

The Effectiveness of Physiotherapy Exercises in Subacromial Impingement Syndrome: A Systematic Review and Meta-Analysis

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Objective: To evaluate the effectiveness of exercise in the treatment of people with subacromial impingement syndrome (SAIS).

Methods: A systematic review and meta-analysis were conducted. Ten electronic databases were searched from the dates of their inception until August 2010. Included studies were randomized controlled trials investigating exercise in the management of SAIS. Outcomes were pain, strength, function, and quality of life. Data were summarized qualitatively using a best evidence synthesis. Treatment effect size and variance of individual studies were used to give an overall summary effect and data were converted to standardized mean difference with 95% confidence intervals (standardized mean difference (SMD) (CI)).

Results: Sixteen studies were included ($n = 1162$). There was strong evidence that exercise decreases pain and improves function at short-term follow-up. There was also moderate evidence that exercise results in short-term improvement in mental well-being and a long-term improvement in function for those with SAIS. The most common risk of bias across the studies was inadequately concealed treatment allocation. Six studies in the review were suitable for meta-analysis. Exercise had a small positive effect on strength of the rotator cuff in the short term (SMD -0.46 ($-0.76, 0.16$); $P = 0.003$) and a small positive effect on long-term function (SMD -0.31 ($-0.57, 0.04$); $P = 0.02$).

Conclusions: Physiotherapy exercises are effective in the management of SAIS. However, heterogeneity of the exercise interventions, coupled with poor reporting of exercise protocols, prevented conclusions being drawn about which specific components of the exercise protocols (ie, type, intensity, frequency and duration) are associated with best outcomes.

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Approximately 1% of adults seek medical attention for shoulder pain each year (1). As such, it is the third most common musculoskeletal reason for general practitioner consultations and estimates of its prevalence in the UK range from 7% to 26% (2-4). Because the shoulder stabilizes the upper limb in its activities, shoulder pain, and particularly subacromial impingement syndrome (SAIS) pain, produces significant impairments in function and quality of life (QoL) (5,6).

SAIS was first described as a reduction in the subacromial space leading to impingement of the rotator cuff

tendons against the coracoacromial arch (7). However, recent literature suggests that SAIS is, in fact, the final pathway for numerous pathologies of the shoulder and that it may be considered a descriptive term for a broad spectrum of symptoms rather than a single diagnosis (8-10).

Physiotherapy management of SAIS can include multiple interventions, eg, exercise, electrotherapy, manual joint mobilizations, acupuncture, advice, and education (1,3,11). The selection of treatment is often subjective and dependent on the skill and training of the therapist rather than on any rigorous evaluation of best evidence; however, one of the fundamentals of any physiotherapy program is exercise (9,11).

The goal of a shoulder exercise program is to relieve pain, increase strength, promote healing, reverse abnormal muscle imbalances, and restore pain-free joint range of motion (12). Stretching exercises are used to improve healing, in addition to reducing tendon stiffness, and enhancing its elasticity (13). Isometric and isotonic exercises are designed to strengthen the weakened rotator cuff musculature, thus restoring its ability to counteract the action of the deltoid muscle (14-16). Scapular stability exercises are included in the rehabilitation of people with SAIS because electromyographical studies have highlighted increased activity in the upper trapezius, with decreased activity in serratus anterior and the middle and lower fibers of trapezius, and asynchronous timing deficits, in subjects with SAIS (16-20).

Despite widespread anecdotal support for exercise in the management of SAIS and some published work on the cost-effectiveness of exercise compared to usual care on the outcomes for patients with chronic musculoskeletal shoulder pain (1,18,21,22), few trials have demonstrated the effectiveness of exercises that target the scapular muscles in the clinical setting.

Several reviews have been published relating to the nonsurgical management of SAIS and all have commented on the effectiveness of conservative modalities in general, but with limited attention to the effectiveness of exercise (11,21,23-29). Only 3 reviews have specifically addressed exercise (23,24,29) and, because they contain few randomized controlled trials (RCTs) and show significant weaknesses, clinicians remain unsure regarding the overall effectiveness of exercise, which muscles should be targeted, and the optimal strengthening approach. The lack of evidence and inconsistency of treatment approach are confirmed by the fact that the long-term outcomes of current conservative management of SAIS are poor (11,30,31).

Given the lack of clear guidelines for clinicians managing people with SAIS, the limitations of previous reviews, and the fact that further studies have been published, there is a need for a thorough, accurate, and transparent review to be conducted.

The aim of this review and meta-analysis was to determine the overall effectiveness of exercise in the manage-

ment of SAIS with respect to pain, function, and QoL. A subsidiary aim was to determine if there is evidence to guide therapists regarding the mode, frequency, duration, intensity, and progression of exercise interventions.

MATERIALS AND METHODS

This study was conducted adhering to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines and the Cochrane Handbook for Systematic Reviews of Interventions (32,33). The protocol for the review was registered with the Centre for Reviews and Dissemination (CRD32010000598).

Data Sources and Searches

One researcher (CH) conducted an electronic literature search of Allied and Complementary Medicine Database, Cochrane Central Register of Controlled Trials, Cumulative Index to Nursing and Allied Health, EMBASE, MEDLINE, Pedro, ProQuest Health and SPORTDiscus, Index to Theses, and openSIGLE databases. All databases were searched from their date of inception to August 2010. The search keywords were dependent on the database. A Cochrane search strategy was used, ie, all keywords were searched independently and then combined using relevant Boolean terms. Reference lists of all retrieved work were searched for further relevant material. Titles and abstracts of potentially eligible studies were screened by CH and ambiguous studies were discussed with two additional researchers (JM_cV, DK).

Study Selection

RCTs published in English, investigating any mode of exercise in the management of stage I or II SAIS or rotator cuff disease/tendinopathy, were reviewed. Trials were excluded if they had recruited patients with rotator cuff rupture, alternative diagnoses (eg, adhesive capsulitis, calcific tendonitis, posterior superior glenoid impingement, and shoulder instability), or postsurgical patients. Studies in which exercise was a minor component of a multimodal approach were also excluded, as the treatment effect of the exercise component could not be determined accurately. Outcomes of interest were pain, strength, patient-reported function (PRF), and QoL.

Data Extraction

One researcher (CH) extracted data on participant characteristics (mean age, duration of symptoms, and medication use), type of exercise intervention, the exercise protocol used, and results. Adverse events were recorded. For statistical analysis, data were extracted for outcomes at short-term (6 to 12 weeks) and long-term follow-up (>12 weeks). Where repeated observations fell within the one category of follow-up, the time point closest to that of the majority of studies was used to allow for accurate comparison of data (33).

Strong evidence	Provided by consistent ^a statistically significant findings in outcome measures in at least two high quality RCTs ^b
Moderate evidence	Provided by statistically significant findings in outcome measures in at least one high quality RCT ^b or Provided by consistent ^a , statistically significant findings in outcome measures in at least two medium quality RCTs ^b
Limited evidence	Provided by statistically significant findings in at least one medium quality RCT ^b or Provided by consistent ^a , statistically significant findings in outcome measures in at least two low quality RCTs ^b
No or insufficient evidence	If results of eligible studies do not meet the criteria for one of the levels of evidence listed above (e.g. no statistically significant findings) or In case of conflicting (statistically significant positive and statistically significant negative) results among RCTs or In case of no eligible studies

RCT, randomized controlled trial;

^a findings are considered consistent if they point in the same direction;

^b if the number of studies showing evidence is lower than 50% of the total number of studies found within the same category of methodological quality, we state no evidence.

Figure 1 Best evidence synthesis guidelines (28).

