Systematic Review

Manual therapy and exercises for shoulder impingement revisited

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Background: Disorders related to shoulder impingement are consistently classified as the most common diagnostic subgroup of shoulder pain. A variety of interventions for shoulder impingement have been proposed, including manual therapy and exercises. Despite a growing body of evidence on these interventions, their effectiveness has not yet been conclusively established.
Objectives: To establish the current state of evidence on the effectiveness of manual therapy and exercises to improve patient-centered outcomes in adults with shoulder impingement.
Methods: This systematic review updates a previous systematic review by the same authors. It includes evidence from randomized controlled trials published between October 2008 and September 2012. Comprehensive searches were made of seven relevant electronic databases including MEDLINE, Cochrane CENTRAL, CINAHL, and PEDro, supplemented by further sources. Methodological quality was assessed with the PEDro scale.
Results: Nine randomized controlled trials were included and synthesized narratively. The trials varied considerably in methodological quality and reporting quality, as well as in terms of the interventions and comparisons considered, and in the outcome measures used. Clinical heterogeneity precluded meta-analysis. The trials provide limited evidence to support the effectiveness of a diversity of manual therapy and exercise approaches for treating shoulder impingement.
Conclusions: This systematic review update provides some further evidence supporting the effectiveness of manual therapy and exercises for shoulder impingement, but methodological deficits/risk of bias warrant cautious interpretation. Further research is needed to establish the optimal manual therapy and exercise techniques and parameters.

Keywords: Manual therapy, Randomized controlled trials, Shoulder impingement syndrome, Systematic review, Therapeutic exercise

Introduction

Disorders related to 'shoulder impingement' are consistently classified as the most common diagnostic subgroup of shoulder pain.[1–3] Since Neer[4] first described 'subacromial impingement' as a clinical entity, the term 'shoulder impingement' has widely been used synonymously as a diagnostic label that encompasses a characteristic clinical presentation of shoulder pain associated with a wide range of structural pathologies of the rotator cuff muscles and the subacromial (and subdeltoid) bursa.[5] Typical signs and symptoms include pain with overhead activities, a 'painful arc', pain through specific manoeuvers such as shoulder elevation with internal rotation, or possibly signs of impaired rotator cuff function.[6,7]

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As yet, the etiology, epidemiology and pathophysiology of shoulder impingement are not sufficiently understood.[8,9] Also, the viability of shoulder impingement and other diagnostic labels for shoulder pain have increasingly been questioned due to concerns as to uniformity, validity and reproducibility.[8–15]

For the present, though, much of the published research addresses subgroups of shoulder pain which clinicians would recognize as shoulder impingement. In this connection, a review on physiotherapy interventions for shoulder pain, Green *et al.*,[16] found that the patient groups studied in primary shoulder pain research could usually be dichotomized into those with stiffness (capsulitis-type conditions) and those without stiffness (impingement-type conditions). We previously incorporated this observation by operationalizing 'patients with impingement-related shoulder pain' as 'patients with pain arising locally in a shoulder with grossly normal mobility'.[6]

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Manual therapy and exercises are common elements of physiotherapy treatments for shoulder pain,[17] and there is a growing body of evidence on the role of these approaches in the treatment of shoulder impingement.[6] Still, their effectiveness has not yet been sufficiently established.[6,18–20]

This systematic review updates a previous systematic review on 'the effectiveness of manual therapy and exercise interventions for impingement-related shoulder pain',[6] which was published in this journal. Our previous review supplemented evidence from existing systematic reviews with evidence from randomized controlled trials (RCTs) that postdated their searches. Based on limited evidence from eight systematic reviews and six RCTs, we concluded that manual therapy and exercise interventions appear effective in improving pain, disability and shoulder function in patients with shoulder impingement. The evidence mainly related to subacute and chronic complaints, and to short- and medium-term follow-up. Heterogeneity of populations, interventions and outcomes hampered the synthesis of RCT results and precluded meta-analysis. Varying methodological quality and risk of bias as well as deficiencies in reporting warranted cautious interpretation of our findings and impacted on the strength of our conclusions. There was no evidence on the use of manual mobilization alone, for rotator cuff tears or for acute impingement. Also, we found that it was not possible to conclude which was the 'best' type or dosage of manual therapy or exercise intervention for the population of interest. For details see our 2010 report.[6] Regarding key implications for further research, we highlighted a need for RCTs on manual therapy and exercises for patients with rotator cuff tears or acute impingement; for RCTs on different types of exercises and manual mobilization interventions (duration, type, frequency); and for RCTs of higher methodological and reporting quality.

Since our previous systematic review, systematic reviews on the effectiveness of conservative interventions for impingement-related shoulder disorders (including partial-thickness rotator cuff tears) have proliferated.[18–27] However, the most recent search cut-off date among these is November 2010.[20] Since we were aware of several relevant RCTs which postdated this date, we perceived a need for a more up-to-date synthesis to inform evidence-based practice. We therefore present an update of our previous review.

Methods

Research question and review design

The research question was, 'Are manual therapy and exercises effective in improving patient-centred outcomes in patients with impingement-related shoulder pain?' We were interested in different types of comparisons which are specified further below. As this review constitutes an explicit systematic review update, the methods are to a great extent predefined by our previous review[6] and are only briefly reported here.

Review criteria

Types of research

We included RCTs and quasi-RCTs. Inclusion was restricted to published full reports in English or German of fully-implemented (i.e. not pilot) trials.

Types of participants

We adopted our previous approach to the population of interest. The full eligibility criteria of our previous review are presented in our previous report.[6] Recognizing that definitions of shoulder impingement are diverse, we aimed to address a reasonably homogeneous population. Based on our previous set of inclusion criteria, we defined three key criteria for this update: First, trials had to clearly address a population of adults with shoulder pain and a diagnosis of any impingement-related disorder (e.g. shoulder impingement, bursitis, rotator cuff disorders including partial-thickness tears). Second, trials had to specify at least one clinical 'impingement sign' among their selection criteria (e.g. painful arc, Neer's sign or Hawkins–Kennedy impingement test). Third, trials had to explicitly exclude patients with substantive restrictions of shoulder range of motion (ROM; i.e. capsulitis-type disorders, frozen shoulder). We included any trial that fulfilled all of these criteria, and excluded any that did not. We excluded trials on shoulder pain due to any other disorder such as shoulder joint degeneration, post-surgery conditions, cervical nerve root disorders or systemic diseases (e.g. rheumatoid arthritis).[6]

For this update we further excluded trials that specifically addressed full-thickness rotator cuff tear populations, as these often show some distinctive clinical features (e.g. muscle weakness) and are commonly viewed as a separate diagnostic entity. No restrictions were made on the impingement stage, epidemiologic factors or care settings. We tabulated the full eligibility criteria of all included trials to offer them for inspection and discussion (Table 3).

Types of interventions

For a trial to be included, at least one of its interventions had to be a manual or exercise intervention, and comparisons had to be designed to assess the effectiveness of a manual therapy or exercise intervention. We accepted as comparators: no treatment, a different manual therapy or exercise treatment, any other conservative treatment, or surgery. We defined 'manual therapy' in accordance with the current definition of the International Federation of Orthopedic Manipulative Physical Therapists.[28] 'Exercises' was not restricted to any

specific type of supervised or home-based exercise regimes. Physical therapy modalities (e.g. heat or cold applications) as part of the treatment were allowed but only to the extent that they were clearly applied only as a supplement to manual therapy, exercise or both. We excluded research on alternative therapies (e.g. osteopathy, chiropractic) in the interests of clinical homogeneity. Provision of treatment by a physical therapist was obligatory.

Types of outcomes

As in our previous review,[6] the outcomes chosen are those considered to be most relevant to patients and clinical decision makers. This update focuses on the following outcomes: pain, disability, health-related quality of life, and self-perceived change. Reporting of at least one of these outcomes was a prerequisite for trial inclusion. We further documented any reports of adverse events.

Search and selection process

Searches covered the period from October 2008 (the search cut-off for our previous review) to 30 September 2012 (week 39). To allow for a potential delay between publication and database entries, we also searched back from June 2008. Searches were made of the Cochrane Central Register of Controlled Trials (OVID), MEDLINE (EBSCO), Embase (OVID), CINAHL (EBSCO), and PEDro. All searches were independently run by two researchers (CB/MB or CB/JH). We applied the same search strategies as in our previous review. For an overview of search terms and filters (as applied in Embase), see Fig. 1. The databases' 'related article functions' served as an additional source, as did the reference lists of relevant papers. Also, for this update two German databases, 'Thieme Connect' and 'Physiotherapeuten.de', which host the archives of the major German physiotherapy journals, were searched.

