to control interventions at short term. These results, despite being based on a set of heterogeneous studies (with high to low ROB and including different comparators), were represented by a moderate effect size. Thus, it seems that the addition of scapular therapeutic exercises is beneficial for the shoulder function of patients with shoulder pain. This could possibly be related to the influence of scapular therapeutic exercise in scapula's positioning, synchronous movement during shoulder motion[5,25] and adequate motor control,[49] and muscular length tension.[5] The mentioned results agree with the ones from two previous systematic reviews, considering exercise effectiveness in patients with subacromial impingement syndrome.[50,63] Despite all the mentioned facts, it should be noted that, according to the sensitivity analysis, 2 studies of high ROB[13,80] seems to be influencing the results to a large extent, requiring their interpretation with caution. Moreover, it should be highlighted that the results of the present study could be influenced by the performance of a higher exercise volume. This is because, with the exception of the Mulligan et al[49] study, scapular exercises were performed in addition to a common intervention performed by both groups.

In turn, considering shoulder pain outcome, the studies included in the present review indicate that adding scapular therapeutic exercises to shoulder pain rehabilitation is as effective as the control intervention, both at postintervention and at follow-up (12 or 16 weeks after randomization). Previous systematic reviews[1,23] and meta-analysis[70] reported similar findings when compared therapeutic exercise to several interventions. Despite the mentioned, it should be noted that the effectiveness of adding scapular therapeutic exercises to a multimodal intervention was verified, from a single study of high ROB,[13] given the higher reduction of shoulder pain. Such results seem relevant once the difference between groups considering the pre to post-intervention mean change (2.7) was higher than visual analog scales minimal clinically important differences (MCIDs = 1.4cm) to assess a shoulder pain condition.[76] Thus, the presented results highlight the need for more studies regarding the effectiveness of scapular therapeutic exercise, particularly about shoulder pain outcome, which is a usual alteration seen in subjects with shoulder pain.[8,36]

Secondary outcomes — scapular motor control-related variables

Despite their relevance, electromyographic data regarding scapular muscular activity level and/or ratio were not found and scapular motion assessment with 3D kinematics was only identified in one study.[80] Evidence from this single study,[80] indicates that the addition of daily multijoint scapular stabilization exercises to a rotator cuff strengthening protocol, increase scapular external rotation (at all humerothoracic elevation angles), posterior tilt (at all humerothoracic elevation angles, except at 120° elevation), and upward rotation (at humerothoracic 30° elevation and 60° lowering) of subjects with unilateral SIS, at postintervention (12 weeks). However, not all the differences found between groups were higher than the measurement error of electromagnetic track system.[22] More specifically, considering the standard measurement

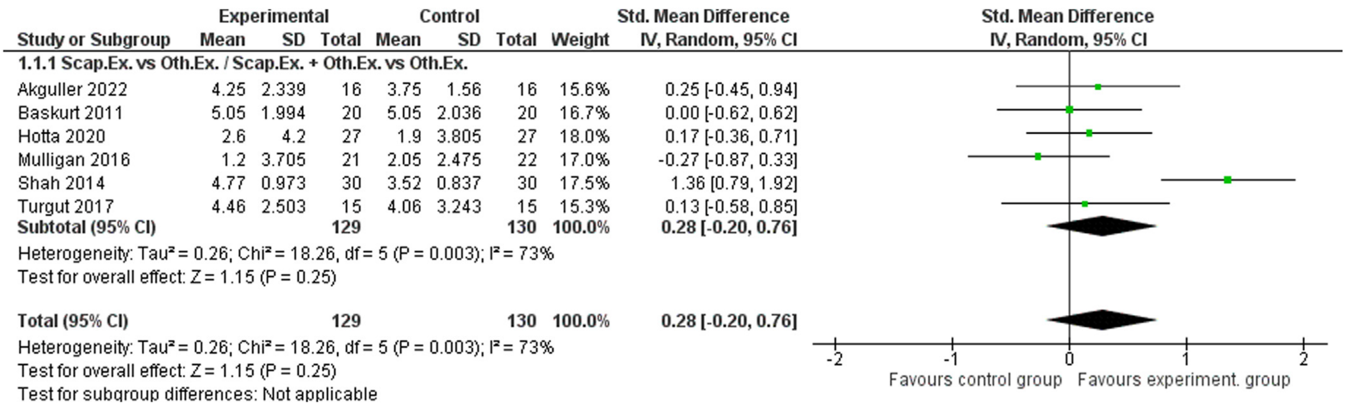

Figure 3 Forest plot of the meta-analysis considering subgroup comparison of scapular therapeutic exercise against other exercises, regarding shoulder pain outcome at post-intervention short-term assessment. *SD*, standard deviation; *CI*, confidence interval.