Risk of Bias Assessment

Each trial was assessed by two independent blinded reviewers. Consensus was reached by discussion, and the level of inter-rater agreement was recorded as a kappa coefficient. The van Tulder Criteria (34) and the Cochrane Risk of Bias tool were used to assess each trial (32,33). There were 2 levels of screening to identify studies for the quantitative meta-analysis. First, as recommended by the Cochrane Collaboration guidelines (34), studies were required to score greater than 6/12 on the van Tulder Scale. Second, studies that scored greater than 6, but were subject to substantial individual biases (ie, if they failed to satisfy at least two of the following: adequate randomization, concealed treatment allocation, or blinding of assessors), were included in quantitative pooling, but subjected to a sensitivity analysis for the meta-analysis.

Best Evidence Synthesis

The clinical relevance of the qualitative results was summarized using best-evidence synthesis criteria as presented by Dorrestijn et al. (28) (Fig. 1), which were modified to reflect items deemed applicable for trials involving exercise. Consequently, threats to bias were inadequate randomization, inadequately concealed treatment allocation, nonblinding of assessors, no intention-to-treat analysis, and no measurement of compliance with the exercise intervention. Studies were deemed to be of high quality if they scored at least 6/12 on the van Tulder Scale and evidenced 4 of the 5 criteria above, which must include concealed allocation. Medium-quality studies were classified as achieving at least 6/12 on the van Tulder Scale and satisfying at least any 3 of the 5 prerequisite criteria listed above. Studies were deemed to be of low quality if they scored less than 6/12 on the van Tulder scale or satisfied 2 or fewer of the 5 listed risks to bias. These 3 quality classifications were then combined with the criteria in Figure 1 to summarize the strength of evidence for each outcome.

Data Synthesis and Analysis

Analysis was conducted using Review Manager (RevMan) computer program (version 5.0) of the Cochrane Collaboration. Treatment effect size and variance of individual studies were used to give an overall summary effect and data were converted to standardized mean difference (SMD) with 95% confidence intervals (CIs). Because all studies involved in the quantitative analysis were descriptively comparable at baseline with respect to the outcomes of interest (their interventions, participants, outcome measures, and duration of follow-up), the mean and SD for each treatment group were used to calculate the SMD at each follow-up point. If these values were not available, authors were contacted. In 2 articles, SDs were calculated from the standard error of the mean or 95% CIs using appropriate statistical formulas (33,35-37). An effect size of 0.8 or more was regarded as a large effect size, between 0.5 and 0.8 as a medium effect size, and between 0.2 and 0.5 as a small effect size (38).

Testing to determine the degree of heterogeneity was conducted using the I^2 measure (33,39). Because the overall number of studies included in the meta-analysis was small and the true effect sizes varied between studies, such that they were deemed to be estimating a distribution of population effects rather than a single population effect, a random effects model was used to determine the overall summary effect (39). Individual treatment effect sizes with 95% CIs and the pooled summary effect were displayed on forest plots. Funnel plots to identify publication bias were not generated because of the small number of trials included for each analysis.

Subgroup Analysis

The protocol for this analysis described stratification of trials according to the type of exercise and location (ie, supervised or home setting) to attempt to determine the effects of different modes of exercise. However, on analysis of the studies, this was modified to reflect more clinically meaningful outcomes and the subgroup analysis therefore examined the effects of exercise on short- and long-term pain, strength, PRF, and QoL. If a trial reported more than 1 potential control arm, the group deemed to have had the least amount of therapist contact and treatment was selected as the control group. A hierarchy was used to determine this, which consisted of active control (no treatment or waiting list), placebo electrotherapy, injection/medication, surgery, and combined physiotherapy with either minimal exercise or not including exercise.

RESULTS

Study Selection

Figure 2 displays the EMBASE database search strategy and Figure 3 outlines the results of the search strategy. The database and hand search yielded 2227 titles, which

1. exercise/ or closed kinetic chain exercise/ or dynamic exercise/ or exercise intensity/ or isokinetic exercise/ or muscle exercise/ or plyometrics/ or resistance training/ or static exercise/
2. STRETCHING/ or MUSCLE STRETCHING/ or STRETCHING EXERCISE/
3. physiotherapy/ or home physiotherapy/
4. isometric exercise/
5. isotonic exercise/
6. rehabilitation/
7. stabili*.mp.
8. strength training.mp.
9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10. shoulder impingement syndrome/dm, pc, rh, si, th [Disease Management, Prevention, Rehabilitation, Side Effect, Therapy]
11. shoulder pain/dm, pc, rh, si, th [Disease Management, Prevention, Rehabilitation, Side Effect, Therapy]
12. shoulder injury/dm, pc, rh, si, th [Disease Management, Prevention, Rehabilitation, Side Effect, Therapy]
13. rotator cuff/
14. TENDINITIS/dm, pc, rh, si, th [Disease Management, Prevention, Rehabilitation, Side Effect, Therapy]
15. tendinopathy.mp.
16. 10 or 11 or 12 or 13 or 14 or 15
17. 9 and 16
18. randomized controlled trial/
19. 17 and 18

Figure 2 EMBASE search strategy.

were reduced to 42 full-text articles that were screened for eligibility. After screening, 16 studies (1997-2010), involving 1162 participants, were eligible for qualitative appraisal. Two trials were analyzed together because they involved the same group of participants followed up at 2.5 years post intervention (40,41). Reasons for exclusion are highlighted in the PRISMA flow chart (Fig. 3). Table 1 shows the characteristics of the included studies.

Description of Studies

All trials presented descriptive statistics relating to the age of subjects with an overall mean age of 49.2 years. One study (42) did not specify participants' gender. The remaining 15 contained 569 men and 602 women. Mean duration of symptoms was 21.9 months. Comparison groups included manual therapy (43-45), usual care (46), placebo electrotherapy (40,41,47), arthroscopic surgery (35,40,41), combined physiotherapy modalities (42,48), cortisone injections (48,49), naturopathic care (50), shoulder bracing (46), radial extracorporeal shock wave therapy (51), simple analgesia (49), active electrotherapeutic modalities (52), and no treatment (36,45,53). Five trials involved comparisons of multiple groups (40,41,45,46,48,49).

There was substantial heterogeneity in outcomes of interest and in how they were measured. Eighteen outcome measures were used to evaluate pain (at rest, at night, during the day, on movement/function), joint/region-specific function, strength, active range of movement, QoL, patient satisfaction, self-rated improvement, work status, and disability. Common outcomes investigated were pain (measured using a visual analogue scale, numer-

ical pain rating scale, or ordinal rating scale) in 14/16 (86%) trials, and function in 14/16 (86%) studies. Function was measured using 10 different tools consisting of joint-specific measures ($n = 14$ trials) or modified non-validated questionnaires ($n = 3$ trials). The most common follow-up times varied from 6 to 12 weeks (35, 36,40,42,43,45-48,50,51,53,54). The shortest length of follow-up was 1 to 3 days (44), whereas the longest was 2.5 years (41).

Description of Exercise Interventions

Various forms of exercise were employed in the studies. These consisted of stretching/flexibility exercises ($n = 7$) (36,42-47), elastic band strengthening exercises for the rotator cuff and scapular muscles ($n = 8$) (36,40,42,43,45-47,51), closed chain scapular stability exercises ($n = 3$) (45-47), isometric and isotonic strengthening exercises without weights, eg, push-ups, wall presses, de-loaded pulley exercises ($n = 6$) (40,43,47,51,53,54), and dumbbell weights to strengthen the rotator cuff ($n = 3$) (46,47,54). Range of movement (ROM) exercises were used in 7 trials and consisted of active ROM exercises ($n = 2$) (42,50), passive ROM exercises ($n = 2$) (50,52), and active-assisted exercises, eg, sling suspension or cane assisted, ($n = 5$) (33,46,51,52,54). Three trials did not describe the type of exercises employed adequately (35,48,49).