The formal selection process comprised two steps and was documented in compliance with PRISMA standards[29] (Fig. 2). First, the titles and abstracts of all results were screened. Irrelevant or duplicate reports were removed. Second, the full texts of all remaining reports were obtained to further verify their suitability for inclusion. The selection process for the results of all database searches was independently done by two researchers (CB/MB or CB/JH). Where there was disagreement about a trial's eligibility, decisions were reached through discussion and consensus (CB/MB/JH). We documented the reasons for exclusion for all studies that were excluded during the second screening step (Table 1).

Data analysis and synthesis

Assessment of quality

For consistency with our previous review, all trials were assessed for methodological quality at trial level using the PEDro scale (Table 2).[30] As in our previous review, we limited ourselves to using the PEDro tool in a qualitative manner, and we deliberately refrained from displaying actual score values.[6] The PEDro tool allows for an overall assessment of the methodological quality of RCTs, but does not provide a standard framework for the derivation of judgments on risk of bias. Consequently, judgments have to be made individually by inspecting the PEDro ratings for the relevant items. Whereas some of the PEDro items (namely, items 2–9) are either known (2, 3, 5, 6, 7) or presumed (4, 8, 9) to potentially affect risk of bias;[31] others (1, 10, 11) primarily relate to the comprehensiveness of reporting. In order to facilitate judgments on risk of bias, we have highlighted in bold items 2, 3, 5, 6, and 7 as 'key risk of bias items', and have ordered the trials in order of the number of 'yes' ratings for these items, from the highest to the lowest (Table 2). Where the number of 'yes' ratings was the same for two or more trials, we have further ordered these according to the number of 'yes' ratings for items 2–9. We deliberately refrained from defining any arbitrary cut-offs for 'good' or 'bad' quality, or for 'low' or 'high' risk of bias.

All ratings of methodological quality were independently done by two researchers (CB/MB or CB/JH). In addition, we compared our ratings with those provided in the PEDro database. Where there was disagreement, decisions were reached through consensus (CB/MB/JH).

All findings were analyzed descriptively. Data extraction was done by two reviewers (CB/MB or CB/JH) using a pre-developed form. Details on the assessment of methodological quality as well as on the characteristics and outcomes of the included trials were presented in summary tables. We proposed to undertake meta-analyses where appropriate but clinical heterogeneity rendered these inappropriate (see further).

Our presentation of results focuses on between-group effect measures for the outcomes of interest. For continuous data, we tabulated mean differences and confidence intervals. For binary data, we tabulated proportions, relative risks and numbers needed to treat. Where relevant statistics were not reported, and where it was possible and suitable, we calculated them from the data provided, using the Cochrane Collaboration's 'RevMan 5.1.7' software. We further documented 'Minimal Clinically Important Difference' (MCID) estimates, either as reported or as available from the literature, to enhance interpretation of clinical significance.

Results

Eight hundred and forty-two results were yielded by the formal systematic search process dated week 39,

#	Search terms
1	Shoulder pain/
2	Shoulder Impingement Syndrome/
3	(shoulder and (impingement or bursitis or tendinopath$ or tend#nitis)).ti,ab.
4	(subacromial adj6 impingement).ti,ab.
5	painful arc.ti,ab.
6	rotator cuff.ti,ab.
7	1 or 2 or 3 or 4 or 5 or 6
8	Manipulative Medicine/
9	Kinesiotherapy/
10	Physiotherapy/
11	manual therap$.ti,ab.
12	mobili#ation.ti,ab.
13	exercis$.ti,ab.
14	physical therap$.ti,ab.
15	physiotherap$.ti,ab.
16	8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
17	7 and 16
18	random$.ti,ab.
19	placebo$.mp.
20	double-blind$.ti,ab.
21	18 or 19 or 20
22	17 and 21

Publication type string: Wong et al. (2006) [60]

Figure 1 Embase (OVID) search strategy.

2012 (Fig. 2). Our definite cut-off was 30 September. No additional results were yielded through the reference lists of relevant papers. After de-duplication, the titles and abstracts of 364 results were assessed. Of these, 334 were excluded on first screening. Of the remaining 30 trials, 21 were excluded on second screening. For reasons, see Table 1. Nine trials[32–41] were finally included in the review, all of which were RCTs, and all in English. One trial[35,36] was represented by two reports (different follow-up periods).

Sample sizes ranged from 14[32] to 140,[38] and the total number of participants was 664 (Table 3). In five trials,[34–39] sample sizes were based on formal sample size calculations.

The majority of trials nominally addressed shoulder (or subacromial) impingement; one trial[35,36] used the label 'subacromial pain', and two trials[32,40] labeled their populations as addressing patients with supraspinatus and/or biceps tendinopathy. All trials specified at least some clinical inclusion criteria consistent with the criteria as defined for this review. The most commonly specified criteria were positive responses to impingement tests (e.g. Neer's sign or Hawkins–Kennedy test) and provocation of pain or signs of dysfunction with tests for the rotator cuff muscles (e.g. Jobe or Speed tests). All of the trials satisfied the criterion of excluding patients with shoulder ROM restrictions and/or capsulitis-type disorders. Engebretsen *et al.*[35,36] restricted inclusion

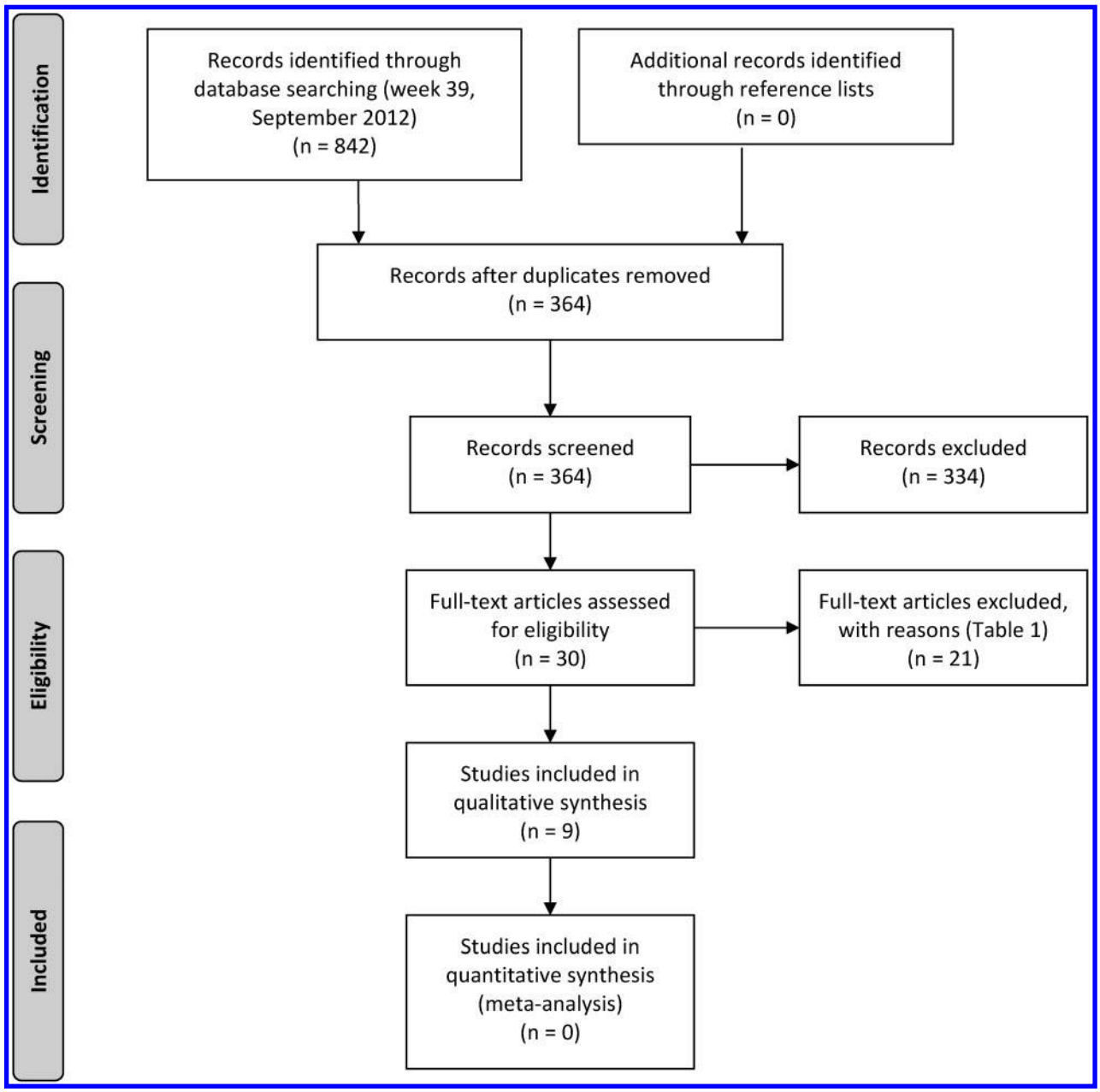

Figure 2 PRISMA[29] flow diagram, search, and selection process.

to patients with 'normal passive glenohumeral range of motion', but reported that for three participants, the diagnosis was changed from impingement to adhesive capsulitis during the treatment period. From the information provided, we assume that these patients were not excluded from the analyses. As these represent a very small proportion of the 104 participants (<3%), we did not exclude this trial. Five trials did not exclude patients with rotator cuff tears. Three trials[32,38,41] excluded patients with full-thickness tears, and one trial[39] excluded patients with either partial-thickness or full-thickness tears. No trial specifically addressed a population of patients with partial-thickness rotator cuff tears.

