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Is exercise effective for the management of subacromial impingement syndrome and other soft tissue injuries of the shoulder? A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration

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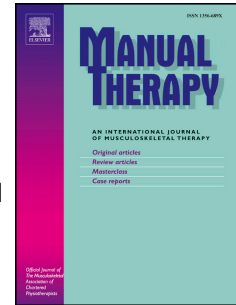
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Is exercise effective for the management of subacromial impingement syndrome and other soft tissue injuries of the shoulder? A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMA) Collaboration.

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ABSTRACT

Background: Exercise is a key component of rehabilitation for soft tissue injuries of the shoulder, however its effectiveness remains unclear.

Objective: Determine the effectiveness of exercise for shoulder pain.

Methods: We searched seven databases from 1990 to 2015 for randomized controlled trials (RCTs), cohort or case control studies comparing exercise to other interventions for shoulder pain. We critically appraised eligible studies using the Scottish Intercollegiate Guidelines Network (SIGN) criteria. We synthesized findings from scientifically admissible studies using best-evidence synthesis methodology.

Results: We retrieved 4853 articles. Eleven RCTs were appraised and five had a low risk of bias. Four studies addressed subacromial impingement syndrome. One study addressed nonspecific shoulder pain. For variable duration subacromial impingement syndrome: 1) supervised strengthening leads to greater short-term improvement in pain and disability over wait listing; and 2) supervised and home-based strengthening and stretching leads to greater short-term improvements in pain and disability compared to no treatment. For persistent subacromial impingement syndrome: 1) supervised and home-based strengthening leads to similar outcomes as surgery; and 2) home-based heavy load eccentric training does not add benefits to home-based rotator cuff strengthening and physiotherapy. For low-grade nonspecific shoulder pain, supervised strengthening and stretching leads to similar short-term outcomes as corticosteroid injections or multimodal care.

Conclusion: The evidence suggests that supervised and home-based progressive shoulder strengthening and stretching are effective for the management of subacromial impingement syndrome. For low-grade nonspecific shoulder pain, supervised strengthening and stretching are equally effective to corticosteroid injections or multimodal care.

Systematic Review Registration Number: CRD42013003928

Keywords: Shoulder pain, subacromial impingement syndrome, exercise, systematic review

ACCEPTED MANUSCRIPT

INTRODUCTION

Musculoskeletal disorders of the shoulder are common with as many as 30.3% of adults experiencing shoulder pain annually^{1,2}. Subacromial impingement syndrome (impingement of rotator cuff tendons, bursa, or ligaments in the subacromial space) accounts for up to 48% of all consultations for shoulder pain within primary care³. In the United States, shoulder injuries in workers is the third largest contributor to total workers' compensation costs after back and knee injuries when taking into account the frequency and cost of injury⁴. In addition to overuse injuries, soft tissue injuries of the shoulder can also be related to traffic collisions. For instance, 36% of individuals injured in traffic collisions report anterior shoulder pain and 75% report posterior shoulder pain⁵. Shoulder pain is also common in adolescents, though the incidence of soft tissue injuries of the shoulder is unclear. In a population-based study, 20% of adolescents aged 17-19 years report frequent neck and shoulder pain (more than once a week) during the last six months in Norway⁶.

Persistent shoulder pain and disability are common and recovery can be prolonged^{7,8}. In the Netherlands, 41% of patients consulting primary care physicians for a new shoulder complaint reported persistent or recurrent symptoms after one year³. The median time to recovery (self-reported absence of symptoms) was 21 weeks³.

Exercise is a key component of clinical rehabilitation for soft tissue injuries of the shoulder⁹⁻¹¹; however its effectiveness remains unclear. Six systematic reviews have studied the effectiveness of exercise for the management of subacromial impingement syndrome⁹⁻¹⁴, but their conclusions vary. Three reviews found moderate to strong evidence supporting the effectiveness of exercise^{11, 13, 14} while the other three reviews concluded that the evidence was limited or unclear^{9, 10, 12}. Similarly, two reviews on the effectiveness of exercise for rotator cuff tendinopathy/tendinitis reported conflicting evidence^{11, 15}. One systematic review

suggested that exercise might be effective¹⁵ while the other found moderate to strong evidence to support exercise¹¹. These mixed conclusions may be attributable to differences in their methodology and definition of exercise therapy. Specifically, differences in literature search methodology, inclusion criteria, and critical appraisal methods (i.e., PEDro^{12, 13 9}, Cochrane Back Group Criteria¹⁵, van Tulder criteria plus Cochrane Risk of Bias tool¹¹, Cochrane Musculoskeletal Injuries Group Assessment Tool¹⁰, criteria not clearly specified¹⁴) may explain conflicting conclusions. Moreover, previous systematic reviews included studies examining the effectiveness of exercise as a part of a multimodal program of care^{12-15 9 10 11}, which makes it impossible to isolate the effectiveness of exercise because it is combined with other interventions.

The purpose of our systematic review is to evaluate the effectiveness of exercise therapy (e.g. stretching, strengthening, aerobic exercises) compared to other interventions, placebo or sham interventions, or no intervention for improving self-rated recovery, functional recovery, pain intensity, health-related quality of life, or psychological outcomes in adults or children with soft tissue injuries of the shoulder (e.g. grade I-II sprain/strains, tendinopathy, subacromial impingement).

METHODS

Registration

The systematic review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on February 25, 2013 (CRD42013003928).

Eligibility Criteria

Population: Our review targeted studies of adults and/or children with subacromial impingement syndrome and other soft tissue injuries of the shoulder.

Soft tissue injuries of the shoulder include but are not limited to grade I-II sprains/strains^{16, 17}, tendonitis, tendinopathy, tendinosis, non-specific shoulder pain (excluding major pathology), and other soft tissues injuries of the shoulder as informed by available evidence. These soft tissue injuries of the shoulder may be of insidious onset, related to overuse/repetitive injuries, trauma (e.g. traffic collision), or sports injuries. We excluded studies of severe injuries including grade III sprain/strain injuries, full thickness rotator cuff tears, glenoid labral tears, adhesive capsulitis, osteoarthritis, fractures/dislocations, infection, neoplasm, and inflammatory disorders.

Intervention: We restricted our review to studies that tested the effectiveness of exercise. We defined exercise as any series of movements with the aim of training or developing the body or as physical training to promote good physical health¹⁸. We excluded studies that listed exercise as one component of a multimodal intervention, because the effectiveness of exercise could not be isolated. For example, an RCT that compares strengthening exercises, massage, and education to manipulation and stretching exercises could not be used to comment on the effectiveness of strengthening or stretching exercises. Exercise that was combined with patient education/instruction on exercises was not considered a multimodal intervention.

Comparison groups: We included studies that compared one or more exercise interventions to one another or one exercise intervention to another intervention, placebo/sham intervention, wait list, or no intervention.

Outcomes: To be eligible, studies had to include one of the following outcomes: self-rated recovery, functional recovery (e.g. disability, return to activities, work, or school), pain intensity, health-related quality of life, psychological outcomes such as depression or fear, or adverse events.