Description of Exercises

Table 2 displays a summary of the exercise parameters (exercise parameters are considered to be the duration, frequency, and intensity of the exercise intervention) in

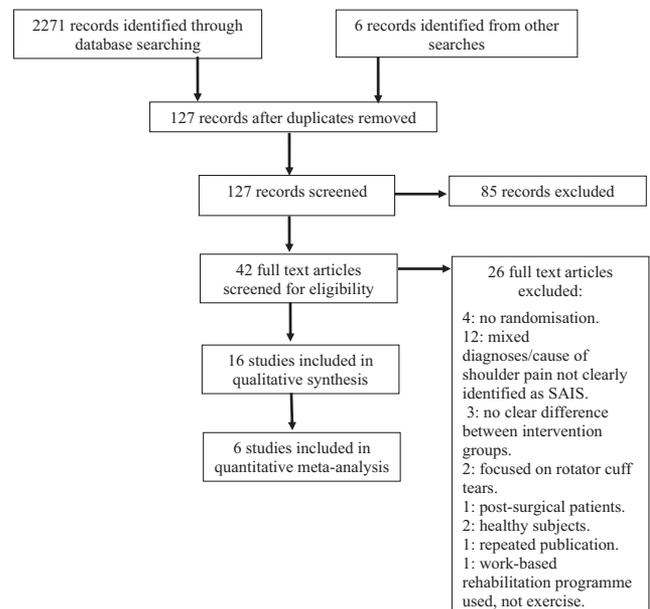


Figure 3 Prisma flow chart. Schematic breakdown of literature search results.

Study	Participants	Interventions	Outcome Measures	Results/Comments
Bang and Deyle 2000 (43)	<i>n</i> = 52 patients; 30 men, 22 women. 18 to 65 yr old. Chronicity not specified. Follow-up: 3 to 4 wk and 2 mo.	Frequency: 2 × 30 min exercise sessions per week for 3 wk. Exercise: Flexibility: anterior and posterior shoulder stretches. Strengthening: seated press up, elbow push-up, scapular exercises with elastic resistance. Manual therapy and exercise: supervised flexibility and strengthening exercises as exercise group <i>plus</i> manual physical therapy.	Pain: 10 cm VAS. Function: modified Oswestry low back disability questionnaire. Strength: IR, ER, and ABD using electronic dynamometer.	2 mo: Both groups reported significant decrease in pain. Manual therapy and exercise group also reported significant increase in strength and function when compared to the exercise only group.
Bennell et al. 2010 (47)	<i>n</i> = 120 patients; 74 men, 46 women. Aged ≥18 yr, shoulder pain onset >3 mo. Follow-up: 11 and 22 wk.	Frequency: patients in both groups received 10 exercise sessions over 10 wk. Exercise group performed home exercises for 12 wk. Control group: placebo-inactive ultrasound therapy. Exercise group: manual therapy and home exercises. Exercises: A progressive program of scapular stability retraining, rotator cuff and scapular muscle resisted exercises against elastic resistance or hand weights, and shoulder girdle and thoracic spine flexibility exercises. All resistance exercises progressed by increasing repetitions, resistance, and working rotator cuff muscles through range to 90° ABD.	Pain: NPRS and VAS Stiffness, weakness and interference with ADLs over previous week also measured using VAS. Function: SPADI. Patient satisfaction: global rating of change in pain, strength, and stiffness on 5-point rating scales. QoL: SF-36, QoL.	11 wk: both groups significantly improved with decreased pain and increased function. No significant between-group difference for pain on movement, or short-term function. There was a significant between-group difference for long-term function. 22 wk: significant decrease in pain in active group Adverse events: ● 31% reported adverse events in exercise group during the intervention. ● 8% reported adverse events in placebo group during intervention. ● 14% in exercise group reported adverse events during follow-up.

Table 1 Continued				
Study	Participants	Interventions	Outcome Measures	Results/Comments
Brox et al. 1993/ 99 (40)	<p><i>n</i> = 125 patients; 54 men, 71 women. Aged 18 to 66 yr old. Onset shoulder pain >3 mo. Analgesics and NSAIDs permitted, not cortisone injections, medication use not recorded. Follow-up: 3 and 6 mo.</p>	<p>Supervised exercise, as described by Bohmer et al. (1998) (see below) twice per wk, plus HEP for 3 to 6 mo. Sling suspension exercises, wall push-ups, pulley exercises and light elastic band (ER/IR) in standing for 1 h daily. 3 education sessions on anatomy of the shoulder, active coping, pain management, and ergonomics. Arthroscopic surgery followed by postoperative physiotherapy, exercises prescribed by surgeon, not documented in article.</p>	<p>Function: Neer shoulder score Pain: (NPRS): 1 to 9 Emotional distress: Hopkins symptom checklist.</p>	<p>6 mo: both exercise and surgery were significantly better than placebo in reducing pain and improving function; neither treatment was superior.</p>
Cloke et al. 2008 (49)	<p><i>n</i> = 112 patients; 48 men, 64 women. Age 22 to 88 yr old. Chronicity not stated. Follow-up: 18 wk and 1 yr.</p>	<p>Detuned laser (placebo) EMTP: 6 sessions over max 18 wk. EMTP not specified. No additional information given re: exercise parameters. Corticosteroid injection: max 3 at 6-wk intervals. Combination of the above. NSAIDs or simple analgesia.</p>	<p>Function: OSS. QoL: SF-36 Patient's perceived improvement: rated better, same, or worse and need for surgery at 1 yr.</p>	<p>No significant between-groups difference at intervention end or 1-year follow-up; however power calculations show 110 patients would be needed for each arm.</p>
Conroy and Hayes 1998 (44)	<p><i>n</i> = 14 patients; 8 men, 6 women. Age and chronicity not stated. Follow-up: 1-3 wk post last treatment (3 wk from baseline).</p>	<p>Frequency: 3 PT sessions per week × 3 wk. Manual therapy: Joint mobilizations plus comprehensive PT. Exercise (control): Exercises 45-60 min: AROM—pendulum exercises, cane-assisted stretching into flex and ER, towel-assisted IR, assisted horizontal ADD. Strengthening—chair press, isometric IR/ER, scapular strengthening exercises (not specified). Stretching—exercises (not specified). Hot packs, soft tissue mobilization, education.</p>	<p>Pain: 100 mm VAS. ROM: Flex, ABD, *Scaption, IR, ER using goniometer. Overhead function: graded by examiner on 3-point rating scale</p>	<p>Manual therapy group improved significantly compared to exercise group on 24-h pain and pain with subacromial compression testing. No significant between-group difference for other outcomes, although both groups improved.</p>