All trials addressed adult patients. The summary mean age of the participants across the trials, calculated from the provided data, was approximately 50 years. Of the 582 participants whose sex was defined, 57% were female and 43% male. The trials mainly addressed subacute (6 weeks to 3 months) and chronic (more than 3 months) shoulder pain. None specifically dealt with acute (up to 6 weeks) impingement. Inexplicit reporting of settings was commonplace, but the available information implied that all trials were conducted in outpatients within secondary care (sites receiving referrals from points of primary healthcare contact).

The interventions and comparisons varied widely across the trials. Of the nine trials, seven[32–34,37,39–41] compared exercise treatments (with or without manual mobilization) with some other exercise treatment (with or without manual mobilization). Of these, one trial[40] compared three rather than two interventions. Whereas home exercises were commonly part of the

Table 1 List of excluded trials (second screening)

Study	Main reason for exclusion
Atkinson *et al.* 2008[61]	Intervention/provision criteria not satisfied: chiropractic intervention delivered by chiropractors
Bansal *et al.* 2011[62]	Population criteria not satisfied: insufficient compliance with the criteria as defined for this review (specifically regarding exclusion of patients with frozen shoulder/substantive ROM restrictions)
Bae *et al.* 2011[49]	Population criteria not satisfied: insufficient compliance with the criteria as defined for this review (specifically regarding exclusion of patients with frozen shoulder/substantive ROM restrictions)
Bennell *et al.* 2010[50]	Population criteria not satisfied: insufficient compliance with the criteria as defined for this review (specifically regarding exclusion of patients with frozen shoulder/ substantive ROM restrictions)
Bergmann *et al.* 2010a,[63] b[64]	Population criteria not satisfied: non-specific shoulder pain population
Bialoszewski and Zaborowski 2011[51]	Population criteria not satisfied: insufficient compliance with the criteria as defined for this review (specifically regarding exclusion of patients with frozen shoulder/substantive ROM restrictions)
Bron *et al.* 2011[65]	Population criteria not satisfied: non-specific shoulder pain population
Calis *et al.* 2011[66]	Intervention criteria not satisfied: same exercise treatment + hotpack alone or in combination with either therapeutic ultrasound or laser
Celik *et al.* 2009[67]	Language criterion not satisfied: full text in Turkish
Crashaw *et al.* 2010[68]	Intervention criteria not satisfied: corticosteroid injections before physical therapy versus physical therapy alone
Djordjevic *et al.* 2012[56]	Outcome criterion not fulfilled: did not include any of the outcomes as defined of interest for this review
Hakguder *et al.* 2011[69]	Study type criteria not satisfied: non-RCT; patients were allocated to two groups according to the diagnosed impingement stage
Johansson *et al.* 2011[70]	Intervention criteria not satisfied: combination of acupuncture and home exercises versus subacromial corticosteroid injections
Just and Stelzer *et al.* 2009[71]	Eligibility criteria not fully satisfied: no specification of clinical presentation
Kaya *et al.* 2011[72]	Intervention criteria not satisfied: Kinesiotape + home exercise program (HEP) versus 'local modalities' (ultrasound, TENS, hot pack) + same HEP
Mörl *et al.* 2011[73]	Population criteria not satisfied: non-specific shoulder pain population
Moosmayer *et al.* 2010[74]	Population criteria not satisfied: patients with full-thickness rotator cuff tears only
Østeras *et al.* 2008,[52] 2009,[53] 2010[54]	Population criteria not satisfied: insufficient compliance with the criteria as defined for this review (specifically regarding exclusion of patients with frozen shoulder/substantive ROM restrictions)
Ozgen *et al.* 2012[75]	Intervention criteria not satisfied: sodium hyaluronate (SH) injections vs 'physical therapy modalities' (PTM) = TENS + ultrasound + hotpack (+ home exercises for both groups)
Surenkok *et al.* 2009[76]	Population criteria not satisfied: mixed population, included patients with frozen shoulder
Yiasemides *et al.* 2011[55]	Population criteria not satisfied: insufficient compliance with the criteria as defined for this review (specifically regarding exclusion of patients with frozen shoulder/substantive ROM restrictions)

trials' interventions, the trial by Senbursa *et al.*[40] was alone in including an explicit unsupervised self-exercise group. One trial[38] compared a physical therapy treatment including exercises and mobilization with arthroscopic subacromial decompression followed by a post-operative physical therapy treatment. This trial was labeled as investigating the effectiveness of adding surgery to a supervised exercise program, and at first sight appeared ineligible. However, we considered that the surgery and post-surgical physiotherapy were an integral package which could legitimately be compared with stand-alone physiotherapy within the scope of our review. One trial[35,36] compared a supervised exercise regime with extracorporeal shock-wave treatment.

The duration of interventions ranged from 4[32] to 12 weeks.[35–37,39,40] Follow-up ranged from 4 weeks[32,40] to 2 years.[38]

The most commonly assessed outcomes (of those considered for this review) were shoulder disability

Table 2 PEDro assessment results

PEDro criterion/ trial	1. Eligibility criteria	2. Random allocation	3. Concealed allocation	4. Baseline comparability	5. Blind subjects	6. Blind therapists	7. Blind assessors	8. Adequate follow-up*	9. Intention-to-treat	10. Between-group comparisons	11. Point estimates and variability
Beaudreuil *et al.* 2011[34]	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
Holmgren *et al.* 2012[37]	✓	✓	✓	✓	✓	×	✓	✓	×	✓	✓
Engebretsen *et al.* 2009,[35] 2011[36]	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓
Ketola *et al.* 2009[38]	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓
Maenhout *et al.* 2012[39]	✓	✓	×	✓	×	×	×	✓	✓	✓	✓
Baskurt *et al.* 2011[33]	✓	✓	×	✓	×	×	×	✓	×	✓	✓
Senbursa *et al.* 2011[40]	✓	✓	×	✓	×	×	×	✓	×	✓	✓
Subasi *et al.* 2012[41]	✓	✓	×	✓	×	×	×	×	×	✓	✓
Barbosa *et al.* 2008[32]	✓	✓	×	×	×	×	×	×	×	✓	✓

Note: ✓=yes; x=no.
*In trials with more than one point of follow-up, a 'yes' rating for this item is given if adequate follow-up was satisfied at one of the points. See Table 3 for the actual rates for all follow-ups.

(shoulder function) and pain. These were assessed with different measures. Pain was most commonly measured using a VAS. In one trial,[35,36] a Likert-type scale was used, and in another a subscale of the Constant–Murley Score.[34] There was a considerable heterogeneity in the assessment of pain, which included pain during movement, at rest or at night. Shoulder function and disability were measured with six different, validated questionnaires, but most often with the Constant–Murley Score. Two trials[37,39] included the assessment of self-perceived improvement using a Likert approach. Health-related quality of life was mainly assessed as an integral part of disability questionnaires (e.g. WORC). In only one trial[37] was a generic quality of life instrument used (Euro-Quol; EQ-5D and EQ-VAS).

Apart from Engebretsen *et al.*,[35,36] none of the reports explicitly mentioned adverse events. Engebretsen *et al.*[35,36] reported aggravations of pain in two out of 104 participants and a 'considerable increase in pain and stiffness' for another, whose diagnosis was changed to adhesive capsulitis after only four treatments. We found some scattered statements in further reports, including, 'no major surgical complications',[38] and 'none of our patients showed signs of rotator cuff injury'.[40]

We obtained MCID estimates on shoulder pain populations for the following outcome measures from the trial reports and elsewhere in the literature, and included them in the results table (Table 3): DASH (10.2 points);[42,43,47] SPADI (8, 10, 13.2, 20 points);[42,44,45] and WORC [245.2, 275 points (11.7, 13%)].[42–44,46] The only shoulder-specific MCID estimate on VAS (pain) that we found relates to 'current level of overall pain' (1.4 cm[48]). As this does not comply with how pain was measured in the trials, we decided not to present it with the results.