Study characteristics: Eligible studies met the following criteria: 1) English language, 2) published between January 1, 1990 and January 23, 2015, 3) randomized controlled trials (RCTs), cohort studies, or case-control studies, and 4) included an inception cohort (i.e. a group of persons who are aggregated together close to disease onset) of a minimum of 30 participants per treatment arm with the specified condition for RCTs or 100 participants per group with the specified condition in cohort studies or case-control studies. In RCTs, a sample size of 30 is conventionally considered the minimum needed for non-normal distributions to approximate the normal distribution¹⁹. The assumption that data is normally distributed is required to ascertain a difference in sample means between treatment arms.

We excluded studies with the following characteristics: 1) letters, editorials, commentaries, unpublished manuscripts, dissertations, government reports, books and book chapters, conference proceedings, meeting abstracts, lectures, consensus development statements, or guideline statements, 2) study designs including pilot studies, cross-sectional studies, case reports, case series, qualitative studies, narrative reviews, systematic reviews, clinical practice guidelines; biomechanical studies, or laboratory studies, 3) cadaveric or animal studies.

Information sources

We developed our search strategy with a health sciences librarian (Appendix 1). A second librarian reviewed the search strategy for completeness and accuracy using the Peer Review of Electronic Search Strategies (PRESS) Checklist^{20, 21}. We searched the following electronic databases: MEDLINE, EMBASE, CINAHL, PsychINFO, Database of Abstracts of Reviews of Effects (DARE), Cochrane Central Register of Controlled Trials, and Index to Chiropractic Literature from January 1, 1990 to January 23, 2015.

The search strategies were first developed in MEDLINE and subsequently adapted to the other bibliographic databases. Search terms consisted of subject headings specific to each database (e.g., MeSH) and free text words relevant to exercise and soft tissue injuries of the shoulder (Appendix I). We used EndNote X6 to create a bibliographic database to manage the search results. As a supplemental search, we hand-searched the reference lists of previous systematic reviews for any additional relevant studies^{9-15, 22}.

Study Selection

We used a two-phase screening process to select eligible studies. In phase one, random pairs of independent reviewers screened citation titles and abstracts to determine eligibility. Phase I screening resulted in studies being classified as relevant, possibly relevant, and irrelevant. In phase II, the same pairs of reviewers independently screened possibly relevant articles to determine eligibility. Reviewers met to resolve disagreements and reach consensus on the eligibility of studies. We involved a third reviewer if consensus could not be reached.

Assessment of risk of bias

Random pairs of independent reviewers critically appraised the internal validity of eligible studies using the Scottish Intercollegiate Guidelines Network (SIGN) criteria²³. This checklist was developed by SIGN to guide the development of evidence based clinical practice guidelines for the National Health Service in Scotland. It has been used internationally in more than 140 clinical practice guidelines²⁴. During critical appraisal, we assessed for the presence of selection bias, information bias, and confounding, and any impact these may have on the internal validity of the study. We did not use a rating scale cut-off or quantitative score to judge the quality of the review²⁵. Rather, the SIGN criteria were used to assist reviewers to make an informed overall judgment on the internal validity of

studies. This methodology has been previously described²⁶⁻³⁴. We focused on the presence or absence of important methodological issues. Studies were considered to have a high risk of bias if reviewers considered the internal validity was markedly compromised due to biases and methodological flaws. Paired reviewers met to resolve disagreements and reach consensus on the admissibility of studies. We involved a third reviewer if consensus could not be reached.

Specifically, we critically appraised the following methodological aspects of RCTs: 1) clarity of the research question; 2) randomization method; 3) concealment of treatment allocation; 4) blinding of treatment and outcomes; 5) similarity of baseline characteristics between/among treatment arms; 6) co-intervention contamination; 7) validity and reliability of outcome measures; 8) follow-up rates; 9) analysis according to intention to treat principles; and 10) comparability of results across study sites (where applicable). For cohort and case-control studies, additional aspects (where applicable) included: 1) participation rate; 2) presence of outcome at time of enrolment; 3) assessment of differences in attrition between participants and groups; 4) clearly defined outcomes; 5) similarity in study processes between groups when blinding is not possible; 6) reliable assessment of exposure or prognostic factors; 7) time-varying exposure; 8) main potential confounders are accounted for in the study design and analysis; and 9) confidence intervals are provided to measure precision of results. For case-control studies, it was also assessed whether cases were clearly defined and differentiated from controls, and that controls were clearly established as non-cases.

Reviewers reached consensus through discussion. An independent third reviewer was used to resolve disagreements if consensus could not be reached. Authors were contacted when additional information was needed to complete the critical appraisal. Studies with adequate internal validity (i.e., low risk of bias)

were included in our evidence synthesis³⁵.

Data extraction and synthesis of results

We computed agreements between reviewers for the screening of articles and reported the kappa statistic (k) and 95% confidence interval (CI)³⁶. When available, we used data provided in the admissible articles to measure the association between the tested interventions and the outcomes by computing the relative risk (RR) and its 95% CI. Similarly, we computed differences in mean changes between groups and 95% CI to quantify the effectiveness of interventions. The computation of 95% CIs was based on the assumption that baseline and follow-up outcomes were highly correlated ($r=0.80$)^{37, 38}. We excluded findings based on outcome measures that had not been tested for validity or reliability or were administered in a non-standardized manner across participants.

The lead author extracted data from scientifically admissible studies into evidence tables. A second reviewer independently checked the extracted data. A meta-analysis would be conducted if there was adequate homogeneity across studies with respect to patient populations, interventions, control interventions, and outcomes. In the absence of adequate homogeneity, we would perform a qualitative synthesis of findings from scientifically admissible studies to develop evidence statements according to principles of best evidence synthesis³⁵. We stratified our results according to type of soft tissue injury of the shoulder and by duration (i.e., recent [<3 months], persistent [≥ 3 months], or variable [all durations included]). We used minimal clinically important difference (MCID) values to determine clinical significance of changes in each trial for common outcome measures. These include a between-group 1.4/10 cm difference on the Visual Analog Scale (VAS)³⁹, 18/100 difference on the Shoulder Pain and Disability Index (SPADI)⁴⁰, 10.5/100 difference on the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH)⁴¹, and 11% or 4/50 unweighted points on the

Shoulder Rating Questionnaire (SRQ)⁴². The MCID for shoulder range of motion is not currently defined in the literature.

Reporting

The systematic review was organized and reported based on the Preferred Items for Systematic Reviews and Meta-Analyses (PRISMA) statement⁴³.

RESULTS

Study selection

Our search retrieved 4853 articles. We removed 1516 duplicates and screened the eligibility of 3337 articles (Figure 1). Primary reasons for exclusion of articles in full text screening are listed in Appendix II. Twelve articles were critically appraised⁴⁴⁻⁵². Of these, five studies (reported in six articles) had a low risk of bias and were included in our synthesis⁴⁶⁻⁴⁸. Two of the articles with a low risk of bias reported outcomes from different follow-up periods from one RCT^{53, 54}. The inter-rater agreement for the screening of articles was $k = 0.75$ (95% CI 0.64-0.86). The percent agreement for the critical appraisal of studies was 82% (9/11 studies). Disagreement was resolved through consensus for two studies. During critical appraisal, we contacted the authors of four studies (3/4 responded). The data from reviewed studies did not allow meta-analysis, so we conducted a best evidence synthesis.