Table 1 Continued				
Study	Participants	Interventions	Outcome Measures	Results/Comments
Engelbrechtsen et al. 2009 (51)	<i>n</i> = 104 patients; 52 men, 52 women. Age 18-70 yr. Onset shoulder pain > 3 mo. Follow-up: 6, 12, 18 wk.	Exercise group: 2 × 45 min PT sessions weekly for 12 wk. Same intervention as Brox et al. (1993, 1999). 2 per wk, plus HEP for 3-6/12. Sling suspension exercises, wall push-ups, pulley exercises, and light elastic band (ER/IR) in standing for 1 h daily. ×3 education sessions on anatomy of the shoulder, active coping, pain management, and ergonomics. Radial extracorporeal shockwave therapy group: ×1/wk × 4-6 wk.	Pain and disability: SPADI. ROM: method not described. Pain: 9-point rating scale. Function: 7-point rating scale. Work status: self-reported questionnaire.	Statistically significant difference in favor of exercise group for SPADI scores at 6, 12, and 18 wk. Adverse events: 1 patient in exercise group reported including pain and stiffness consistent with adhesive capsulitis; 2 patients reported increased pain in radial extracorporeal shockwave therapy
Ginn and Cohen 2005 (48)	<i>n</i> = 138 patients; 82 men, 56 women. Aged 18 yr and over. Onset shoulder pain >1 mo. Follow-up: after 5 wk treatment.	Frequency: Group 1: 1 injection. Group 2: daily HEP and 1 session per week with PT. Group 3: daily HEP and 2 sessions per week with PT Group 1: Cortisone injection 40 mg methylprednisone acetate with lignocaine. Group 2: Specific exercises, not described. Pain-free exercises. Group 3: MPM IFT, US, hot and cold packs, passive joint mobilizations of A/C, S/C, and GH joints, AROM exercises: Flex, ABD, ext, HBB, horizontal flexion (did not have to be performed in a pain-free manner).	Pain: 100 mm VAS. Function: (nonalidated questionnaire) 4-point rating scale used to rate upper limb tasks.** Strength: ABD strength measured using dynamometer ROM: pain free flexion, ABD. (Taken from photographs in which bony landmarks where marked). Self- assessed improvement: Perceived change in symptoms.	All interventions were equally effective in short-term treatment of shoulder pain. No significant between-group differences were found.

Table 1 Continued				
Study	Participants	Interventions	Outcome Measures	Results/Comments
Haahr et al. 2005 (35)	<i>n</i> = 90 patients; 32 men, 58 women. Aged 18-55 yr. Chronicity between 6 mo and 3 yr. Follow-up: 3, 6, and 12 mo.	Physiotherapy (exercise) Frequency ×19 sessions × 60 min, over 12 wk (×3/wk in 1st 2 wk, ×2/wk for next 3 wk, ×1/wk in last 7 wk). —Active training of scapular stability (specific exercises not documented in article). —Hot/cold packs, and soft-tissue treatments—no further detail given in article. Arthroscopic surgery.	Pain and function: Constant Murley subscores. 4-point rating scale rating pain and dysfunction.	No significant between-group differences were found.
Kachingwe et al. 2008 (45)	<i>n</i> = 33 patients; 17 men, 16 women. Aged 18-74 yr. Chronicity not stated. Follow-up: 6 wk. Patients to remain on current level and type of medication for duration of study. No further usage recorded.	Frequency: Groups 1-3 received PT ×1/wk × 6 wk with HEP daily. Group 1: supervised exercise: Posterior capsular stretching, postural correction exercises, rotator cuff strengthening (elastic resistance ER), scapular stability exercise (scapular exercises with elastic resistance), ice-pack. Group 2: Supervised exercise as per group 1 with GH joint mobilizations. Group 3: Supervised exercises as per group 1 with MWM technique (Mulligan mobilizations). Group 4: Control group with advice only.	Pain: 10 point VAS. ROM: Goniometric measurement of flex and *scaption. Function: SPADI.	All groups had statistically significant decreases in pain intensity pre-post treatment. Three intervention groups had higher % change on SPADI. Groups 1 and 2, receiving manual therapy with exercise, had higher % change on all pain measures compared to exercise alone, but no significant between-group differences were found.

Table 1 Continued				
Study	Participants	Interventions	Outcome Measures	Results/Comments
Lombardi et al. 2008 (53)	<i>n</i> = 60 patients; 14 men, 46 women. Age and chronicity not stated. Shoulder pain onset > 2 mo between 3 and 8 on NPRS. Follow-up: 2 mo. Both groups prescribed 750 mg acetaminophen 8-hourly when in pain and 50 mg diclofenac if pain >7/10 on VAS.	Exercise group: Progressive resistance training ×2/wk for 2 mo: Resisted flex/extension/LR/MR, 1 set of 8 repetitions at 50% of the 6RM followed by 2-min rest and 1 set of 70% of the 6RM. Speed of the movement 2 s for the concentric and eccentric phase. Multi-pulley muscle building equipment used for exercises. Control group: No treatment.	Pain:10 cm VAS. Function: DASH 2 and DASH 3 QoL: Brazilian version of SF-36. ROM Strength: Isokinetic assessment, measured in 3 planes of movement at 600/s and 1800/s. Self-assessed improvement: 5-point rating scale.	Progressive resistive exercise group displayed statistically significant reduction in pain at rest (<i>P</i> = 0.001) and during movement (<i>P</i> = 0.001), improved QoL, and patient reported function and strength (extension only) over the control group.
Ludewig and Borstad 2003 (36)	<i>n</i> = 67 male patients (overhead construction workers). Age and chronicity not stated. Follow-up: 8-12 wk post treatment.	Exercise group: Stretches: anterior and posterior shoulder stretch. Strengthening: ER using blue elastic band resistance, starting in neutral and progressing to 90° ABD. Frequency/intensity: 3 days per week, increasing reps over 3 wk. After progressing to 3 × 20 reps for 3 consecutive sessions; patients instructed to increase resistance by shortening elastic band. Control group: No treatment.	Pain and Function: (i) Shoulder Rating Questionnaire. (ii) Modified SPADI (nonvalidated).	Control subjects remained stable while subjects in the exercise group showed statistically significant improvements in SRQ and SPADI scores and patient satisfaction.

Table 1 Continued				
Study	Participants	Interventions	Outcome Measures	Results/Comments
Osteras et al. 2009 (54)	<i>n</i> = 61 patients, 10 men, 51 women. Aged 18-60 yr. Onset shoulder pain >3 mo. Follow-up: 3 mo.	Frequency: ×3 PT sessions/wk × 12 wk Progressive resistance, high-dose (HD) exercise: 11 exercises, total of 36 treatments (3 × 30 repetitions × 3/wk × 3 mo) including 35-40 min static cycling at moderate to high intensity, 70-80% MHR. Resisted shoulder flexion (deloaded pulley exercise), resisted extension (dumbbells), elbow flexion/extension (dumbbells), IR, ER, ABD (deloaded shoulder pulley). Progressive resistance, low-dose (LD) exercise: 6 exercises (2 × 10 reps each exercise) plus 5-10 min of static cycling at moderate to high, 70-80% MHR.	Pain: 100 mm VAS. Function: SRQ Strength: Isometric strength Flexion/ER/IR/ABD using dynamometer.	Significant difference between groups (<i>P</i> < 0.05), HD group experienced less pain and improvement in function and significantly greater isometric ABD and ER strength.
Polimeni et al. 2003 (52)	<i>n</i> = 50 patients; 14 men, 36 women. Aged 29-85 yr. Onset shoulder pain <3 mo. Follow-up: 5 days, end of treatment, 30 days after end of treatment (duration of treatment period not stated).	All groups received functional rehabilitation (FR) (passive exercises × 10 min and active assisted exercise × 20 min-specific methods not detailed in article) frequency of treatment not detailed. Group 1: FR only. Group 2: FR plus radar. Group 3: FR plus diadynamic current. Group 4: FR plus US.	Pain and Function: Constant-Murley Score	All groups showed statistically significant improvement (<i>P</i> = 0.0027). FR only (group 1) responded better to treatment than the combined therapies.