Methodological quality and risk of bias

Methodological quality, qualitatively assessed using the PEDro checklist, varied considerably across the trials (Table 2). Items 1 ('eligibility criteria'), 2 ('random allocation'), 10 ('between-group comparisons'), and 11 ('point estimates and variability') were satisfied by all trials. Item 4 ('baseline comparability') was addressed and assured by all but one trial report.[32] Item 8 ('adequate follow-up') was satisfied by seven trials.[33–40] The remaining aspects were not conducted or reported as consistently. Only four trials[34–38] satisfied item 7 ('blind assessors'). Item 3 ('concealed allocation') was only satisfied by the same four trials. Just two trials[34,37] satisfied item 5 ('blind subjects').

Evidence for effectiveness of interventions

Only outcomes relevant to the present review are considered. Full details, including all relevant effect

Table 3 Characteristics and results of included trials

Study	Participants	Interventions	Outcomes and follow-up	Results
Barbosa *et al.* 2008[32]	*N*[†]=14 *Inclusion:* Patients with chronic tendinopathy of the supraspinatus and/or biceps brachii muscles; adults; shoulder pain and/or dysfunction for >6 months *Clinical criteria:* Pain on palpation of the supraspinatus and/or biceps brachii muscle tendons; positive in one or more special tests for supraspinatus (e.g. Jobe test) or biceps brachii tendon (e.g. Speed or Yergason tests) dysfunction *Exclusion:* Diagnosis of a frozen shoulder, complete rotator cuff ruptures (one or more tendons), closed calcified tendinopathy *Duration of symptoms:* No information provided *Age, mean years (SD*[‡]*)*: 46.14 (7.62) *Sex, numbers females/males:* 9/5 *Setting*: Outpatient; Physical Therapy Section, University hospital; Sao Paulo, Brasil; referral for physiotherapy by orthopaedists	*Group A* (n=7): Eccentric muscle training ('empty can movement' (abduction movements in scapular plane with medial rotation) for supraspinatus; 'right curl movement' (elbow flexion with arm abducted beside the body) for biceps brachii; manual resistance by therapist (researcher) ('respecting patients' pain limit'); 3×20 rep/session. Joint mobilization: accessory movements: front, back, lower longitudinal and lateral relaxation for glenohumeral joint; anteroposterior mobilization of acromioclavicular joint; antero-posterior, inferior-superior and superior-inferior mobilization of the sternoclavicular joint. 2 series/session of 1 minute. mobilization for each movement (2–3 cycles per second)+1 minute of active free abduction in scapular plane *Group B* (*n*=7): Eccentric exercises as for group A; no mobilizations *Both groups*: Therapeutic ultrasound (supraspinatus or biceps tendon) *Duration/frequency*: Both groups: 10 sessions, 3/week (conclusion within 4 weeks)	*Shoulder 'functional capacity'*: Disabilities of the Arm, Shoulder and Hand questionnaire (DASH), *score 0–100* (0=best shoulder function). Available MCID[$] estimate: 10.2 points Constant–Murley Score (CMS), score 0–100 (100=best shoulder function) *Follow-up (rate)*: at end of t-reatment=within 4 weeks after commencement of treatment (rate unspecified)	For all results: between-group MD[‖] (95% CI[¶]) at end of treatment (after 4 weeks); CI calculations based on numbers randomized *Shoulder functional capacity*: DASH: 15 (7.84–22.16) favoring group A CMS: 10.29 (3.86–16.72) favoring group A

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
Baskurt *et al.* 2011[33]	*N*=40 *Inclusion:* Patients with unilateral subacromial impingement syndrome (Neer stages I & II) *Clinical criteria:* Pain reproduction through Neer, Hawkins and Jobe tests *Further assessment:* radiography & ultrasonography for confirmation of diagnosis (not further specified) *Exclusion:* Adhesive capsulitis, restricted range of motion < 140° of shoulder elevation; shoulder instability; cervical pathology; upper extremity neurological deficit; upper extremity surgery; musculoskeletal and cardiovascular pathologies limiting rehabilitation *Duration of symptoms,* mean months (SD): 10,1 (10.2) *Age,* mean years (range)*:* 51 (24–71) *Sex,* numbers females/males: 27/13 *Setting:* University Physiotherapy and Rehabilitation Department, Isparta/Turkey; clinical diagnosis by orthopaedic surgeon	Group I (*n*=20): Supervised standardized set of exercises; shoulder flexibility (shoulder capsule stretching, flexion/abduction/internal rotation mobilizing/stretching exercises); strengthening (subscapularis, supraspinatus, infraspinatus, anterior and posterior deltoid); 'Codman exercises'. Individual progression through number of repetitions (3 sets of up to 10 repetitions for each exercise) and strength of elastic bands. *Intensity:* 'without feeling substantial pain or fatigue' Group II (*n*=20), experimental group: Same program as group I; addition of a supervised standardized set of scapular stabilization exercises (scapular proprioceptive (PNF) exercises, 'scapular clock exercise', 'standing weight shift', 'double arm balancing', scapular depression, wall push-up, wall slide exercises) *Duration/frequency*: 6 weeks, 3 times/week	*Pain:* *At rest/during activity:* VAS, 0–100 mm, not further specified *Disability, Health-related quality of life (HrQoL):* Western Ontario Rotator Cuff Index (WORC), score 0–2100 (0=best); WORC was evidently reported as percentages rather than raw scores (100=best) Available MCID estimates: 245.26, 275 points (11.7%, 13%) *Follow-up (rate):* at end of treatment=at 6 weeks (100%)	For all results: between-group MD (95% CI) at 6 weeks *Pain:* *At rest:* 0.55 (−0.36–1.46) favoring group II *During activity:* 0.20 (−0.95–1.35) favoring group II *Disability, HrQoL:* WORC : 11.79 (2.04–21.54) favoring group II (Note: trial report specifies this result as statistically non-significant)

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
Beaudreuil *et al.* 2011[34]	*N*=69 *Inclusion:* Patients with shoulder pain and impingement syndrome; age >30 years; pain duration >1 month *Clinical criteria:* At least two positive impingement tests (Neer, Hawkins, Yocum tests); Constant–Murley score <80 *Exclusion:* Reduced passive range of motion; anteroposterior shoulder instability; tendinous calcification; corticosteroid injections within the previous 30 days; previous surgery; humeral fractures; inflammatory joint disease; neoplastic disorders *Duration of symptoms,* mean months (SD): 28.3 (54.6) *Age,* mean years (SD): 58.7 (10.4) *Sex,* numbers females/males: 47/22 *Setting:* Outpatient (university hospital), University Paris/France	*Intervention group* (*n*=34): Standardized staged program of 'Dynamic Humeral Centering' (DHC) exercises: (1) learning the lowering of the humeral head during passive shoulder abduction; this included exercises for the perception of the passive lowering of the humeral head in the glenohumeral joint, for muscular control of the scapula, active contractions and perception of lowering effect and cocontraction of the muscles during passive shoulder abduction; home exercise (10 cocontractions, 3x/day). (2) Active lowering of the humeral head by co-contraction of the pectoralis major and latissimus muscles during active shoulder abduction; this included active abduction movements with the co-contracted muscles, first with the elbow flexed, then with the elbow extended, first without and then with a 0.5 kg weight held by the patient (supplementary online information on interventions available, see study report) *Control group* (*n*=35): Standardized staged program of shoulder mobilization: (1) passive mobilization within painless ROM (home exercise: 10 pendular movements, 3x/day); (2) active mobilization within painless ROM (home exercise: 10 active anterior elevation movements of the shoulder (in external rotation), 3x/day); (3) active mobilization with slight manual resistance applied by the physiotherapist (home exercise: same as for stage 2) *Both groups:* Each session started with a 10 min. massage (neck and shoulder region) *Duration/frequency*: 6 weeks; 15 sessions (3/3/3/2/2/2 per week)	*Disability/Health-related Quality of Life (HrQoL):* Constant-Murley Score (CMS), score 0-100 (100=best) *Pain:* CMS subscale (score 0-15; 15=best); *Activity:* CMS subscale (score 0-20; 20=best) *Follow-up (rate): at* 3 (89%) and 12 months (69%) after commencement of treatment	For all results: between-group least square MD, (95% CI) at the 3- and 12-month follow-ups Disability/HrQoL: 7.2 (−1.1–15.5) at 3 months 2.8 (−5.5–11.2) at 12 months (note: trial report specifies this result as non-significant after adjustment for multiplicity) both favoring DHC *Pain:* 2.1 (0.7–3.5) at 3 months 2.0 (0.4–3.5) at 12 months both favoring DHC *Activity:* 1.8 (−0.2–3.9) at 3 months 1.6 (−0.4–3.7) at 12 months both favoring DHC