Study characteristics

All five studies with a low risk of bias were RCTs. Four RCTs assessed the effectiveness of exercise for the management of shoulder impingement syndrome (two targeting persistent duration^{48, 49, 55} and two targeting variable duration^{47, 48}). One RCT studied exercise for the management of nonspecific

shoulder pain lasting more than one-month⁴⁶. The median pain intensity at baseline was lower than 3/10 cm on the VAS; therefore, we have categorized this study population as low-grade nonspecific shoulder pain.

All exercise programs aimed to strengthen the rotator cuff^{46-48, 53-55}; three also aimed to strengthen the scapular stabilizing musculature^{46, 48, 53, 54}, and two included stretching exercises^{46, 48}. The duration of exercise programs were five⁴⁶, eight^{47, 48}, 12 weeks⁵⁵, or individually planned^{53, 54}. The level of supervision varied between exercise programs: one program was only performed at home⁵⁵; one program involved minimal supervision by a physical therapist (one instructional session and one to two follow-up visits)⁴⁸; one involved biweekly supervised visits⁴⁷; one involved weekly supervised visits⁴⁶; and one with individualized number of visits (supervised and at home)^{53, 54}. Three studies incorporated home-based exercises into supervised exercises^{46, 48, 53, 54}. The exercise programs were added to physiotherapy and another exercise program⁵⁵ or compared to surgery^{53, 54}, no intervention^{47, 48}, corticosteroid injections⁴⁶, or multimodal care (electrophysical modalities, passive joint mobilization and ROM exercises)⁴⁶. Overall, the exercise interventions were described in sufficient detail for replication in further studies or for implementation into practice (Appendix III).

Risk of bias within studies

Four studies with a low risk of bias used appropriate randomization and blinding methods, and all five studies performed an intention to treat analysis (Table 1A). Four RCTs had follow-up rates greater than 85%. Nevertheless, these studies had limitations: one study did not describe the method of randomization and blinding; three studies did not describe the method used to conceal treatment allocation^{46, 48}; all five studies did not describe co-interventions or reported unbalanced co-interventions between groups. The participants and treatment providers of all studies were not blinded due to the nature of the intervention. Two studies used outcome measures that have not been validated or were

administered in a non-standardized manner (i.e., a functional limitation score developed by the authors; VAS administered while participants were lifting weights in a non-standardized manner; SPADI with modified occupational pain and disability questions i.e. modified version had not been tested for its validity^{46, 48}). Findings using these outcome measures were excluded from our synthesis and conclusions are based only on valid and reliable outcome measures.

The six RCTs with high risk of bias had important limitations (Table 1B)^{44, 45, 49-52}. These included: inadequate⁵⁰ or non-disclosed^{49, 51, 52} methods of randomization (4/6)⁴⁹⁻⁵²; inadequate concealment of treatment allocation (3/6)^{44, 49, 52}; and no blinding of outcome assessor (4/6)⁴⁹⁻⁵². Clinically important differences in baseline characteristics between groups were reported in 4/6 RCTs^{45, 50-52} and one study did not describe the baseline characteristics of participants⁴⁹. All studies with high risk of bias did not describe or properly account for co-interventions^{44, 45, 49-52}. Two trials reported drop-outs of greater than 30%^{45, 52} one trial had large differences in the number of drop-outs between treatment arms⁴⁴, and one did not report on attrition⁴⁹.

Summary of evidence

Low-grade nonspecific shoulder pain of variable duration (excluding major pathology)

Evidence from one RCT suggests that supervised strengthening and stretching exercises, a single corticosteroid injection, and a multimodal program of care lead to similar short-term outcomes for the management of low-grade nonspecific shoulder pain⁴⁶. Ginn and Cohen randomized patients with mechanical shoulder pain of more than one month duration (mean = 7.3 months) to: 1) five weeks of individualized home-based exercises (strengthening and stretching of the rotator cuff and scapulohumeral muscles) with weekly supervision by a physical therapist; 2) a single subacromial corticosteroid injection; or 3) five weeks of

multimodal care by a physical therapist (electrophysical modalities, passive joint mobilization, daily range of motion exercises). There were no statistically significant differences between groups in range of motion, strength or the self-reported improvement in symptoms immediately following the intervention (Table 2). As the study population had low-grade shoulder pain at baseline, floor effects may have been responsible for the lack of superior effectiveness of any one or all of the tested interventions.

Subacromial impingement syndrome of variable duration

Evidence from one RCT suggests that home-based stretching and strengthening exercises for the rotator cuff and scapular muscles are effective for the management of subacromial impingement syndrome of varied duration⁴⁸. Ludewig and Borstad randomized construction workers with subacromial impingement syndrome to: 1) eight weeks of home exercise with two follow-up visits with an exercise therapist; or 2) no treatment⁴⁸. The exercise program included daily stretching and resistance training for the scapular stabilizer and rotator cuff muscles. Following the intervention, there were greater improvements in shoulder pain and disability (difference in mean change in SRQ from baseline: 11.4/100) and satisfaction (difference in mean change from baseline 1.5/10) in the exercise group than the group receiving no treatment (Table 2). Although these results were statistically and clinically significant, the precision of these estimates could not be calculated.

Evidence from another RCT suggests that clinic-based progressive shoulder strengthening exercises are effective for the management of subacromial impingement syndrome of varied duration⁴⁷. In a trial by Lombardi et al., participants with subacromial impingement syndrome (mean duration = 13.7 months) were randomized to: 1) eight weeks of progressive resistance exercises for the shoulder (flexion, extension, medial and lateral rotation) or 2) wait list⁴⁷. Both groups used acetaminophen or diclofenac as required. Immediately post-intervention, the exercise group reported clinically significant reductions favoring

the exercise group in pain at rest (difference in mean change in VAS: 2.2/10 cm [95% CI 1.3; 3.1]), pain with movement (difference in mean change in VAS: 2.2/10 cm [95% CI 1.4; 3.0]), disability (difference in mean change in DASH 2: 17.7/100 [95% CI 2.9; 16.0]), and abduction ROM (difference in mean change: 22.6 degrees [95% CI 13.0; 32.2]). Moreover, there were statistically significant improvements in health-related quality of life favoring the exercise group (mean difference in change in SF-36 domains from baseline: physical function: 8.9 [95% CI 2.2; 15.6]; bodily pain: 8.2 [95% CI 1.6; 14.8]; social function: 15.0 [95% CI 5.3; 24.7]; emotional role limitation: 21.0 [95% CI 7.4; 34.8]) (Table 2). However, to our knowledge, the clinical importance of change on these subscales of the SF-36 has not been established in the literature.

Persistent subacromial impingement syndrome

Evidence from one RCT suggests that supervised and home-based strengthening exercise leads to similar outcomes as surgery plus post-surgical rehabilitation for the management of persistent subacromial impingement syndrome^{53, 54}. Ketola et al. randomized patients with subacromial impingement syndrome (≥ 3 months) to: 1) individually planned and progressive supervised exercises in seven visits and a home-based exercise program; or 2) arthroscopic decompression and post-surgical rehabilitation. The exercise program included strengthening exercises using elasticated stretch bands and light weights. There were no statistically significant differences between groups in pain, disability, working ability, shoulder disability, reported painful days, or proportion of pain-free patients at two and five year follow-up. Although there were statistically significant differences in days of absence from work at two years follow-up (but not five year follow-up) favouring the surgery group, the difference (i.e., 3.7 days over two years) was small and likely not clinically important.