Table 1 Continued				
Study	Participants	Interventions	Outcome Measures	Results/Comments
Senbursa et al. 2007 (42)	<i>n</i> = 30 patients (gender not stated). Aged 30-55 yr. Chronicity not stated. Follow-up: Post treatment (4 wk) and 3 mo after initiation of treatment.	Exercise group: Unsupervised self-training of humeral head depressors (no detail given). AROM, stretching, elastic resistance strengthening of rotator cuff, and scapular stabilizers. Frequency: ×7/wk for 10-15 min for 4 wk. Combined physiotherapy group (CPT): 12 sessions (3 sessions × 4 wk) of: Self-training as group 1 plus joint and soft-tissue mobilizations, ice, radial nerve mobilizations, and proprioceptive neuromuscular facilitation.	Pain: 10 cm VAS. AROM: goniometry Flex/ABD/ER/IR Function: Neer Questionnaire.	CPT group showed significantly greater improvements in function scores (<i>P</i> = 0.002). Both groups experienced a statistically significant decrease in pain, CPT > exercise (<i>P</i> = 0.01).
Szczurko et al. 2008 (50)	<i>n</i> = 85 patients; 35 men, 50 women. Aged 18-65 yr. Onset shoulder pain >6 wk. Follow-up: baseline, 4, 8, and 12 wk.	Naturopathic care (NC): Acupuncture, anti-inflammatory diet, Phlogenzym (hydrolytic enzyme supplement) for 12 wk. Physical exercise (PE): Placebo tablets, physical exercise: passive, active-assisted, and AROM exercises (no further detail given).	Pain and disability: (i) SPADI (ii) VAS 0-7 cm. QoL: SF-36 Patient satisfaction: Measure Yourself Medical Outcomes Profile (MYMOP) AROM: flexion/extension/ABD/ADD/IR/ER using goniometer.	Both groups showed significant improvements in shoulder pain and QoL indices. NC group improved significantly over the PE group in SPADI total, pain, and disability subcategory scores. 12 wk: PE group VAS scores pre-post test: 4.85 (+1.48) to 4.05 (+1.69) (<i>P</i> = 0.0431). Mean change from baseline 0.64. Adverse events: 2 adverse reactions in NC group. PE group reported 5 adverse reactions. Gastrointestinal upset was most common event reported (4/5 in PE, 1/2 in NC group).

Study	Participants	Interventions	Outcome Measures	Results/Comments
Walther et al. 2004 (46)	n = 60 patients; 34 men, 26 women. Age and chronicity not stated in eligibility criteria. Follow-up: 6 and 12 wk.	Exercise: Standardized self-training: centering and stretching using elastic resistance, scapular stability with and without elastic resistance. Weighted pendulum exercises for ROM Frequency: ×4 sessions, plus ×5/wk × 10-15 min HEP. Conventional physiotherapy: Centering training for the rotator cuff and stretching with advice. Frequency × 10 sessions-given 2-3 sessions/wk Functional brace: Coopercare Lastrap shoulder brace.	Pain: 100 mm VAS. Function: Constant-Murley scale	All groups displayed a significant improvement in shoulder pain and function. No significant between-group differences were found. No significant difference in NSAID usage among the groups. Adverse events: 2 adverse reactions in functional bracing group.

ABD, abduction; ADD, adduction; ADLs, activities of daily living; AROM, active range of movement; ER, external rotation; HEP, home exercise program; IR, internal rotation; MHR, maximum heart rate; NPRS, numerical pain rating scale; NSAIDs, nonsteroidal anti-inflammatory drugs; PT, physiotherapy; QoL, quality of life; RM, repetition maximum; SF-36, short form 36; SPADI, shoulder pain and disability index; SRQ, shoulder rating questionnaire; VAS, visual analogue scale. *Scaption, abduction in the scapular plane. **Tasks used were identified at initial assessment and therefore different for each subject.

the included studies and highlights the heterogeneity in exercise protocols.

Risk of Bias Assessment Within Studies

Results of the Cochrane Risk of Bias Tool and the van Tulder Scale are shown in Tables 3 and 4. The mean score for the van Tulder Scale was 6.9/12 (range 2 to 10). Interrater agreement for all items on each scale was examined and average kappa coefficients, with 95% CI, were calculated to be 0.78 (95% CI 0.71, 0.86, *P* < 0.001) for

Description	Number of Studies	Studies
Frequency of exercise		
Daily home strengthening/stretching	5	(40,45,47,48,51)
30 min strengthening ×2/wk	1	(43)
30 min strengthening ×1/wk	1	(36)
×2/wk	1	(53)
×3/wk	2	(44,54)
×5/wk	1	(46)
Frequency gradually reduced	1	(35)
Not stated	4	(42,49,50,52)
Duration of individual exercise sessions		
Insufficient detail	8	(36,45,47-50,53,54)
1 h daily	2	(40,51)
45-60 min	2	(35,44)
30 min	2	(43,52)
10-15 min	2	(42,46)
Duration of overall exercise protocol		
3 wk	3	(40,43,44)
5 wk	1	(48)
6 wk	1	(45)
8 wk	1	(53)
12 wk	3	(35,51,54)
18 wk	1	(49)
22 wk	1	(47)
Not stated/insufficient detail	3	(36,50,52)
Intensity of exercise ^a		
3 sets of 10 repetitions using 10RM resistance of Theraband with 60 s rest	1	(43)
50% of 6RM to 70% 6RM multi-pulley resistance machines	1	(53)

RM, repetition maximum.
^aData provided in 2 articles only.

Author(s) (yr)	Sequence Generation Random	Concealed Allocation	Blinding of Key Personnel	Addressed Incomplete Outcome Data	Free of Selective Outcome Reporting	Free of Other Bias
Bang and Deyle (2000)	Y	U	Y	Y	Y	N
Bennell et al. (2010)	Y	Y	Y	Y	Y	N
Brox et al. (1993/9)	Y	U	U	Y	Y	N
Cloke et al. (2008)	U	Y	N	Y	Y	N
Conroy and Hayes (1998)	U	Y	Y	Y	Y	N
Engelbrechtsen et al. (2009)	Y	Y	Y	Y	Y	N
Ginn and Cohen (2005)	Y	U	Y	N	Y	Y
Haahr et al. (2005)	Y	N	N	Y	Y	N
Kachingwe et al. (2008)	N	U	Y	N	Y	U
Lombardi et al. (2008)	Y	Y	Y	Y	Y	Y
Ludewig and Borstad (2003)	Y	U	N	Y	Y	N
Osteras et al. (2009)	U	N	N	N	Y	Y
Polimeni et al. (2003)	U	U	Y	U	Y	U
Senbursa et al. (2007)	U	U	N	Y	N	Y
Szczurko et al. (2009)	Y	Y	Y	Y	Y	N
Walter et al. (2004)	U	U	N	Y	N	Y

N, No; U, unclear; Y, yes.

the van Tulder Scale and 0.82 (95% CI 0.72, 0.92, $P < 0.001$) for the Cochrane Risk of Bias tool, indicating moderate and substantial agreement, respectively (55). Twelve studies obtained a score of 6 or more, indicating a low risk of bias (35,36,40,43,44,47-51,53,54). Four trials scored less than 6, indicating substantial bias (42,45,46,52).

Risk of Bias Assessment Across Studies

Figure 4 displays the overall risk of bias across the studies. Common methodological shortfalls were inadequate randomization ($n = 7$) (42,44-46,49,52,54), inadequately concealed treatment allocation ($n = 10$) (35,36,40,42,43,45,46,48,52,54), and lack of blinding of assessors ($n = 7$) (35,36,40,42,46,49,54). Only 4 trials reported both randomization and concealed treatment allocation adequately (47,50,51,53). Additional failings noted were between-group differences at baseline ($n = 5$) (36,43,45,47,49), lack of intention-to-treat analysis ($n = 7$) (42,44-46,48,52,54), and a failure to measure compliance with the exercise intervention ($n = 7$) (35,40,42,50-53).

Risk of Bias Assessment Across Outcomes

Pain

Fourteen studies evaluated pain at short-term follow-up. Eleven studies had a low risk of bias (35,36,40,43,44,47,48,50,51,53,54) and 3 had a high risk of bias (42,45,46). Six of the 11 articles with a low risk of bias (36,40,43,51,53,54) reported reductions in pain that

were statistically significant between groups. Four studies with low risk of bias evaluated pain at long-term follow-up (35,40,47,51). One of these articles reported a statistically significant between-group decrease in pain (40), whereas the remaining 3 articles reported improvements in pain that were not statistically significant between groups.