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
Engebretsen *et al.* 2009,[35] 2011[36]	*N*=104 *Inclusion:* Patients with subacromial shoulder pain; age 18–70 years; pain lasting at least 3 months *Clinical diagnosis:* Dysfunction or pain on abduction; normal passive glenohumeral range of motion; pain on two of three isometric tests (abduction at 0 or 30°; external or internal rotation); positive Hawkins–Kennedy sign. Patients with rotator cuff rupture were included if they fulfilled the above criteria. *Exclusion:* Bilateral shoulder pain; previous surgery on affected shoulder; instability; clinical signs of cervical syndrome; rheumatoid arthritis; clinical and radiological signs of acromioclavicular arthritis; serious psychiatric disorders; use of anticoagulant drugs (except low dose aspirin); pregnancy; previous experience of one of the study interventions; inability to understand Norwegian; unwillingness to accept either of the interventions in this study *Duration of complaint,* % of participants: 3–6 months: 33% 6–12 months: 29% 12–24 months: 13.5% >24 months: 25% *Age,* mean years (SD): 48 (10.5) years *Sex, numbers females/males:* 52/52 *Setting:* Outpatient clinic, Department of Physical Medicine and Rehabilitation, Ulleval University Hospital,; Oslo, Norway	*Supervised exercises group* (*n*=52): Graded exercise regime including postural exercises, manual muscle techniques, endurance exercises (closed and open kinetic chain, plyometric exercises), use of elastic rubber bands and sling fixed to ceiling, adjusted home program (correction of alignment during daily living, simple low load exercises with a thin elastic cord), advice. (Presentation of exercises by figure in 2011 report) *Radial extracorporeal shockwave treatment group* (*n*=52): Extracorporeal shockwave treatment, 3–5 tender points treated per session; 12-8 Hz, 2000 pulses/session; 2.5–4.0 bar Analgesics (including inflammatory medication) were allowed for both groups *Duration and frequency: Supervised exercises group:* weekly sessions of 45 minutes for maximum of 12 weeks *Extracorporeal shockwave treatment group:* 1 session/week for 4–6 weeks (median: 5 treatments)	*Disability (primary outcome measure):* Shoulder Pain and Disability Index (SPADI), 0–100 points (0=best shoulder function); 'clinically improved' threshold set at 19.6 points. Available MCID estimates: 8, 10, 13.2, 20 points *Pain:* *Intensity of pain during rest/during activity previous week):* 9-point Likert-type scale (1=no pain, 9=severe pain) *Follow-up (rate):* at 6 weeks (87%, via postal questionnaire), at 12 weeks (98%, at hospital), at 18 (96%, at hospital) weeks, at 1 year (90% analyzed, via email questionnaire)	*Disability:* between-groups *treatment effect* (95% CI): 10 (2.3–17.6) at 6 weeks 10.3 (0.8–19.8;) at 12 weeks 8.4 (0.6–16.5) at 18 weeks 7.6 (−0.5–16.6;) at 1 year all favoring supervised exercises Dichotomized effect: 'clinically improved' at 18 weeks follow-up: 32 (64%) versus 18 (36%); OR** (95% CI) 3.2 (1.3–7.8) favoring supervised exercises; NNT†† 4; at 1-year follow-up: 29 (60.4%) versus 24 (52.2%), treatment effect (95% CI) 1.03 (0.96–1.1), favoring supervised exercises; NNT 13. *Pain:* between-groups effect (95% CI) *At rest:* 0.3 (−0.4–0.9) at 6 weeks 0.3 (−0.3–0.9) at 12 weeks 0.2 (−0.3–0.7) at 18 weeks 0.4 (−0.3–0.7) at 1 year all favoring supervised exercises *During activity:* 0.7 (−0.1–1.6) at 6 weeks 0.5 (−0.4–1.3) at 6 weeks 0.6 (−0.2–1.3) at 12 weeks 0.4 (−0.4–1.4) at 1 year all favoring supervised exercises

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
Holmgren *et al.* 2012[37]	*N*=102 *Inclusion:* Longstanding (>6-months duration of current episode) persistent subacromial impingement syndrome; age 30–65; on the waiting list for arthroscopic subacromial decompression; lack of response to various conservative treatments (including exercises) for at least 3 months *Clinical diagnosis:* pain in proximal lateral aspect of the upper arm, specifically with arm raised; positive result of three of the following tests: Neer impingement sign, Hawkins–Kennedy, Jobe test, Patte test; positive Neer impingement test with injection *Exclusion:* Frozen shoulder, radiologically verified malignancy; glenohumeral joint osteoarthritis; os acromiale; acromioclavicular arthritis; previous fractures in the shoulder region; shoulder surgery on the affected side; clinically verified polyarthritis; rheumatoid arthritis; fibromyalgia; instability in any joint of the shoulder complex, symptoms from the cervical spine and pseudoparalysis; receipt of corticosteroid injections in the previous 3 months for current problem *Duration of complaint,* median months (range): 18 (6–156) *Age, mean years (SD):* 52 (9) *Sex, numbers females/males:* 36/61 (data provided for 97 participants) *Setting:* Department of orthopaedics, University hospital; Linköping, Sweden; diagnosis by orthopaedic specialist	*Specific exercise group (n=52):* Supervised standardized exercise program (6 different exercises): two eccentric strengthening exercises for the rotator cuff (supraspinatus, infraspinatus, teres minor); three concentric/eccentric exercises for the scapular stabilizers (middle and lower trapezius, rhomboideus and serratus anterior), posterior shoulder stretch; exercises were done 2x/day for first 8 weeks, then 1x/day; strengthening exercises: each 3 × 15 repetitions; posterior stretch: 3 × 30–60 seconds, 2x/day; individual adjustments and progression; use of weights and rubber bands; postural corrections. Additionally, where considered necessary, manual techniques (stretching posterior capsule and pectoralis minor) were applied. *Intensity:* 'pain monitoring model': pain should not exceed 5 on 0–10 scale when performing exercises, but patients were recommended to feel some pain during loading (for further details see study report) *Control exercise group (n=50):* Exercise program of 6 non-specific movement exercises for the neck and shoulder without any external load; shoulder movements and stretching exercises of upper trapezius and pectoralis major). Fixed number of repetitions, no progression *Both groups:* Initial subacromial corticosteroid injection at inclusion visit; exercises started 2 weeks later; information, ergonomic advice, postural correction *Duration and frequency:* 12 weeks, 7 visits (1-1-0-1-0-1-0-1-0-1); first visit 60 minutes; subsequent visits 30 minutes; daily home exercises. Participants in the specific exercise group were recommended to continue the daily home exercises for another two months (after 12 weeks)	*Shoulder function/disability: Constant-Murley Score* (CMS, primary outcome measure), 0-100 points (100=best shoulder function); *Disabilities of the Arm, Shoulder and Hand questionnaire (DASH),* 0–100 points (0=best, 100=worst shoulder function). Available MCID estimate: 10.2 points *Pain:* *At rest, during arm activity, and at night (during previous 24 hours),* VAS 0–100 mm *Health-related Quality of Life (HrQoL):* EURO-Quol (EQ-5D, EQ VAS), EQ-5D index 1 to −0.59 (−0.59=lowest QoL); EQ VAS, 0–100 (0=lowest health status) *Patient's global impression of change in symptoms through treatment:* 5-point Likert scale ('worse', 'unchanged', 'small improvement', 'large improvement', 'recovered') *Follow-up (rate):* at end of treatment=at 3 months: 95%	For all: between-group differences of changes baseline→3 months, MD (95% CI), except for where noted *Shoulder function/disability:* *CMS:* 15 (8.5–20.6) favoring specific exercises *DASH:* 8 (2.3–13.7) favoring specific exercises *Pain:* *at rest:* 5.4 (−3.4–14.1) *during arm activity:* 10.6 (−2.4–23.6) *at night:* 20 (7.2–30.9) all favoring specific exercises *Health-related Quality of Life:* *EQ-5D index:* 0.09 (−0.07–0.18) (Note: trial report specifies this result as statistically significant) *EQ VAS:* 0.5 (−8.7–9.8) all favoring specific exercises *Patient's global impression of change:* Successful outcome ('large improvement' or 'recovered'); specific exercises versus control exercises, numbers (percent): 35/51 (69%) versus 11/46 (24%); odds ratio (95% CI): 7.6 (3.1–18.9) favoring specific exercises