Evidence from one RCT suggests that home-based heavy load eccentric loading training does not provide added benefits to home-based traditional rotator cuff strength training for the management of persistent subacromial impingement syndrome⁵⁵. Maenhout et al. randomized adults with subacromial impingement syndrome (≥ 3 months) to 12 weeks of home-based progressive: 1) traditional rotator cuff training (internal and external rotation resisted with an elastic band); or 2) traditional rotator cuff training combined with heavy load eccentric training (full can abduction in the scapular plane with a dumbbell weight). Both groups received nine sessions over 12 weeks of identical physiotherapy (information, glenohumeral and scapulothoracic mobilization, scapula setting and posture correction). There was no statistically significant or clinically important difference in shoulder pain and disability between groups post-intervention. Participants in both groups had a similar likelihood of perceiving improvement in shoulder pain post-intervention.

Adverse events

None of the included studies commented on the frequency or nature of adverse events.

DISCUSSION

Summary of evidence

We found five RCTs with a low risk of bias that inform the effectiveness of exercise for the management of soft tissue injuries of the shoulder. The evidence suggests that supervised progressive shoulder exercises alone or combined with home-based shoulder exercises (strengthening with or without stretching) are effective over the short-term for the management of subacromial impingement syndrome of variable duration^{47, 48}. Supervised and home-based progressive strengthening exercise leads to similar outcomes as shoulder decompression surgery over the long-term for persistent subacromial impingement syndrome⁵³,

⁵⁴. However, home-based heavy load eccentric training provides no added benefit to home-based traditional rotator cuff strength training for persistent subacromial impingement syndrome⁵⁵. Based on our review, supervised strengthening and stretching exercises provide similar short-term benefits to a single corticosteroid injection or a multimodal program of care for the management of low-grade nonspecific shoulder pain (excluding major pathology) of variable duration⁴⁶.

Previous Systematic Reviews

Previous systematic reviews reported conflicting results on the effectiveness of exercise for the management of shoulder pain. Our conclusion on the effectiveness of exercise for the management of subacromial impingement syndrome agrees with three previous systematic reviews^{11, 13, 14}, but disagrees with three others^{9, 10, 12}. The diverging conclusions between our review and previous systematic reviews can be attributed to differences in methodology and outdated literature searches (past five years)^{9, 12-14}¹⁰. First, the studies included in previous systematic reviews may have affected their conclusions. For example, all three reviews included studies where exercise was one component of a multimodal intervention. This may lead to biased conclusions about the effectiveness of exercise, as the effectiveness of exercise cannot easily be extracted from the effects of other included interventions⁵⁶. Moreover, all reviews included trials with small sample sizes, which decreases the statistical efficiency and increases the risk of residual confounding^{9, 10, 12}. In addition, one systematic review used an incomplete search strategy and may have excluded relevant studies¹⁰. Finally, all three systematic reviews used a checklist method to critically appraise studies and relied on a cutoff score for the final decision on internal validity of RCTs. These methods may result in overlooking important sources of bias and may neglect their impact on study results^{9, 10, 12}.

Our review identified 11 relevant studies on exercise for the management of shoulder pain. More than half of these studies (55%) were appraised to have high risk of bias^{44, 45, 49-52}. The large number of low quality trials identified in our review highlights the need for high quality trials on the effectiveness of exercise for the management of shoulder pain. Future studies should: 1) focus on the short-term and long-term effectiveness of exercise; 2) investigate the management of clinically meaningful subgroups of shoulder diagnoses; 3) assess the role of exercise throughout the course of care from recent injuries to more persistent pain and disability and 4) report on any adverse events resulting from these interventions.

Strengths and Limitations

Our review has strengths. First, we implemented a comprehensive and rigorous search strategy that was reviewed by a second librarian to help minimize errors. Second, we defined clear inclusion and exclusion criteria for the selection of possibly relevant studies. Third, we utilized two trained independent reviewers to screen and critically appraise the literature to minimize error and bias. Fourth, the SIGN criteria were utilized to standardize the critical appraisal process and to inform our scientific judgment. Lastly, our conclusions were based on best-evidence syntheses, omitting studies of low quality to minimize the risk of bias.

Our review also has limitations. First, we limited our search to studies published in the English language, which may have excluded some relevant studies. However, this is an unlikely source of bias as the majority of trials are published in English. The restriction of systematic reviews to the English language has not led to biased results in previous publications⁵⁷⁻⁶¹. Secondly, our search strategy may have missed potentially relevant studies despite our broad definition of soft tissue injuries of the shoulder. Third, our review may have missed potentially relevant studies published prior to 1990. Finally, the critical appraisal process entails scientific judgment that may differ between reviewers. This potential bias was minimized by training reviewers on the use of a standardized critical

appraisal tool.

Conclusion

The current evidence on the effectiveness of exercise for shoulder soft tissue injuries is limited. However, we found evidence from RCTs with low risk of bias suggesting that supervised and home-based progressive shoulder strengthening and stretching exercises for the rotator cuff and scapular muscles are effective options for the management of subacromial impingement syndrome of varied duration. For persistent subacromial impingement syndrome, supervised and home-based strengthening exercise leads to similar outcomes as surgery plus post-surgical rehabilitation. Furthermore, supervised combined stretching and strengthening exercises for the rotator cuff and scapular muscles, a single corticosteroid injection and a multimodal program of care lead to similar short-term outcomes in patients with low-grade nonspecific shoulder pain of varied duration. More research is needed on the short- and long-term effectiveness of exercise in clinically meaningful subgroups of shoulder diagnoses.

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Table 1A: Risk of Bias for Scientifically Admissible Randomized Control Trials Based on the Scottish Intercollegiate Guidelines Network Criteria

Author, Year	Research Question	Randomization	Concealment	Blinding	Similarity at baseline	Similarity between arms	Outcome measurement	Percent drop-out ^a	Intention to treat	Comparable results between sites
Ginn and Cohen, 2005 ⁴⁶	Y	Y	CS	Y	Y	CS	N	5 weeks: Injection: 6.3% MPM: 6.2% Exercise: 10.4%	Y	N/A
Ketola et al., 2009/2013 ^{53,54}	Y	Y	Y	Y	Y	N	Y	2 years: Exercise: 5.7% Surgery: 2.9% 5 years Exercise: 25.7% Surgery: 18.6%	Y	CS
Lombardi et al., 2008 ⁴⁷	Y	Y	Y	Y	Y	N	Y	2 months: Control: 10% PRTP: 0%	Y	N/A
Ludewig et al., 2003 ⁴⁸	Y	Y	CS	Y	Y	CS	Y	10 weeks: Exercise: 11.8% Control: 3%	Y	N/A
Maenhout et al., 2013 ⁵⁵	Y	CS	N	CS	Y	CS	Y	12 weeks: TT+ET: 9.7% TT: 26.7%	Y	NA

^aPercent drop-out incorporates both participant withdrawal and loss to follow-up.