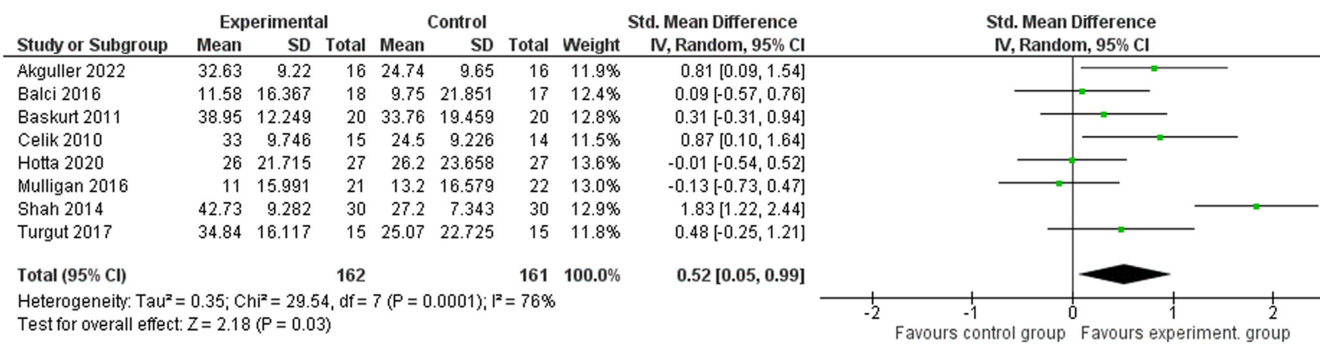

Figure 4 Forest plot of the meta-analysis overall comparison of scapular therapeutic exercise against other types of control, regarding shoulder function outcome at post-intervention short-term assessment. *SD*, standard deviation; *CI*, confidence interval.

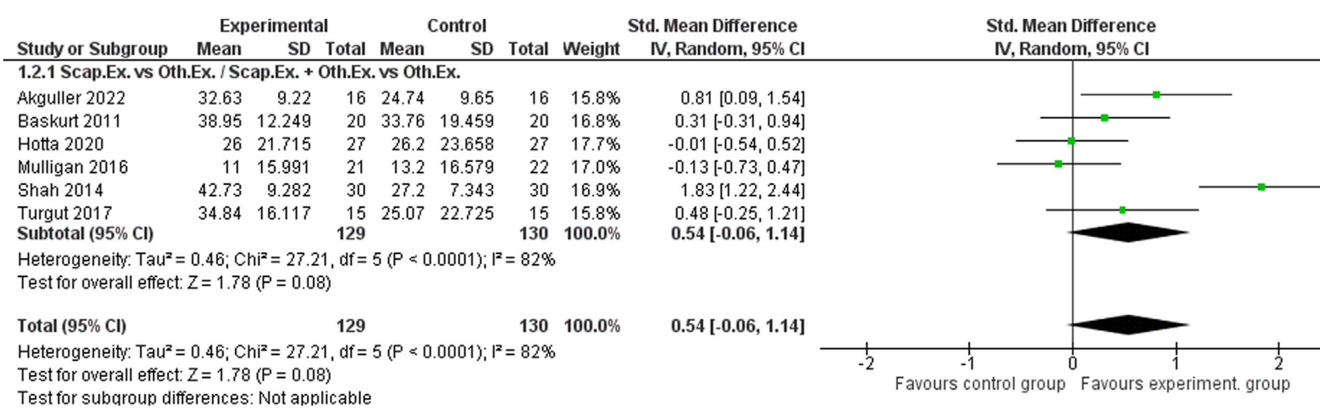

Figure 5 Forest plot of the meta-analysis considering subgroup comparison of scapular therapeutic exercise against other exercises, regarding shoulder function outcome at postintervention short-term assessment. *SD*, standard deviation; *CI*, confidence interval.

error, the clinically significant postintervention changes were found for: a) external rotation, at all humerothoracic levels assessed; b) upward rotation, at 30° elevation; and c) posterior tilt, at all humerothoracic elevation angles excepting 120° elevation and 90 lowering°.