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
Ketola *et al.* 2009[38]	*N*=140 *Inclusion:* Patients with shoulder impingement syndrome; age 18–60 years; shoulder pain lasting for at least 3 months; symptoms resistant to rest, anti-inflammatory drugs, subacromial glucocorticosteroid injections and physiotherapy *Clinical criteria:* Positive Neer's test *Exclusion:* Adhesive capsulitis; glenohumeral or acromioclavicular osteoarthritis; signs of glenohumeral instability; previous surgery of the affected shoulder; full thickness rotator cuff tears; cervical radicular syndrome; neuropathy of the shoulder region *Duration of complaint,* mean years (SD): 2.5 (3.0) *Age,* mean years (range): 47.1 (23.3–60.0) *Sex,* numbers females/males: 88/52 *Setting:* two hospitals; Finland	*Exercise group* (*n*=70): Instruction and supervision of an individually planned home exercise program addressing mobility of the shoulder complex and dynamic stability of the glenohumeral joint (supra- and infraspinatus, teres minor and subscapularis muscles) and the scapula (trapezius, rhomboid, serratus anterior, pectoralis minor muscles). Use of elastic stretch bands and light weights. 9 different exercises, each 3 × 30–40 reps. Progression over time through increase of resistance, decrease of reps; evaluation through control visits until the patient was found to be able to maintain the established level independently *Combined treatment group* (*n*=70): Arthroscopic subacromial decompression: debridement, decompression, release of coracoacromial ligament where considered appropriate, acromioplasty. Post-operative treatment: first treatment included anti-inflammatory analgesics, collar and cuff slings, active mobilization starting with gravity-assisted rotation movements. Removal of sutures and dressings after 7–10 days. Further treatment was reported as 'similar' to that of the exercise treatment group. *Both groups:* Use of nonsteroidal anti-inflammatory drugs (NSAIDs) as well as subacromial corticosteroid injections allowed as considered necessary *Duration/frequency: Exercise group:* Overall/maximum duration of interventions unspecified; participants generally had 7 control visits; the exercise program was done at least four times/week. *Combined treatment group:* participants generally had 6 control visits	*Pain (specified as primary outcome measure at 24 months),* not further specified: VAS ('of 0–10'); MCID defined as 'two points on VAS equalling one unit' (presumably, an NRS was used rather than a VAS) *Pain at night:* VAS; *Number of painful days* during the recent 3 months; Proportion of pain-free patients (VAS equal or below 3) *Disability:* Shoulder Disability Questionnaire (SDQ), score 0–100 (0=best shoulder function); VAS (0–10) *Follow-up (rate):* At 3, 6, 12, and 24 months after randomization (follow-up rate only specified for 24-month follow-up: 96%)	For all: between-group differences, means (99% CIs) at the different follow-ups *Pain:* 1.2 (0.02–2.45) at 3 months 1.2 (0.01–2.40) at 6 months 1.4 (0.13–2.63) at 12 months 0.4 (-0.78–1.60) at 24 months change baseline→24 months: 0.2 (−1.14–1.61) ; all favoring combined treatment *Pain at night:* 1.1 (−0.44–2.53) at 3 months 1.0 (−0.42–2.54) at 6 months 1.5 (0.07–2.83) at 12 months 0.6 (−0.65–1.95) at 24 months Change baseline→24 months: 0.4 (−1.17–2.00); all favoring combined treatment *Number of painful days* during the recent 3 months: 16.1 (−0.90–33.06) at 3 months 12.3 (−3.73–28.28) at 6 months 11.9 (−2.63–26.35) at 12 months 5.8 (−6.52–18.16) at 24 months Change baseline→24 months: 1.7 (−16.22–?) all favoring combined treatment *Proportion of pain-free patients* (VAS ⩽ 3): 0.3 (0.03–0.57) at 3 months 0.16 (−0.09–0.40) at 6 months 0.16 (−0.07–0.39) at 12 months 0.01 (−0.20–0.22) at 24 months; all favoring combined treatment *Shoulder disability (SDQ):* 18.2 (2.45–34.01) at 3 months 17.1 (1.67–32.53) at 6 months 16.9 (1.19–32.53) at 12 months 8.7 (−6.10–23.34) at 24 months Change baseline→24 months: 3.1 (−12.75–19.11); all favoring combined treatment

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
				Shoulder disability (VAS): 1.1 (−0.32–2.48) at 3 months 0.8 (−0.59–2.10) at 6 months 1.4 (0.12–2.76) at 12 months 0.6 (−0.62–1.81) at 24 months Change baseline→24 months: 0.4 (−1.00–1.76); all favoring combined treatment
Maehnhout *et al.* 2012[39]	*N*=61 *Inclusion:* Patients with subacromial impingement; age >18 years; unilateral pain in the anterolateral shoulder region for at least 3 months *Clinical criteria:* Painful arc; 2 out of 3 impingement tests positive (Neer, Hawkins, Jobe), 2 out of 4 resistance tests painful (full can, abduction at 90°, resisted abduction at 0°, resisted external or internal rotation with the arm adducted), pain with palpation of supraspinatus and/or infraspinatus tendon palpation *Exclusion:* Frozen shoulder, partial or full-thickness rotator cuff tears (MRI or ultrasound), history of shoulder surgery, shoulder fracture or dislocation, traumatic onset of symptoms, osteoarthritis, traumatic glenohumeral joint instability, shoulder nerve injuries, concomitant disorders such as cervical pathology or systemic musculoskeletal disease, no physical therapy or corticosteroid injections within 2 months before the study *Duration of symptoms:* No information provided *Age,* mean years (SD): 39.8 (13) *Sex,* numbers females/males: 36/25 *Setting:* Outpatient; affiliation to Department of Physiotherapy and Rehabilitation Sciences, Ghent University; Ghent, Belgium. All participants were recruited by a specialized shoulder surgeon	*TT Group (n=30):* Traditional rotator cuff strengthening exercises, performed at home: 2 traditional strengthening exercises performed daily (once a day, 3 × 10 reps.) at home: resisted internal and external rotation with an elastic band. Standardized speed: 6 seconds/rep. (2 second concentric, 2 second isometric, 2 second eccentric phase); progression of load by strength of band *TT+ET group (n=31):* TT combined with 'heavy load eccentric training': same exercises as TT group, plus a heavy load eccentric exercise (twice a day, 3 × 15 repetitions): eccentric phase of 'full can' abduction in the scapular plane performed with a dumbbell weight. Standardized speed of eccentric phase: 5 second/rep. Progression through increase of dumbbell weight stepwise by 0.5 kg. *Intensity:* 'pain monitoring model', pain during and after exercises not to exceed 5/10 (VAS); further details available in study report *Both groups:* Additional individualized physiotherapy treatment, including information, glenohumeral and scapulothoracic mobilizations, scapula setting and postural control (further details specified in study report) *Duration/frequency:* 12 weeks, 1 session (30 minutes)/week for 6 weeks, one in every 2 weeks for the following 6 weeks	*Pain and function:* SPADI score, 0–100 (0=best shoulder function); (reference to 'Minimal Important Difference', MID: change of score of >10). Available MCID estimates: 8, 10, 13.2, 20 points *Perception of improvement:* 'improved', 'not changed', 'worse'. 'improved', and 'worse' ratings were further categorized with a 5-point scale: 0=no change; 1=very small improvement; 2=small improvement; 3=some improvement; 4=large improvement; 5=very large improvement *Follow-up (rate):* At 6 (85%) and 12 (82%) weeks after start of treatment	*Pain and function,* SPADI*:* Between-group MDs (95% CI) at the 6 and 12 week follow-ups (covariate-adjusted means, from linear mixed model; CI calculations based on numbers randomized): 7.70 (1.70–13.70) at 6 weeks 2.5 (−3.30–8.30) at 12 weeks both favoring TT Between-group MDs (95% CI) for progression over time (covariate-adjusted): 7.0 (−0.15–14.15) from 0→6 weeks 1.3 (−7.62–10.22) from 0→12 weeks both favoring TT 85% of TT+ET versus 89% of TT had a reduction in SPADI of >10 points (MID) *Perception of improvement:* % of ratings/group at 6 weeks→at 12 weeks; TT versus TT+ET: 0=7 versus 6→0 versus 0 1=15 versus 0→0 versus 4 2=15 versus 10→10 versus 11 3=26 versus 37→25 versus 33 4=33 versus 47→45 versus 33 5=3 versus 0→20 versus 19 All between-group differences non-significant. None of the participants rated his problem as having worsened