Patient Reported Function

Thirteen studies evaluated the effectiveness of exercise on short-term PRF. Two articles used nonvalidated measures (35,43) and 1 article did not report raw data for this outcome, meaning that no judgment of improvement or otherwise could be made (48). Eight articles had a low risk of bias (36,44,46,47,50,51,53,54), of which 4 reported statistically significant between-group improvements in function (36,51,53,54). Four articles with a low risk of bias evaluated the impact of exercise on long-term PRF. Two trials (47,51) reported statistically significant between-group improvements in function in favor of exercise, whereas 1 article (40) reported between-group improvements that did not reach statistical significance.

Strength

Five studies evaluated short-term strength using a dynamometer or isokinetic testing. Two studies had a low risk of bias (47,53), and 3 had a high risk of bias (40,46,54). Two of these 5 articles reported statistically significant between-group improvements in strength (47,54). A third article also reported a statistically significant between-group improvement in muscle strength. However, on closer analysis, this was only detected in the strength of

Table 4 Results of van Tulder Scale													
Article	1 Randomization Adequate	2 Concealed Allocation	3 Patient Blinded	4 Therapist Blinded	5 Assessor Blinded	6 Dropout Accounted	7 ITT	8 Free of Selective Outcomes	9 Similar Baseline	10 Cointerventions Avoided	11 Compliance Acceptable	12 Outcome Timing Similar	Total Score
Bang and Deyle (2000)	Y	U	N	N	Y	Y	Y	Y	N	Y	Y	Y	8
Bennell et al. (2010)	Y	Y	Y ^a	N	Y	Y	Y	Y	N	Y	Y	Y	10
Brox et al. (1993/9)	Y	U	N	N	U	Y	Y	Y	Y	Y	U	Y	7
Cloke et al. (2008)	U	Y	N	N	U	Y	Y	Y	U	Y	Y	Y	7
Conroy and Hayes (1998)	U	Y	N	N	Y	Y	U	Y	Y	Y	Y	Y	8
Engebretsen et al. (2009)	Y	Y	N	N	Y	Y	Y	Y	Y	N	U	Y	8
Ginn and Cohen (2005)	Y	U	N	N	Y	Y	U	Y	Y	Y	Y	Y	8
Haahr et al. (2005)	Y	N	N	N	N	Y	Y	Y	Y	Y	U	Y	7
Kachingwe et al. (2008)	N	U	N	N	Y	Y	U	Y	N	Y	Y	U	5
Lombardi et al. (2008)	Y	Y	N	N	Y	Y	Y	Y	Y	Y	U	Y	9
Ludewig and Borstad (2003)	Y	U	N	N	U	Y	Y	Y	U	Y	Y	Y	7
Osteras et al. (2009)	U	N	U	N	N	Y	U	Y	Y	Y	Y	Y	6
Polimeni et al. (2003)	U	U	N	N	Y	N	N	Y	Y	Y	U	Y	5
Senbursa et al. (2007)	U	U	N	N	U	U	U	N	Y	N	U	Y	2
Szczurko et al. (2009)	Y	Y	N	N	Y	N	Y	Y	Y	Y	U	Y	8
Walther et al. (2004)	U	U	N	N	U	Y	U	N	Y	Y	Y	Y	5

Y, yes; N, no, U, unsure; ITT, intention to treat principle used.
 Bold values signify total van Tulder Scale scores.
^aPatient blinded to comparison treatment.

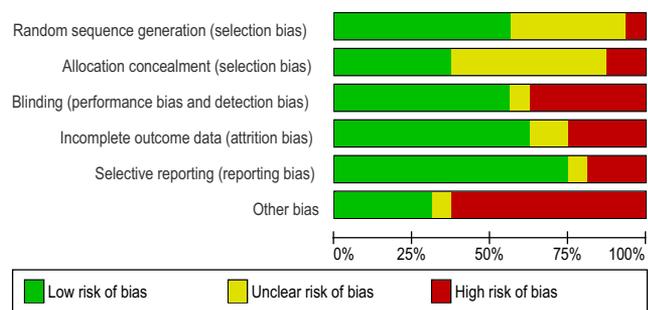


Figure 4 Risk bar chart showing risk of bias across studies. (Color version of figure is available online.)

shoulder extension (53); the strength of other shoulder movements did not change significantly. No study assessed strength at long-term follow-up.

Quality of Life

Three articles with a low risk of bias measured QoL at short-term follow-up. One article detected a statistically significant between-group difference (53). One article assessed QoL at long-term follow-up and reported no between-group differences (47).

Qualitative Summary of Strength of Evidence for Effectiveness of Exercise

To construct best evidence synthesis, 4 studies were rated to be of high quality (47,50,51,53); 7 were rated as medium quality (35,36,40,43,44,48,49), and 5 were deemed to be low quality (42,45,46,52,54). There is strong evidence that exercise is effective at reducing pain and improving PRF at short-term follow-up. These findings are supported by consistent, statistically significant between-group differences in 2 of the 4 high-quality RCTs (51,53). There is strong evidence that exercise is effective

at improving long-term PRF, supported by consistent, statistically significant between-group differences in 2 of the 4 high-quality RCTs (47,51). There is moderate evidence demonstrating the effectiveness of exercise for improving strength (47,53) and QoL (53) at short-term follow-up, supported by 2 and 1 high-quality RCTs, respectively. There is limited evidence that exercise is effective in reducing pain at long-term follow-up, supported by 1 medium-quality RCT (40). There was insufficient evidence for the effectiveness of exercise in improving QoL at long-term follow-up.

There is insufficient evidence to describe a definitive evidence-based exercise protocol for those with SAIS. However, common exercises contained within 3 high-quality articles are scapular stability training and progressive rotator cuff strengthening exercises using pulley equipment or elastic resistance bands. Exercises should be conducted through range to 90° abduction (47,51,53). These forms of exercise are also employed in 3 medium-quality articles (36,40,43). There is insufficient evidence to recommend any particular frequency of exercise that may be associated with better outcomes; however, 4 studies, 2 of high quality and 2 of medium quality (40,47,48,51), conducted supervised exercises 1 to 2 times per week along with daily home exercises. Results for overall effectiveness of exercise and best evidence synthesis across outcomes and follow-up are summarized in Table 5.

Quantitative Analysis

Six studies were eligible for inclusion in the statistical pooling of data (35,36,47,50,51,53). Reasons for exclusion of the remaining trials were as follows: high risk of bias/scoring less than 6/12 on the van Tulder Scale as recommended (34) ($n = 4$) (42,45,46,52); groups received comparable exercise regimens therefore effect size of exercise is uncertain ($n = 2$) (43,44); no determinable

Outcome and Follow-Up	Effectiveness (Risk of Bias)	Best Evidence Synthesis
Pain		
Short-term	*Yes (low (36,43,46,51,53,54)) ^a Yes (high (42,45,46))	Strong
Long-term	*Yes (low (40)) ^a Yes (low (35,47,51))	Limited
Patient reported function		
Short-term	*Yes (low (36,51,53,54))	Strong
Long-term	^a Yes (low (44,47,50) high (46)) *Yes (low (47,51)) ^a Yes (low (40,49))	Strong
Strength		
Short-term	*Yes (low (47) high (54))	Moderate
Long-term	^a Yes (low (40,53) high (46))	—
Quality of life		
Short-term	*Yes (low (53)) ^a Yes (low (47))	Moderate
Long-term	^a Yes (low (47))	Insufficient
—, no data available. *Yes, results supported exercise and were statistically significant between groups. ^a Yes, improvement detected, but not statistically significant between groups.		