The three previous systematic reviews that included studies assessing the effectiveness of therapeutic exercises for shoulder pain (not only focused on scapula) through 3D scapular kinematics,[50,63,75] only found the same single study considered in the present review[63] or reported no significant[75] or conflicting[50] findings.

The relevance of considering outcomes related to scapular structures and function, was already highlighted by previous systematic reviews[64] and meta-analysis,[65] which reported that more benefits could possibly be obtained if the participants' inclusion criteria also considered scapular presentation and its relation with pain. This seems relevant once previous studies reported a variable presence of scapular dyskinesis[50,80] and scapular kinematics' alterations[63] in patients with shoulder conditions, as well as a high variability considering the type of scapular kinematics' alteration.[63] In the case of the present review, only one study[80] defined scapular dyskinesis types

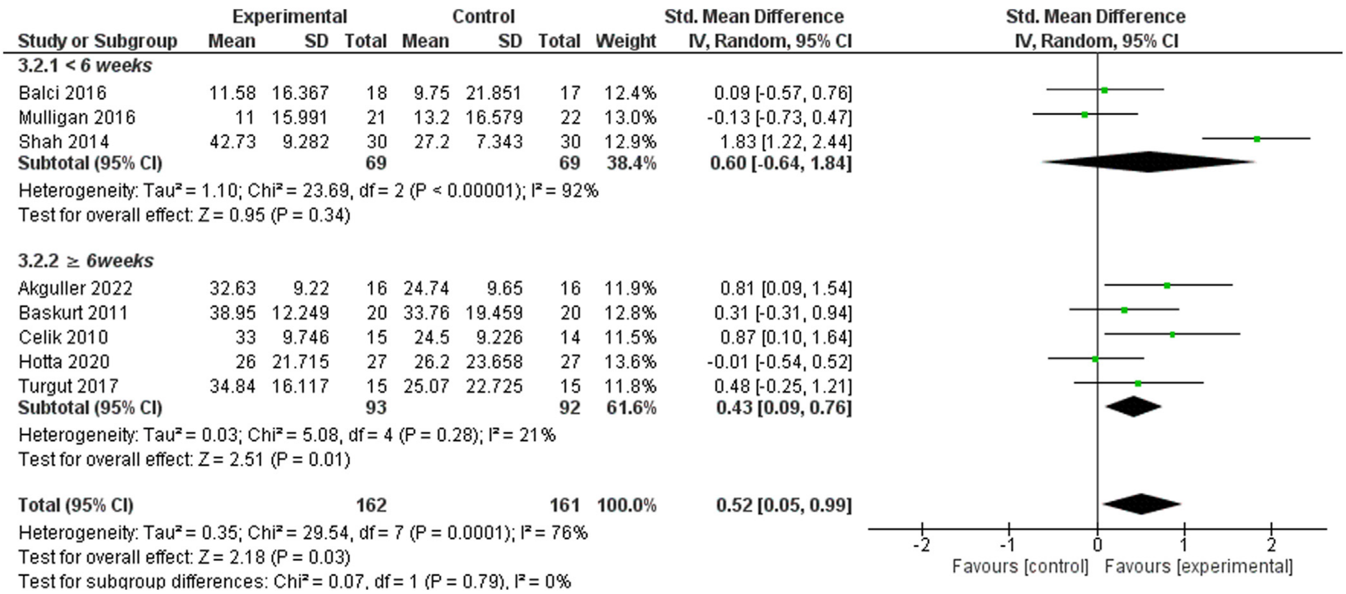

Figure 6 Forest plot of the meta-analysis considering subgroup comparison about intervention total duration, namely, comparing the execution of the scapular therapeutic exercises less than 6 weeks (<6 weeks) against 6 or more (≥6 weeks) weeks, regarding shoulder function outcome at postintervention short-term assessment. *SD*, standard deviation; *CI*, confidence interval.