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
Senbursa *et al.* 2011[40]	*N*=77 *Inclusion:* Patients with symptomatic supraspinatus tendinopathy, diagnosis of subacromial impingement syndrome and/or partial supraspinatus tear (stage I) *Clinical criteria:* Neer and Hawkins tests *Further assessments:* MRI *Exclusion:* History of frozen shoulder; shoulder trauma; shoulder instability; acromioclavicular and glenohumeral joint problems; calcific tendinitis; shoulder surgery and/or history of disease involving the hand, wrist or cervical region; treatment with physical therapy and rehabilitation within the recent 2 years *Duration of complaint:* no information provided *Age*, mean (SD): 48.9 (9.2) years; range 33–55 years *Sex,* numbers females/males: no information provided *Setting:* Physiotherapy and Rehabilitation Department, Hacettepe University; Ankara, Turkey	*Group I: Supervised exercise group* (*n*=25): Supervised glenohumeral and scapulothoracic exercises: range of motion, stretching and strengthening exercises for the rhomboid, levator scapulae, serratus anterior and rotator cuff muscles *Group II: Manual treatment group* (*n*=30): Joint and soft tissue mobilization exercises in addition to exercise program of group I. Manual treatment: deep friction massage on supraspinatus, radial nerve stretching, scapular mobilization, glenohumeral joint mobilization, proprioceptive neuromuscular facilitation (PNF) techniques *Group III: Home-based exercise group* (*n*=22): Provision of a self-exercise program to do at home. Spectrum of exercises as described for group I (instructions were provided by a physiotherapist) *Duration and frequency:* 12 weeks, group I/II: 3 sessions/week; all exercises were done daily (3 × 10 repetitions)	*Pain:* *Night pain, rest pain, and pain with movement,* VAS 10 cm, not further specified *Function:* Modified American Shoulder and Elbow Surgeon's questionnaire (M-ASES) (no data available on scoring) Follow-up (rate): At 4 weeks, at 12 weeks (100% as judged from results Table 2)	The relevant outcome data (apart from *P* values) is presented graphically, and extraction of actual values was impossible *Night pain, rest pain, pain with movement, function:* Statistically non-significant improvements in pain and function. Exemption: statistically significant difference in M-ASES score at 4 weeks, favoring grade II

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
Subasi *et al.* 2012[41]	*N*=57 (70 shoulders) *Inclusion:* Patients with subacromial impingement syndrome *Clinical criteria:* Neer's and Hawkins' impingement tests; painful arc; supraspinatus, drop-arm, Yergason's, Speed tests; subacromial impingement test (Lidocaine) with 50% improvement threshold for impingement diagnosis *Further assessments:* routine biochemical tests and antero-posterior radiographs for differential diagnosis; further radiographs or MRI when needed *Exclusion:* adhesive capsulitis; non-shoulder-related pathologies that could cause shoulder pain; infections, malignancies, shoulder instability, calcific tendinitis, calcified bursitis; history of shoulder, cervical spine or back surgery; corticosteroid injections, or physiotherapy due to a similar complaint within the previous 6 months; cervical radiculopathy; complete rotator cuff tears; fractures or dislocations as a result of severe acute trauma; dementia or other psychiatric diseases *Duration of complaint,* mean months (SD): 9.5 (10.4) *Age,* mean years (SD): 57.2 (10.0) *Sex,* numbers females/males: 36/21 *Setting:* Outpatient clinic, Turkey	*Land-based exercise group (LG) (n=28):* supervised exercises; sessions 1–10: ROM and stretching exercises, sessions 11–20: strengthening exercises (not further specified); home exercise program (2x/day) after end of supervised treatment *Water-based exercise group (WG) (n=29):* same exercise regime as for LG group, but in 28–30 warm water (use of dumbbells with strengthening exercises). Same home exercise program as for LG group *Both groups:* Physical therapy treatment (before exercise treatment): heat packs (20 minutes); TENS (20 minutes); therapeutic ultrasound ultrasound (8 minutes) *Duration and frequency:* Overall duration unspecified; both groups: total of 20 supervised sessions (5x/week) followed by home exercises	*Pain:* *pain severity (not further specified):* VAS scale *Shoulder function:* Shoulder pain and Disability Index (SPADI), *score 0–100* (0=best function); Available MCID estimates: 8, 10, 13.2, 20 points *Western Ontario Rotator Cuff Index (WORC),* score 0–2100 (0=best) Available MCID estimates: 245.26, 275 points (11.7–13%) *Follow-up (rate):* At end of treatment; at 3 months after start of treatment (rates unspecified)	Note: we decided against the calculation of any CIs for this trial, the main reason being unit of analysis error (randomisation at level of patients (*n*=57), analysis obviously at level of shoulders (*n*=70) For all: means (SD) at baseline→at end of treatment→at 3 months, except for where stated differently *Pain severity:* LG: 7.1 (1.2)→3.7 (1.4)→4.1 (1.7) WG: 7.3 (1.1)→3.2 (1.4)→2.8 (1.5) *SPADI pain subscale:* *SPADI pain subscale:* LG: 33.4 (4.6)→14.1 (7.8)→14.6 (8.1) WG: 32.7 (4.7)→12.5 (8.0)→9.3 (6.2) *Shoulder function:* *SPADI (total score):* LG: 45.0 (7.3)→20.1 (10.5)→20.9 (10.2) WG: 42.4 (7.8)→16.7 (12.6)→12.0 (9.1)

Table 3 Continued

Study	Participants	Interventions	Outcomes and follow-up	Results
				SPADI (disability subscale): LG: 56.6 (10.0)→26.2 (13.3)→27.2 (12.4) WG: 52.1 (10.9)→20.9 (17.2)→14.7 (12.1) *WORC (total score):* LG: 1348.4 (185.9)→739.7 (332.9)→733.1 (331.6) WG: 1353.2 (240.3)→599.7 (417.5)→475.0 (269.9) For all: Between-groups differences non-significant at end of treatment, significant at 3 months, both favoring WG

Note: [†]*N* (or *n*)=number.
[‡]SD=standard deviation.
[$]MCID=Minimal Clinically Important Difference.
[‖]MD=mean difference.
[¶]CI=confidence interval.
**OR=odds ratio.
[††]NNT=Number Needed to Treat.

estimates and MCID estimates (if available) are displayed in Table 3, which thus characterizes the clinical, as well as the statistical, significance of the results. Taking the yet limited amount of evidence on relevant MCID estimates into account, we decided not to derive any explicit judgments on the clinical significance of the trials' results from the available estimates, but to tabulate them (Table 3) and to offer them for individual consideration. The following text is limited to brief summaries of between-group results and statements of statistical significance. The trials' findings could broadly be categorized as follows.

Exercises and/or manual therapy versus non-exercise and/or non-manual therapy treatment

Ketola *et al.*[38] compared a combined treatment of arthroscopic subacromial decompression followed by a post-operative exercise program with a supervised exercise program. The combined treatment was found to lead to larger improvements of pain and disability at the earlier follow-ups, but all between-group differences were non-significant at the 24-month follow-up, and over time. Engebretsen *et al.*[35,36] found supervised exercises led to larger improvements in shoulder function, pain, and health-related quality of life than a treatment with extra-corporeal shockwave therapy. Except for the outcome of shoulder disability up to the 18 week follow-up, all relevant between-group treatment effects were non-significant. The proportion of participants who were 'clinically improved' was significantly larger in the supervised exercise group at 18 weeks.

Exercises plus manual therapy versus exercises alone

Barbosa *et al.*[32] found adding shoulder joint mobilizations to eccentric exercises more effective in improving shoulder function than eccentric exercises alone. All between-group differences were significant.

Exercises (with or without manual therapy) versus different exercises (with or without manual therapy)

Baskurt *et al.*[33] found specific scapular stabilization exercises in addition to a standardized shoulder exercise program improved pain and disability/health-related quality of life more than a standardized shoulder exercise program alone. The between-group differences, though, were overall non-significant for the relevant outcomes. Beaudreuil *et al.*[34] found 'dynamic humeral centring' improved disability/health-related quality of life, pain and activity more than non-specific (passive and active) shoulder mobilization, but, apart from the outcome of pain at 3 months, the between-group differences were non-significant. Holmgren *et al.*[37] found a specific supervised exercise strategy, addressing the rotator cuff and scapula stabilizers, improved shoulder function, pain, and health-related quality of life more than a non-specific home-based exercise program. The between-group differences were significant for shoulder function, pain at night, and quality of life. A significantly larger proportion of patients in the specific exercise group perceived the outcome as successful. Maenhout *et al.*[39] found a combination of 'traditional rotator cuff strengthening exercises' and 'heavy load eccentric exercises' to be overall not more effective in improving pain and function than traditional exercises alone. The relevant between-group differences favored the traditional exercises group, but were non-significant at the 12-week follow-up. There were no significant differences in perception of improvement either. Senbursa *et al.*[40] found a combination of a supervised exercise program with joint and soft tissue mobilization improved pain and shoulder function more than a supervised exercise program alone or than an unsupervised home-based exercise program. The between-group differences for these outcomes, though, were non-significant at the 12-week follow-up. Subasi *et al.*[41] found supervised water-based exercises improved pain and shoulder function more than land-based exercises. The between-group differences were significant for all outcomes at the 3-month follow-up.