Acronyms: CS- can't say; N- no; NA- not applicable; Y- yes; LLLT: low level laser therapy; MPM: multiple physical modalities; PRTP: progressive resistance training program; TT: traditional rotator cuff strength training; TT+ET: traditional rotator cuff strength training combined with heavy load eccentric training

Table 1B: Risk of Bias for Scientifically Inadmissible Randomized Control Trials Based on the Scottish Intercollegiate Guidelines Network Criteria

Author, Year	Research Question	Randomization	Concealment	Blinding	Similarity at baseline	Similarity between arms	Outcome measurement	Percent drop-out ^a	Intention to treat	Comparable results between sites
Andersen et al., 2008 ⁴⁴	Y	Y	CS	Y	Y	CS	Y	12 months: SRT:26.7% APE: 14.4% REF: 22.4%	Y	CS
Beaudreuil et al., 2011 ⁴⁵	Y	Y	Y	Y	N	N	Y	12 months: DHC: 37.1% Control: 25.7%	Y	NA
Melegati et al., 2000 ⁴⁹	Y	N	CS	N	CS	CS	CS	No information on drop-out	CS	NA
Osteras et al., 2010 ⁵¹	Y	N	Y	N	N	CS	Y	3 months: HD: 12.9% LD: 16.7%	Y	CS
Osteras et al., 2010 ⁵⁰	Y	CS	Y	N	N	CS	Y	15 months: HD:16.1% LD:23.3%	Y	
Sandsjo et al., 2010 ⁵²	Y	N	CS	N	N	CS	Y	3 months: Teletreatment: 39.4% Usual care: 40.6%	N	CS

^aPercent drop-out incorporates both participant withdrawal and loss to follow-up.

Acronyms: CS- can't say; N- no; NA- not applicable; Y- yes; APE: all-round physical exercise; DHC : dynamic humeral centering; HD: high-dosage medical exercise therapy; LD: low-dosage medical exercise therapy; REF: reference intervention; SRT: specific resistance training;

Table 2: Evidence Table for Accepted Randomized Controlled Trials on Exercise for Soft Tissue Injuries of the Shoulder

Author(s), Year	Subjects and Setting; Number (n) Enrolled	Interventions; Number (n) of Subjects	Comparisons; Number (n) of Subjects	Follow-up	Outcomes	Key Findings
Ginn and Cohen 2005 ⁴⁶	<p>Patients > 18 y.o., with unilateral mechanical shoulder pain of > 1 month duration recruited from a metropolitan public hospital in Australia I (n=138)</p> <p>Case definition: pain over the shoulder joint and/or the proximal arm exacerbated by active shoulder movements</p>	<p>Exercise: individualized daily home-based exercises supervised by a physical therapist 1x/week/5 weeks; stretching, strengthening, exercises; gradual increase in intensity and complexity as indicated.</p> <p>(n=48)</p>	<p>Corticosteroid injection: single subacromial injection by rheumatologist; 40 mg methylprednisolone acetate; patient encouraged to use affected upper limb in a normal manner.</p> <p>(n=48)</p> <p>Multiple physical modalities (MPM): 2 x/week/5 weeks by a physical therapist; electrophysical modalities (interferential therapy, ultrasound, hot packs, ice packs), passive joint mobilization, daily ROM.</p> <p>(n=42)</p>	Post-intervention	<p>Hand-behind-back ROM: distance between T1 spinous process and the radial styloid process; unaffected side – affected side;</p> <p>Isometric strength (abduction): hand-held dynamometer;</p> <p>Self-rated improvement: 3-point Likert scale</p>	<p>Exercise vs. Corticosteroid Injection: Difference in mean change (Exercise – Corticosteroid Injection):</p> <p>No significant difference between groups for hand-behind-back ROM, strength, or proportion reporting improvement in symptoms)</p> <p>Exercise vs. MPM:</p> <p>No significant difference between groups for hand-behind-back ROM, strength, or proportion reporting improvement in symptoms.</p>

<p>Ketola et al., 2009/2013^{53,54}</p>	<p>Patients (18-60 y.o.) referred to the Kantahäme Central or Riihimäki Regional Hospital, Finland between June 2001 and July 2004. (n=140)</p> <p>Case definition: chronic shoulder impingement symptoms (≥ 3 months) with positive Neer's test and pain resistant to conservative treatment.</p>	<p>Supervised and home strengthening exercises provided by physiotherapist: individually planned and progressive supervised exercises in 7 visits and home exercise program (≥ 4 times/week using 9 different exercises with 30-40 repetitions 3 times); strengthening exercises using elasticated stretch bands and light weights; as strength improved, resistance was increased and repetitions diminished; NSAIDs and subacromial corticosteroid</p>	<p>Surgery + post-surgical exercises: arthroscopic decompressions by an orthopaedic surgeon; post-operative treatment: anti-inflammatory analgesics (e.g., ibuprofen), one week collar and cuff sling, mobilization, similar individually planned strengthening exercise as the exercise group in 6 visits, NSAIDs and subacromial corticosteroid injections if pain interfered with the exercise. (n=70)</p>	<p>2 and 5 years after randomization</p>	<p>Primary outcome: pain (10 cm VAS);</p> <p>Secondary outcomes: disability (10 cm VAS), pain at night (10cm VAS), working ability (10cm VAS), shoulder disability (SDQ, 0-100), number of painful days during previous three months, proportion of pain-free patients (defined as pain ≤ 3 on VAS), absence from work due to shoulder symptoms (days, during 3 months prior to 2 years follow-up and 1 year prior to 5 years follow-up)</p>	<p><u>2 years</u> Difference in mean change (exercise – surgery)</p> <p>Pain (10cm VAS): -0.2 (99%CI -1.61, 1.14) Disability (10cm VAS): -0.4 (99%CI -1.76, 1.00) Working ability (10cm VAS): -0.3 (99%CI -1.52, 0.93) Pain at night (10cm VAS): -0.4 (99%CI -2.00, 1.17) Shoulder disability (SDQ, 0-100): -3.2 (99%CI -19.11, 12.75) Reported painful days: -1.7 (99%CI -19.68, 16.22) Proportion of pain-free patients : -0.01 (99%CI -0.20, 0.22) Absence from work (days): -3.7 (p=0.03)</p> <p><u>5 years</u> Difference in mean change (exercise – surgery)</p> <p>Pain (10cm VAS): -0.6 (99%CI -2.13, 1.01) Disability (10cm VAS): -0.4 (99%CI -2.07, 1.16) Working ability (10cm VAS): -0.6 (99%CI -2.18, 0.81) Pain at night (10cm VAS): 0.0 (99%CI -1.75, 1.73) Shoulder disability (SDQ, 0-100): -1.3 (99%CI -18.34, 15.74) Reported painful days: -1.4 (99%CI -20.57, 17.83) Proportion of pain-free patients: 0.02 (99%CI -0.20, 0.22) Absence from work (days): -2.8 (p=0.22)</p>
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		injections if pain interfered with the exercise. (n=70)				
Lombardi et al., 2008 ⁴⁷	<p>Patients from clinics of the Federal University of Sao Paulo with shoulder impingement syndrome. (n=60)</p> <p>Case definition: positive Neer and Hawkin tests, and pain rated between 3-8/10 using NRS.</p>	<p>Progressive resistance training program (PRTP): 2 sessions per week/8 weeks supervised by a physiotherapist; shoulder exercises using multi-pulley muscle-building equipment (flexion, extension, medial rotation, lateral rotation); 2 series of 8 repetitions (50% and 70% of maximum weight for 6 repetition).</p> <p>750 mg acetaminophen or 50 mg diclofenac every 8 hours as</p>	<p>Control group: wait list</p> <p>750 mg acetaminophen or 50 mg diclofenac every 8 hours as required for pain.</p> <p>(n=30)</p>	Post-intervention	<p>Primary outcome: Pain at rest and during movement (10 cm VAS).</p> <p>Secondary outcomes: Function (DASH 2, DASH 3); Quality of life (Brazilian SF-36); ROM (goniometer); Strength (peak torque and total work) (Cybex 6000); Analgesic and NSAID use (self-report); Satisfaction (5 point Likert scale).</p>	<p>Difference in mean change (PRTP – Control):</p> <p>Pain at rest (cm): 2.2 (95% CI 1.3; 3.1)^a</p> <p>Pain with motion (cm): 2.2 (95% CI 1.4; 3.0)^a</p> <p>DASH 2 (0-100): 17.7 (95% CI 9.3; 26.1)^a</p> <p>DASH 3 (1-100): 9.4 (95% CI 2.9; 16.0)^a</p> <p>Abduction (degrees): -22.6 (95% CI -32.2; -13.0)^a</p> <p>Extension (degrees): -4.2 (95% CI -7.7; -0.7)^a</p> <p>SF-36 physical function (0-100): -8.9 (95% CI -15.6; -2.2)^a</p> <p>SF-36 pain (0-100): -8.2 (95% CI -14.8; -1.6)^a</p> <p>SF-36 social function (0-100): -15.0 (95% CI -24.7; -5.3)^a</p> <p>SF-36 emotional role limitation (0-100): -21.0 (95% CI -34.8; -7.4)^a</p> <p>Total Work (joules)- extension: -9.7 (95% CI -18.7; -0.7)^a</p> <p>Total Work (joules)- medial rotation: -3.8 (95% CI -7.6; -0.1)^a</p> <p>No important difference in mean change for ROM (flexion, lateral Rotation, and medial rotation), SF-36 (physical role limitation, general health, vitality, and mental health domains), peak torque, or total work (lateral rotation, flexion, abduction, adduction, and lateral rotation)</p> <p>Statistically significant difference in average number of analgesic pills taken during study: PRTP: 2.0; Control: 14.4</p>