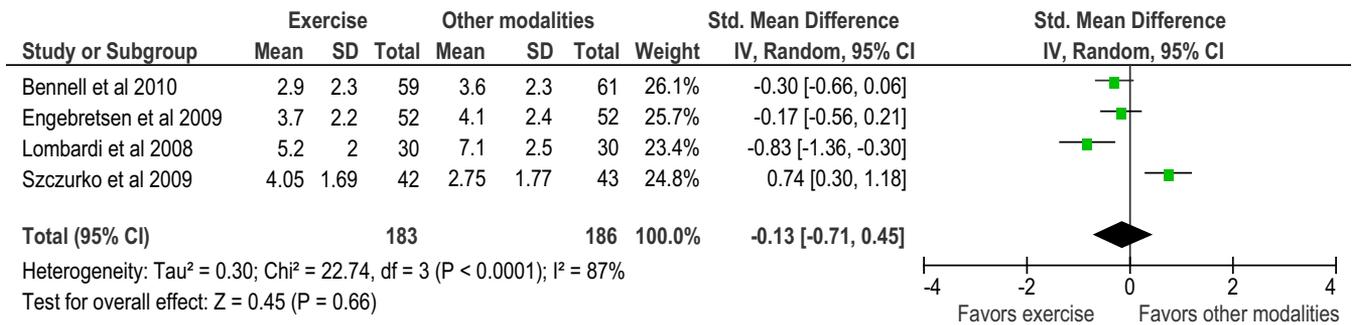


Figure 5 Forest plot showing results of exercise versus other modalities for short-term pain. (Color version of figure is available online.)

control group ($n = 1$) (54); exercise intervention vague with no detail regarding parameters and type ($n = 1$) (49); use of nonvalidated outcomes and a lack of description of the exercise protocol ($n = 1$) (48); and insufficient data and attempts to contact the authors were unsuccessful ($n = 1$) (40).

Pain

It was only possible to analyze the effect of exercise on pain in the short term because of limited data. Four studies ($n = 369$ participants) provided data relating to the effect of exercise therapy on short-term pain. Figure 5 demonstrates that there was no significant effect of exercise on short-term pain (SMD 0.13 (95% CI -0.71, 0.45); $P = 0.66$).

Patient-Reported Function

Five studies ($n = 409$ participants) provided data relating to the effect of exercise therapy on short-term PRF and 2 studies ($n = 224$ participants) reported long-term PRF. There was no significant effect of exercise on short-term PRF (Fig. 6) (SMD -0.17 (95% CI -0.56, 0.21); $P = 0.37$), but exercise had a small effect in improving long-term PRF (SMD -0.31(95% CI -0.57, 0.04); $P = 0.02$) (Fig. 7).

Strength

It was possible to analyze data relating to the effect of exercise on strength in the short term only. A combined

index of strength of external and internal rotation was created from 2 articles ($n = 180$ participants). This showed that exercise was effective in providing short-term improvement in strength of the rotator cuff (SMD -0.45 (95% CI -0.75, 0.15); $P = 0.003$) (Fig. 8).

Quality of Life

Three articles used appropriate measures of QoL; however, discrepancies in reporting permitted pooling of data for mental health composite scores in only 2 articles ($n = 205$ participants). Exercise has a small and statistically nonsignificant effect on mental health function compared to other modalities (SMD -0.2 (95% CI -0.56, 0.16); $P = 0.29$) (Fig. 9).

DISCUSSION

The aim of this review was to determine the overall effectiveness of exercise in the physiotherapy management of SAIS, and to guide clinicians regarding the most effective mode, frequency, duration, intensity, and progression of exercise interventions. We were able to come to a number of conclusions on the basis of the 16 studies we analyzed. All, however, are accompanied by caveats. First, the overall results of the qualitative synthesis suggest that exercise is effective at reducing pain and improving function for the 6 to 12-week period following treatment, with this assessment being accepted with caution because it is supported by only 6 and 4 medium/high-quality RCTs, respectively. Second, there is strong evidence that the im-

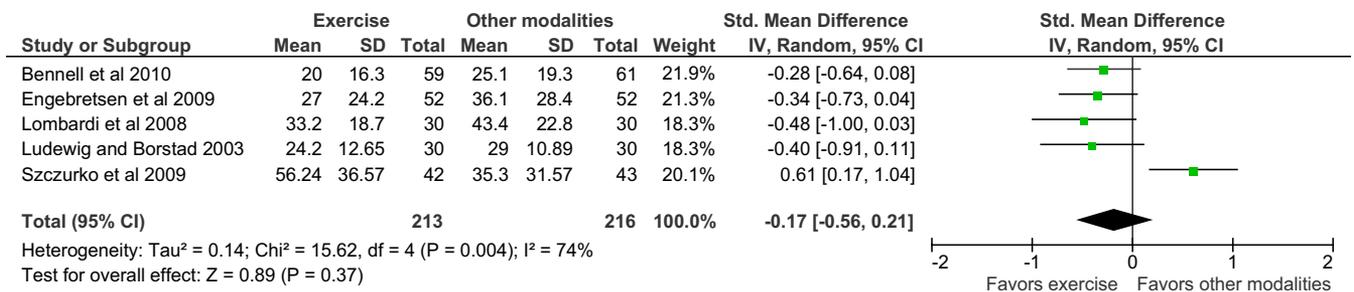


Figure 6 Forest plot showing results of exercise versus other modalities for short-term PRF. (Color version of figure is available online.)

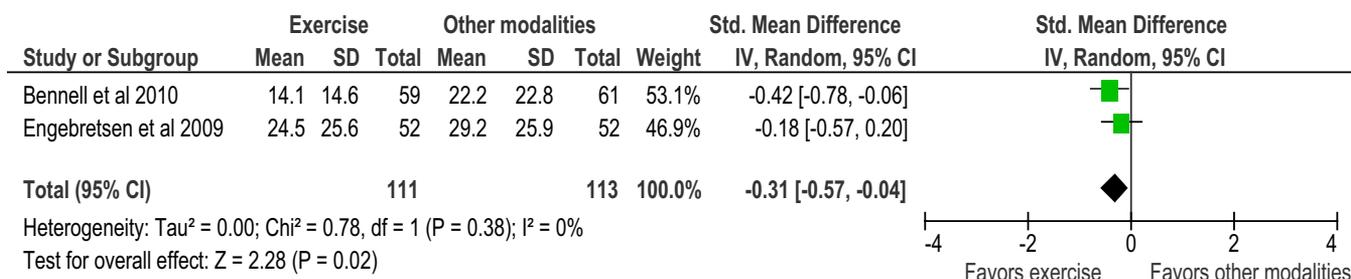


Figure 7 Forest plot showing results of exercise versus other modalities for long-term PRF. (Color version of figure is available online.)

improvements in function are maintained at long-term follow-up. Again this conclusion is accepted cautiously because it is supported by only 2 high-quality RCTs. Third, there is moderate evidence that exercise is effective in terms of improving short-term mental health and strength. Quantitative analysis added some additional support, in that statistical pooling of the results of a subset of 6 qualifying studies demonstrated that exercise may be effective in providing short-term strength gains and improving function in the longer term. The wide variety of exercise interventions, coupled with inadequate, irreproducible descriptions of the exercise protocols, prevented definitive conclusions about which types of exercises and exercise parameters are associated with better outcomes. However, common types of exercise used in high- and medium-quality articles, and associated with decreased pain and increased function, were scapular stability exercises and rotator cuff strengthening exercises using pulley equipment or elastic band resistance and progressing through range to 90° abduction. These were conducted in supervised sessions 1 to 2 times per week and in daily home exercise programs.