Discussion

Our systematic review update provides some corroborative evidence to confirm our previous review's conclusions on the effectiveness of manual therapy and exercise interventions for impingement-related shoulder pain. The nine new RCTs illustrate a marked increase in published research activity on our research question, and present a variety of innovative approaches to the physiotherapy treatment of patients with shoulder impingement.

Methodological quality, as assessed with the PEDro instrument, varied across the trials (Table 2). Four trials[34–38] fulfilled most of the key risk of bias criteria explained with the methods. As research on manual therapy and exercise interventions generally does not allow for blinding of study personnel, and as blinding of participants is either impossible or very difficult to achieve, these items were largely not satisfied, i.e. rated with a 'no'. Consequently, these trials are at some risk of bias despite being conducted to the highest possible standards. More than half of the trials showed more extensive methodological deficits (Table 2). Interpretation of the PEDro ratings requires consideration of the possibility that 'no' ratings may also be due to deficiencies in reporting.

This update revealed a number of further relevant issues for discussion that are largely consistent with the findings from our previous review as well as with other recent systematic reviews.[18–20] Our previous review had shown a remarkable variability in the

diagnostic labeling of shoulder impingement. This still seems to be prevalent. We consider our approach to the definition of eligibility criteria a reasonable and helpful approach to enhancing homogeneity. We were surprised, though, to find that specifically the exclusion of substantive restrictions of shoulder ROM (i.e. capsulitis-type disorders, frozen shoulder) was insufficiently addressed by a number of trials to allow for clear judgments.[49–55] Consequently, even though some of these trials were potentially relevant, and may not have included participants with capsulitis-type disorders, we of necessity excluded them from this review.

Heterogeneity was present with further aspects such as the exclusion of full-thickness rotator cuff tears. Despite our key criteria, the study populations still differed, and the presentation of a summary statement on external validity is not feasible. Table 3 presents all information on the trials' eligibility criteria to allow for individual assessment.

Our previous review had shown that there was a marked heterogeneity of approaches to interventions and comparisons, and this was also a salient finding of the present update. Trials' interventions and comparisons were each unique, differing from others' in terms of their overall approaches, and the frequency, duration, and dosage of treatments. It was hardly possible to identify any conformity apart from the broad categories presented with the results. The same applies to the duration of follow-ups. This diversity poses a considerable challenge to the development of a coherent body of evidence. There appears to be a growing body of trials that are too heterogeneous for synthesis. As yet, replication of physiotherapy trials for shoulder impingement appears to be nonexistent. Considering that access to research resources for physical therapists is mainly still very limited, this argues for a new, more coherent, research strategy.

With respect to the choice of outcomes, our impression is that overall, homogeneity has improved. Only one trial had to be excluded because it did not include any one of the predefined outcomes.[56] Pain and disability (shoulder function) were assessed by all trials, and the majority included some measure of health-related quality of life. Most trials made use of validated outcome measures to assess the outcomes of interest. Despite this, the variety of outcome measures used still indicates a lack of clear consensus.

The main factor precluding meta-analyses was the diversity of comparisons. We could not identify sufficient commonality for a meaningful pooling of results. We carefully extracted and calculated all relevant outcome data (Table 3) to allow for individual assessment of the trials' results, and of their clinical significance. Only a minority of the trials considered the availability of MCID estimates for the chosen outcome measures. Even though there is a clear need for further research on MCID estimates for shoulder outcome measures, available MCID estimates may at least provide some preliminary orientation to facilitate interpretation of the clinical relevance of results.[57,58]. Four trials[32,33,40,41] were conducted on small samples that were not based on formal sample size calculations and may have been insufficiently powered to show significant results.

Conclusions

This systematic review update synthesizes current evidence from RCTs on the effectiveness of manual therapy and exercises for shoulder impingement. The conclusions relate to the outcomes of pain, disability, quality of life, and self-perceived change of symptoms in adults with a diagnosis of impingement-related shoulder pain, clinical signs associated with shoulder impingement, and grossly normal shoulder ROM (the inclusion criteria for this review). They further mainly relate to chronic conditions, and to secondary outpatient care. Lengths of follow-up varied, but most were limited to the short-term (up to 3 months). Methodological shortcomings and risk of bias, as well as deficits in the completeness and quality of reporting, warrant cautious interpretation. The conclusions are divided into implications for clinical practice and implications for research. They should not be taken as recommendations.

Implications for clinical practice

There is evidence from a limited number of RCTs of varying methodological quality to support the effectiveness of manual therapy and exercise interventions for patients with shoulder impingement. The range of studied approaches includes passive and active mobilizations of the shoulder region joints, manual muscle techniques, stretching and strengthening exercises for the rotator cuff, shoulder, and scapular muscles, scapular positioning and stabilization exercises and dynamic humeral centering exercises. Still, the available evidence does not allow for the determination of the most appropriate treatment approach. The same accounts for the type or dose of techniques and exercises. Evidence from one methodologically compromised RCT provides insufficient evidence to strengthen our previous review's conclusion that the addition of manual mobilizations to exercises may be more effective than exercises alone. Evidence from another methodologically compromised RCT provides insufficient evidence to allow for conclusions on the superiority of either supervised physiotherapy or unsupervised self-exercises. Physiotherapists may consider any of the manual therapy and/or exercise regimes for use in their daily practice, but still largely need to rely on their expertise and

experience in individually determining the best approach for their patients. Manual therapy and exercise interventions appear to be safe, i.e. not to have adverse effects.

There is limited evidence from one RCT to indicate that arthroscopic subacromial decompression surgery may not provide superior effects compared with a physiotherapeutic exercise regime. This tends to support the findings from previous research,[22,59] and strengthens the role of conservative treatment with physiotherapy as the first-line treatment for patients with shoulder impingement. There is limited evidence from one RCT to indicate that supervised exercises may be more effective than extracorporeal shockwave treatment (up to 18 weeks).

There is still no guidance available regarding the effectiveness of manual therapy and exercise interventions for acute impingement, and on manual therapy (manual mobilization) as a stand-alone approach. Patients with partial-thickness rotator cuff tears were largely included in the study populations. This illustrates that partial-thickness tears are largely considered an integral subgroup of shoulder impingement; thus, the available evidence overall refers to this group of patients, too. As yet, no RCTs are available on distinct populations of patients with partial-thickness rotator cuff tears.

In summary, this update overall tends to confirm the findings of our previous review, but reveals no conclusive advancement of the evidence in this area.

Implications for research

There is a clear need for strategies to enhance homogeneity of approaches to the diagnostic classification of shoulder impingement as well as to approaches to interventions and comparisons. There is a need for further, and specifically for larger trials on comparable approaches. To achieve this, replication of promising high-quality trials may be one reasonable strategy. This clearly calls for multicentre, and possibly international, collaboration. The pooling of resources including research skills, professional expertise but also sources of financial support may be a major task for the coming years to allow for sufficiently large and methodologically rigorous trials on consented and comparable approaches to manual therapy and exercise interventions for impingement-related shoulder pain. Improvements should also consider the quality and completeness of research reports. Comparisons should consider both 'within-physiotherapy' approaches but also the current 'major competitors', such as surgical interventions or medical treatment, as trials on the latter are yet underrepresented. Within research on manual therapy and exercises for impingement-related shoulder pain, there is still a lack of research on acute conditions and on specific populations of patients with partial-thickness rotator cuff tears.

Strengths and Weaknesses of this Review

We consider the thoroughly planned and rigorously conducted systematic approach to this review update as a clear strength. We followed the systematic methodology of our previous systematic review, but specified any adjustments that we considered appropriate and justified. We extended the database searches of our previous review by two German databases in order to include, where available, research from the major relevant German physiotherapy journals. We consider it a further strength that all searches, the selection process as well as data extraction and all assessments of methodological quality were independently done by two researchers, with a third being available for consultation if needed. This approach minimizes the risk of mistakes or misjudgments. A further strength lies in the comprehensiveness of our data extraction. Not least, our review complies with PRISMA standards.[29]

Limitations

We restricted inclusion to trials published in English or German, and might thus have failed to include relevant studies that have been published in other languages. We nevertheless searched regardless of language, and are aware that there have been few trials published in other languages (see also Table 2). We also recognize that the inclusion of further sources such as grey literature or citation indices is an important means to minimize the risk of inclusion bias. Author contact may have enabled the clarification of relevant details of the trials. Our resources did not allow for this.

Declaration of Interests

We declare that there are none known. This was a non-funded project.

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