		required. (n=30)				Statistically significant difference in average number of NSAID pills taken during study: PRTP: 1.9; Control: 17.4
Ludewig and Borstad, 2003 ⁴⁸	Construction workers from Minnesota, USA with shoulder impingement syndrome (n=67) Case definition: Current pain localized to the glenohumeral joint with ≥2 positive shoulder impingement tests and pain reproduction during 2 of 3 addition tests	Home exercise: 8 weeks; instruction by therapist with 1-2 follow-up visits; daily stretching for pectoralis minor and posterior shoulder (30 second hold, 5 repetitions per day); relaxation exercise for upper trapezius; progressive strengthening for serratus anterior and rotator cuff 3x/week (week 1: 3 sets of 10 repetitions, week 2: 3 sets of 15 repetitions, week 3: 3 sets of 20 repetitions); resistance increased after 3 sessions of performing 3	Control: no treatment provided (n = 33)	Average of 10 weeks after initial visit (range 8-12 weeks)	Primary outcome: Shoulder pain and disability (SRQ; range: 17-100) Secondary outcomes: satisfaction (SRQ; 1-10), work-related pain (occupational pain score (1-10) using 6 questions from modified SPADI); work-related disability (occupational disability score (1-10)) using 4 questions from modified SPADI)	Difference in mean change (Home Exercise – Control): SRQ (17-100): -11.4 ^b Satisfaction (1-10): -1.5 ^b

		sets of 20 repetitions. (N=34)				
Maenhout et al., 2013 ⁵⁵	Adults (>18 y.o.) recruited by a specialized shoulder surgeon, Belgium. (n=61) Case definition: subacromial impingement symptoms with unilateral pain in the anterolateral region of the shoulder (≥3 months), painful arc, 2/3 positive impingement tests (Hawkins, Jobe and Neer), 2/4 positive resistance tests, and pain with palpation of suprapinatus	Traditional rotator cuff strength training combined with heavy load eccentric training (TT+ET) at home: twice a day for 3 sets of 15 repetitions at speed of 5"/repetition over 12 weeks; full can abduction in the scapular plane with a dumbbell weight; load increased once on pain during the last set of repetitions, dumbbell weight increased with 0.5kg; same exercise and physiotherapy treatment as the traditional rotator cuff training group. (n=31)	Traditional rotator cuff strength training (TT) at home: once a day for 3 sets of 10 repetitions at speed of 6"/repetition (2" concentric phase, 2" isometric phase and 2" eccentric phase) over 12 weeks; home-based internal and external rotation resisted with an elastic band; load increased once pain decreased; physiotherapy treatments (9 sessions, 1 session/week for first 6 weeks and 1 session/2 week for the following 6	Immediately after 12-week intervention	Isometric strength (N, dynamometer) ^c , shoulder pain and disability (SPADI, 0-100), subjective perception of improvement in shoulder pain (6 point scale, 0=no change, 5=very large improvement)	<u>Difference in mean change (TT+ET – TT)</u> Shoulder pain and disability (SPADI, 0-100): 1.3 (95%CI -7.0, 9.7) Relative risk of perception of improvement (some, large and very large improvement): 1.24 (95%CI 0.86, 1.77) ^a