Sixteen studies were qualitatively evaluated. Four were assessed as having high-quality/low risk of bias (47,50,51,53), 7 as having medium-quality (35,36,41,43,44,48,49), and 5 as having low-quality/high risk of bias (42,45,46,51,54). The most common cause of an increased risk of bias was inadequately concealed treatment allocation, which in combination with small sample sizes and use of self-reported/subjective outcome measures has been associated with an exaggerated treatment effect (32,33,56-58). Blinding of the assessors was not reported in 7 trials, which would have a greater impact if objective

outcomes such as dynametric measurement of strength were evaluated. This type of measurement was performed in 5 trials, of which only 2 were of a high enough quality to assess quantitatively (47,53).

Overall, quantitative analysis was limited to 6 trials. Studies were limited by heterogeneity in the type, reporting, or length of follow-up of clinically relevant outcome measures. Two articles of otherwise sufficient quality could not be included in statistical pooling as results were presented as medians without the range of scores; hence, means and standard deviations could not be calculated (40,48). Of the 3 studies that evaluated the impact of exercise on QoL (47,50,53), inadequate reporting of results permitted pooling of data for just 1 domain (mental health) at 12 weeks in 2 articles (47,50).

Comparison with Previous Literature

This is the first review that we know of that has assessed the effectiveness of exercise systematically in the treatment of SAIS. One previous qualitative review had a similar aim as the current review; using best evidence synthesis, it concluded that there was limited or unclear evidence for the effectiveness of exercise in the management of SAIS (24). The authors examined 8 RCTs using the Physiotherapy Evidence Database (PEDro) scale to rate quality. However, the PEDro scale has a number of limitations; for example, it focuses on quality of reporting rather than factors that influence the risk of bias (as recommended by PRISMA guidelines and the Cochrane Collaboration) and it does not consider the timing of outcomes or compliance with the intervention, which are highly relevant when reviewing exercise interventions.

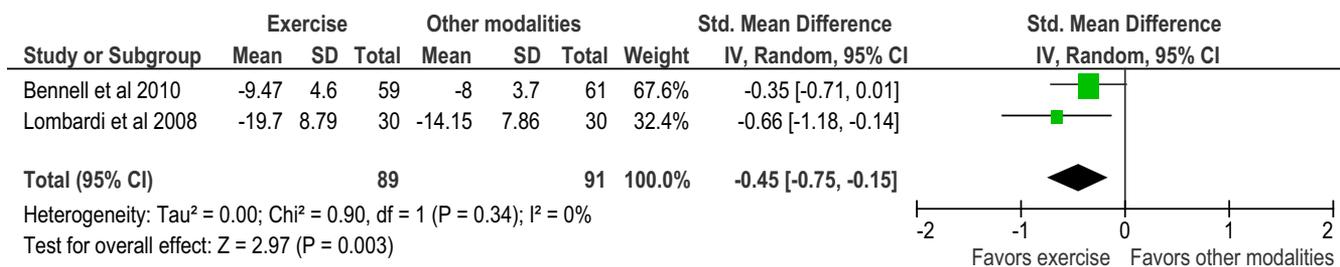


Figure 8 Forest plot showing combined index of strength. (Color version of figure is available online.)

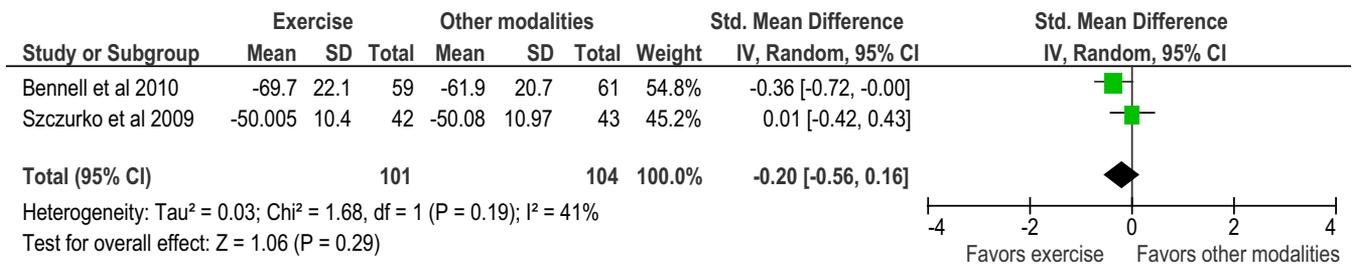


Figure 9 Exercise versus other modalities for SF-36 composite mental health function. (Color version of figure is available online.)

Additionally, the authors did not describe how the best evidence synthesis was formulated. Our work permits a somewhat stronger assessment in that we found moderate to strong evidence for the benefits of exercise in the management of SAIS. We also found that exercise is effective in decreasing pain and improving function (23), adding that there is moderate evidence that exercise has a positive effect on short-term strength, which was previously thought not to be the case (23). Further high-quality research is required to allow statistical pooling and quantitative confirmation of these statements (24,29,36). It is disappointing that the quality of the data available prevents clarification regarding the nature or duration of an optimal exercise approach (24). There is also a need for longer follow-ups and studies that contain control groups either with no exercise or that investigate different modes and parameters of exercise (24,29).

Strengths and Limitations of Current Review

This meta-analysis has several limitations. The search strategy was limited to English articles. This may introduce English language bias, because reports are more likely to be published in English if they contain significant results (59). Also, because the overall number of participants statistically analyzed is relatively low, the inclusion of a small trial reported in any language could have a significant impact on the magnitude or even the direction of the effect size (60).

Within the current meta-analysis, 3 studies involved exercise as part of a multimodal treatment incorporating treatments such as manual therapy (shoulder, spinal, soft tissue, and radial nerve mobilizations), postural taping, ice, heat, and placebo medication (35,42,47). Although it was deemed that the exercise component was the substantial intervention, the effect sizes calculated from these studies are not solely reflective of the exercise component and could therefore be somewhat imprecise.

Although there have been 2 recently published reviews on this topic (24,29), this current review rigorously assessed bias both within and across the studies using the Cochrane risk of bias tool and the van Tulder scale. Although recommended (32,33), this assessment has not been previously conducted in this area. The latter rating scale was used as it highlights two specific criteria funda-

mentally important when deciding if improvement could be attributed to any exercise intervention, ie, acceptable rate of compliance and similar timing of outcome assessment.

This article additionally contains several trials that had not previously been reviewed (45,47,49-54), that may not have been available at the time of publication of previous reviews (47,51,54), or that were either excluded or not detected by previous search strategies (45,49,50,52).

Implications for Future Research

Several recommendations can be made for future work. Future trials should meet basic requirements that minimize selection, performance, and detection bias (adequate randomization, concealed allocation, and assessor blinding). There is also a need for trials to be adequately powered with realistic follow-up periods, which may enable more useful and in-depth statistical pooling of data. In particular, studies involving follow-up outcomes for function and QoL beyond 3 months are required. Because no single tool can capture the impact of SAIS completely (61), a combination of validated, generic, region-specific, and disease-specific outcomes is recommended for those working in this area (5,61,62). Furthermore, because it is only possible to blind assessors when investigating exercise, future studies should include objective outcomes such as dynamic measurement of strength in association with subjective measures of pain and function. There is a clear need for future trials not only to describe interventions in a manner that is transparent and reproducible, but also to investigate the treatment effect of exercise alone compared to other modalities and to consider specific modes and parameters of exercise to determine if there is a dose-response effect.

Clinical Relevance

This review shows that exercise is effective in the management of patients with SAIS. High-quality trials displaying statistically significant benefits with regard to pain and function appear to involve multiple types of exercise, such as scapular stability exercises, strengthening of the rotator cuff through range, and flexibility exercises for the ante-

rior and posterior shoulder. There is not enough evidence to say whether one mode of exercise is superior to another, nor is there enough evidence to direct the clinician toward optimal intensities or frequency of exercise.

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