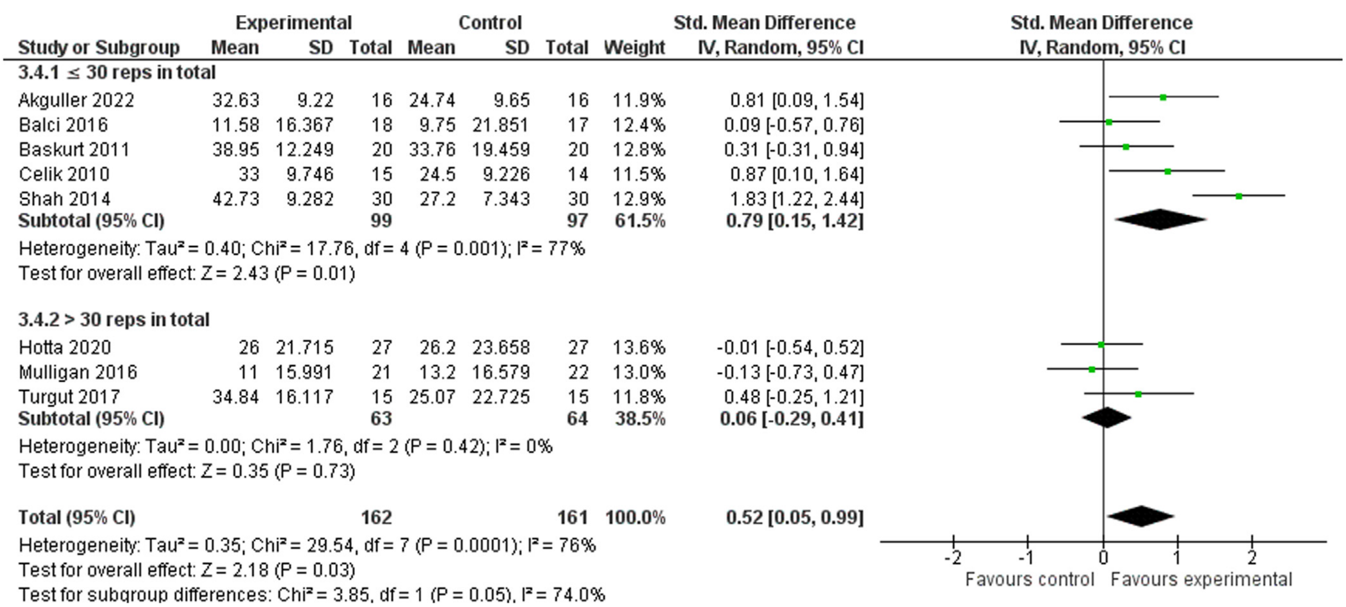

Figure 7 Forest plot of the meta-analysis considering subgroup comparison about maximum number of exercise repetitions (considering all sets performed), namely, comparing the execution of each scapular therapeutic exercise 30 or less repetitions in total (≤30 reps in total) against more than 30 repetitions in total (>30 reps in total), regarding shoulder function outcome at postintervention short-term assessment. *SD*, standard deviation; *CI*, confidence interval.

and scapular assistance or reposition tests as a criteria for eligibility.

Effectiveness of scapular therapeutic exercises considering their type and ways of delivering

The identification of the most effective exercise type and ways of delivering (dose and progression characteristics), adds knowledge about the total duration of the intervention and the maximum number of exercise repetitions, regarding shoulder function outcome. More specifically, while the use of scapular therapeutic exercises is as effective as the comparators for shoulder pain; when the protocol total duration is equal or higher than 6 weeks and/or the maximum number of each exercise repetitions are not higher than 30, the addition of scapular exercises seems to be beneficial.

The findings regarding the total duration of the intervention seem to be consistent with the knowledge regarding the adaptations induced by exercise. According to previous studies, fast changes exist considering the selection and establishment of a plan to execute a task[28] or considering the increase in muscle mass (by neuromuscular and connective tissue adaptations and/or oedema).[43] However, motor skill learning[28,81] and other changes in musculoskeletal tissues[43] require time and continued practice. More specifically, neural and muscular incremental gains associated with exercise are expected to occur until, approximately, the sixth and eighth weeks of intervention, respectively.[26] Then, these gains seem to slow down or reach a plateau, and hypertrophy becomes the major gain.[26] Based on the mentioned adaptations cause by exercise, it is thought that the performance of scapular therapeutic exercise during at least 6 weeks seems to benefit from most functional, neural, and muscular effects of exercises, increasing patients' shoulder function. Moreover, the performance of regular exercise (without knowledge of the exact duration needed) could help relieve chronic pain, namely by modulating some receptors involved in the hyperalgesia processes or using the endogenous inhibitory systems.[37] However, in the present study, the scapular exercise performance did not add benefits to the comparators in the reduction of shoulder pain. A previous narrative review regarding the effects of exercise in chronic pain[71] and a systematic review with meta-analysis regarding the effectiveness of specific exercises for patients with SIS,[70] also did not find the most appropriate dose or minimal dose needed for exercise to effective in chronic pain. In turn, consensus for physiotherapy regarding conditions of shoulder pain[33,39] recommends and expects improvements with at least 12 weeks of intervention.