	and/or infraspinatus tendon insertion.		weeks): information, glenohumeral and scapulothoracic mobilization, scapula setting and posture correction. (n=30)			
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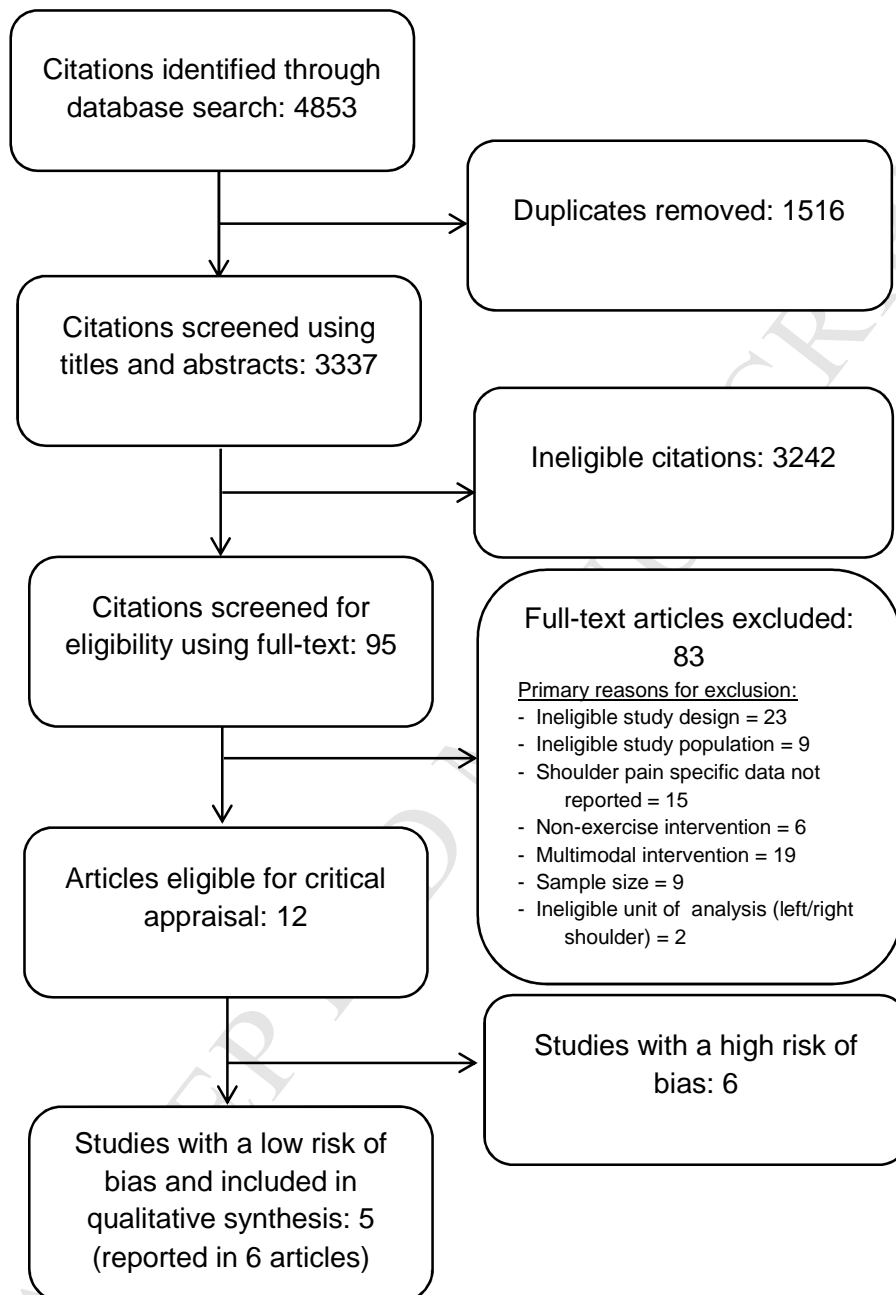
^aBetween group difference in mean change and 95% confidence intervals calculated by authors based on the assumption that pre- and post-intervention outcomes were highly correlated ($r=0.8$)^{29, 30}

^bNot possible to calculate precision for estimates related to ITT analysis, statistical significance based on calculation of 95% CI using data from original analysis.

^cResults are not accepted because the outcome assessor was not blinded to this examination-based outcome measure.

Acronyms: DASH: Disabilities of the Arm, Shoulder and Hand; ET: heavy load eccentric training; NRS: Numeric Rating Scale; NSAIDs: Non-steroidal Anti-inflammatory Drugs; ROM: Range of Motion; SDQ: Shoulder Disability Questionnaire; SF-36: the Short Form (36) Health Survey; SRQ: Shoulder Rating Questionnaire; SPADI: Shoulder Pain and Disability Index; TT: traditional rotator cuff strength training; VAS: Visual Analog Scale; y.o: years old

Figure 1: Identification and Selection of Articles



Highlights

- Evidence on exercise for shoulder soft tissue injuries is limited
- Rotator cuff strengthening/stretching is effective for subacromial impingement.
- Shoulder strengthening/stretching is effective for nonspecific shoulder pain.
- More research is needed

Appendix I: MEDLINE Search Strategy

1. Shoulder Pain/
2. Shoulder Impingement Syndrome/
3. Shoulder Joint/in [Injuries]
4. Rotator Cuff/
5. Shoulder/in [Injuries]
6. "Sprains and Strains"/
7. "shoulder*".ab,ti.
8. 6 and 7
9. (shoulder* and (pain or sprain* or strain* or injur* or impair* or impingement)).ab,ti.
10. (shoulder* and (tendinopathy or tendinitis or tendonitis or capsulitis)).ab,ti.
11. ((glenohumeral or scapul* or acromioclavicular) and (pain or sprain* or strain* or injur*)).ab,ti.
12. (rotator cuff and (sprain* or strain* or tear* or bursitis tendinitis or impingement)).ab,ti.
13. ((supraspinatus or infraspinatus or subscapularis or teres minor or teres major or trapezius or deltoid or bicep* or bicipital) and (impingement or strain* or tear*)).ab,ti.
14. biceps tendinitis.ab,ti.
15. painful arc.ab,ti.
16. (shoulder and capsul* and (sprain* or tear*)).ab,ti.
17. or/1-6
18. or/8-16
19. exp Exercise/
20. exp Exercise/
21. exp Exercise Movement Techniques/
22. exp Physical Fitness/
23. exp Physical Therapy Modalities/
24. exp Biofeedback, Psychology/
25. exp Combined Modality Therapy/
26. exp Motor Activity/
27. exp Muscle Strength/
28. Physical Endurance/
29. Physical Exertion/
30. Relaxation Therapy/
31. Behavior Therapy/
32. (alexander and (technique or method)).ab,ti.
33. dynamic muscle training.ab,ti.
34. "dynamic multimodal treatment protocol*".ab,ti.
35. "dynamic resisted strengthening exercise*".ab,ti.
36. (exercis* and (strengthening or home or fitness or neck or mobilization or mobilisation or mobility or supervis* or MedX)).ab,ti.
37. (exercis* and (eye-neck coordination or low load or low-load or low-tech or Mackenzie or proprioceptive or strength* or aerobic or therapy)).ab,ti.
38. (exercis* and (stretch-shortening or stretch shortening or postural)).ab,ti.

39. (training and (fitness or endurance or physical or postural or program* or strength* or supervis* or plyometric)).ab,ti.
40. (rehabilitat* and (eye-head coupling or program* or training)).ab,ti.
41. Feldenkrais.ab,ti.
42. "behavio* graded activity program*".ab,ti.
43. (stretch* and (active or ballistic or dynamic or isometric or static)).ab,ti.
44. "early active mobili*".ab,ti.
45. physical conditioning.ab,ti.
46. (shoulder and (isometric or endurance or strength* or training)).ab,ti.
47. (physiotherap* and (program* or regimen*)).ab,ti.
48. (physical therap* and (program* or regimen*)).ab,ti.
49. pilates.ab,ti.
50. kinesthesia.ab,ti.
51. Proprioceptive Neuromuscular Facilitation.ab,ti.
52. (scapul* and (repositioning or positioning or rehabilitat* or strength* or mobilis* or mobiliz*)).ab,ti.
53. (Qigong or Qi Gong or Ch'i Kung).ab,ti.
54. (Tai-ji or Tai Chi or Tai Ji Quan or Tai Ji or Taiji or Taijiquan or T'ai Chi or Tai Chi Chuan).ab,ti.
55. Practice Guidelines as Topic/
56. Guideline Adherence/
57. exp Controlled Clinical Trials as Topic/
58. consensus development conferences as topic/
59. exp case-control studies/
60. exp Cohort Studies/
61. Double-Blind Method/
62. Single-Blind Method/
63. Placebos/
64. randomized controlled trial.pt.
65. controlled clinical trial.pt.
66. practice guideline.pt.
67. guideline.pt.
68. consensus development conference.pt.
69. (meta analys* or meta-analys* or metaanalys*).ab,ti.
70. (cohort adj4 (study or studies or analys*)).ab,ti.
71. (random* adj4 (control* or clinical or allocat*)).ab,ti.
72. "guideline*".ab,ti.
73. (case adj control*).ab,ti.
74. ((double or single) adj3 blind*).ab,ti.
75. "placebo*".ab,ti.
76. or/19-54
77. or/55-75
78. or/17-18
79. 76 and 77 and 78
80. limit 79 to (english language and yr="1990 -Current")

Appendix II: Articles Deemed Irrelevant During Full Text Screening (with Primary Reasons for Exclusion)

Primary reasons for exclusion:

- Ineligible study design or publication type¹⁻²⁴
- Ineligible study population²⁵⁻³¹
- Shoulder pain specific data not reported³²⁻⁴⁷
- Non-exercise intervention^{48, 49}
- Cannot isolate the effectiveness of exercise^{50, 51}
- Multimodal intervention⁵²⁻⁶⁹
- Sample size too small⁷⁰⁻⁸⁰
- Ineligible unit of analysis (left/right shoulder)^{81, 82}
- Non-English language⁸³

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Appendix III: Description of Exercises in the Studies with Low Risk of Bias

Author, Year, Reference	Description of Exercises
Ginn and Cohen, 2005 ¹	<p>Exercise treatment was directed toward the restoration of normal shoulder muscle function in order to restore dynamic stability and muscle co-ordination at the shoulder region. This comprised stretches aimed at lengthening shortened shoulder muscles, exercises aimed at strengthening weakened shoulder muscles, including improving co-ordination between muscles, and motor retraining aimed at restoring scapulohumeral rhythm during the performance of upper limb tasks. All exercises were to be pain-free and subjects in this treatment group were also advised to avoid/limit pain producing activities. Particular emphasis was placed on restoring the normal muscle force couple co-ordination and the dynamic stabilizing function of shoulder muscles. The exercise treatment was devised and upgraded using motor learning principles designed to improve shoulder function by gradually increasing the complexity of the exercises. Full range movements of the shoulder were considered to be difficult exercises in this treatment group as they involve multiple shoulder muscle force couples. The specific exercises for each of the subjects was individually determined by the treating physical therapist, using data from the initial interview and musculoskeletal assessment and</p>

	<p>any additional information gathered by the treating physical therapist. The exercise treatment was administered as a home-based, daily exercise program with supervision by the physical therapist once per week, to correct and upgrade the intensity and complexity of the exercises.</p>
<p>Ketola et al., 2009/2013^{2,3}</p>	<p>The aim of the supervised exercise treatment was to restore painless, normal mobility of the shoulder complex and to increase the dynamic stability of the glenohumeral joint and the scapula. Series of long painless movement with repetition were undertaken with the aim of strengthening the tendons. Patients were instructed to do nine different exercises at least four times a week, with three courses of 30 to 40 repetitions. As the self-assessed ability and strength improved, resistance was increased and repetitions diminished. The progress was evaluated at control visits (mean of seven) and continued until the patient and the therapist considered that the trainee was independently able to maintain the practise level.</p>
<p>Lombardi et al., 2008⁴</p>	<p>The patients in the exercise group participated in the muscle strength assessment using a repetition maximum (RM) exercise in which patients performed 6 repetitions with the maximum bearable weight, thereby determining the 6 repetition maximum (6 RM). Once the 6 RM load was determined, training was divided into the following regimen: 2 series of 8 repetitions, the first series with 50% of the 6 RM and the second series with 70% of the 6 RM, respecting the patient's pain threshold; the exercise was interrupted if the patient felt pain and performed another</p>

	<p>movement. Between the first and second series, there was a resting period of 2 minutes; the speed of movement was 2 seconds for both the eccentric and concentric phases. The exercises were flexion, extension, medial rotation, and lateral rotation of the shoulder. Training was carried out twice a week for a period of 8 weeks. The 6 RM load was reevaluated every 2 weeks.</p> <p>Multipulley muscle-building equipment was used for the exercises. To strengthen the flexors of the shoulder, the patient was positioned with his or her back to the equipment and the elbow flexed at 90°, the patient performed the flexion movement of the shoulder from 0° to 90°. In the extensor strengthening exercise, the patient faced the equipment with the elbow flexed at 45° and the shoulder at 60° of flexion and 30° of extension. In the strengthening of the medial and lateral rotators, the patient was positioned alongside the equipment with the elbow flexed at 90°; for the medial rotation, the patient started at 45° of lateral rotation and moved to 45° of medial rotation; for the lateral rotation, the patient began the movement at 45° of medial rotation and moved to 30° of lateral rotation.</p>
Ludewig et al., 2003 ⁵	<p>Intervention subjects were asked to perform two stretches for 30 seconds each repetition and five repetitions each day. The pectoralis minor stretch was performed by asking the subject to place each hand at shoulder height on adjacent walls of a corner and lean into the corner. The second</p>

stretch for the posterior shoulder was performed by reaching towards the opposite scapula and then using the uninvolved hand to further horizontally adduct the humerus until a stretch was achieved. A muscle relaxation exercise for the upper trapezius was performed five times daily by having the subjects raise the arm overhead in the scapular plane without shrugging the shoulder. Relaxation was enhanced through visual input by performing the exercise in front of a mirror, or by proprioceptive input by placing the uninvolved hand on the active upper trapezius.

Subjects were instructed to perform progressive resistance strengthening exercises three days per week for two muscle groups. For the serratus anterior muscle, strengthening was performed supine by protracting the scapula and raising a hand held weight superiorly. Humeral external rotation was resisted with Thera-Band (blue resistance level; The Hygenic Corporation, Akron, OH, USA) while subjects were in a standing position. Subjects were instructed to progress from an initial position of the arm close to their side, to a position of abduction of the arm. For both strengthening exercises, subjects were instructed to perform three sets of 10 repetitions the first week, progress to three sets of 15 repetitions the second week, and three sets of 20 repetitions the third week. After achieving three sets of 20 repetitions for three consecutive sessions, subjects were to further progress their programme by increasing weight resistance or Thera-Band tension (by shortening the band), and repeating

	<p>the repetition sequence as described. Subjects were instructed that exercises may induce muscle fatigue but should not cause increased shoulder pain.</p>
Maenhout et al., 2013 ⁶	<p>The eccentric phase of full can (thumb up) abduction in the scapular plane was performed with a dumbbell weight. Patients were instructed to perform the eccentric phase at a speed of 5"/repetition. Three sets of 15 repetitions were performed twice a day. Starting position of the eccentric phase at full scapular abduction had to be pain free, and, if not, patients were advised to stretch out the arm at a slightly lower degree of scapular abduction. Dosing the eccentric exercises was based on the pain monitoring model.</p> <p>Three conditions had to be met:</p> <ol style="list-style-type: none">1. During the last set of 15 repetitions, the patient should feel pain exceeding the pain at rest, but no more than a score of 5 on the VAS (0–10) is allowed.2. Pain after the exercise should not exceed 5 on the VAS and should have subsided the following morning.3. Pain should not increase from day to day. <p>Whenever the pain was no longer present during the last set of repetitions, dumbbell weight was increased with 0.5 kg.</p>

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