Considering the total number of repetitions per exercise, in previous studies it was found recommendations based on the type of exercise purpose (as resistance, flexibility, and neuromotor control)[19] and not on patient pain condition or recommendations to adapt at the exercise dose according to each patient symptom response and requirements.[33,39] In our study, up to 30 repetitions seemed to be a suitable dose to obtain beneficial effects for shoulder function. Possibly, the lower benefits obtained with higher repetitions could be related to a reduction in participants' adherence to the intervention protocol, once adherence[39] has been highlighted as an important factor in enhancing exercise effects. Also, the lack of time was negatively related to adherence when considering the number of exercises performed.[33] However, adherence was not considered in the present review, and, therefore, future studies are required to confirm this hypothesis.

The mentioned results regarding shoulder function outcomes should be interpreted with caution once the exclusion of a study of high ROB[13] seems to influence them, and should take into account the influence of the higher exercise volume performed.

Beyond the mentioned suggestion, the fact that the present meta-analysis does not support other recommendations indicates the necessity of more studies and highlights the importance of adjusting the chosen parameters to exercise goals and to each patient.[33] Moreover, the lack of recommendations about the scapular exercise type (focal scapular exercises vs. multijoint), seems to agree with a previous systematic review[50] which found that independently from the type of exercise performed, significant effects could be achieved, namely, changes in scapular position and movement and/or pain and disability reduction.

Strengths and limitations

The present review did not limit the search to a specific shoulder pain condition, as in the previous ones.[7,9,23,63,64,65,70,83] Therefore, the conclusions are based on more studies. This decision was made since scapular changes have been reported in several shoulder conditions,[41,74,78] and because recommendations regarding physiotherapy intervention highlight the relevance of making choices considering physical assessment findings instead of structural pathologies.[33] Also, considering data from the studies included in the present review with meta-analysis, for both adhesive capsulitis and SIS conditions, similar scapular exercises were used for both conditions such as, for example, scapular proprioceptive neuromuscular facilitation, push-ups or scapular retraction.

In turn, some limitations were identified. First, the low quality found in some of the included studies may have limited the results of the present review with meta-analysis. Then, despite the intention of including several musculoskeletal shoulder pain conditions, the present review only found about 2 conditions,-with a higher number of reports about SIS. Also, it was not possible to differentiate the results considering the chronicity of the shoulder symptoms. This is because only 4 studies[3,4,25,80] defined a minimum time of pain duration as an inclusion criteria, and from them, 2 studies may have included patients with both acute or chronic conditions, once the least time of shoulder pain considered was of 1[25] or 6[80] weeks, without a limited maximum range. Considering the overall results found, the ones from the present review with meta-analysis were obtained by gathering studies that used different comparators. However, despite their differences, all control interventions were composed of procedures that a physiotherapist could use. As highlighted in the manuscript, with the exception of a crossover study, the results of the included studies may possibly be influenced by the differences in exercise volume between groups. Moreover, considering the conclusions about secondary outcomes, these were insufficient or not possible, given the lack of studies reporting them. Future studies should include these outcomes and/or other scapular-related clinical variables, namely observation or manual testing for scapular position like the ones applied in some of the included studies,[2,4,5,69] not only to monitor the participants but also as an inclusion criteria.

Conclusion

The present meta-analysis revealed that the addition of scapular therapeutic exercise interventions is more effective than comparators to improve shoulder function at postintervention. It also found the benefits of adding scapular exercises to the control interventions when the protocol has a total duration of 6 or more weeks and/or when a maximum of 30 repetitions of each exercise are done.

Considering shoulder pain, the use of scapular therapeutic exercises was as effective as the comparators.

Regarding secondary outcomes, no data were found considering muscular activity level or ratios. The only study assessing scapular 3D kinematics, revealed clinically significant results such as increased scapular external rotation, posterior tilt, and, at 30° elevation, upward rotation.

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Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.xrrt.2023.12.006.

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