Naunton, Josh, Littlewood, Christopher ORCID logoORCID:
<https://orcid.org/0000-0002-7703-727X>, Street, Gabrielle, Haines, Terry
and Malliaras, Peter (2020) Effectiveness of Progressive and Resisted and
Non-Progressive or Non-Resisted Exercise in Rotator Cuff Related Shoulder
Pain: A Systematic Review and Meta-analysis of Randomised Controlled
Trials. *Clinical Rehabilitation*, 34 (9). pp. 1198-1216. ISSN 0269-2155

Downloaded from: <https://e-space.mmu.ac.uk/625819/>

Version: Accepted Version

Publisher: SAGE Publications

DOI: <https://doi.org/10.1177/0269215520934147>

Please cite the published version

Clinical Rehabilitation

Effectiveness of Progressive and Resisted and Non-Progressive or Non-Resisted Exercise in Rotator Cuff Related Shoulder Pain: A Systematic Review and Meta-analysis of Randomised Controlled Trials

Journal:	<i>Clinical Rehabilitation</i>
Manuscript ID	CRE-2020-9306.R2
Manuscript Type:	Original Article
Date Submitted by the Author:	24-May-2020
Complete List of Authors:	Naunton, Josh; Monash University Faculty of Medicine Nursing and Health Sciences, Department of Physiotherapy Street, Gabrielle; Monash University Faculty of Medicine Nursing and Health Sciences, Department of Physiotherapy Littlewood, Chris; Keele University, Research Institute for Primary and Health Sciences Haines, Terry; Monash University Faculty of Medicine Nursing and Health Sciences, Physiotherapy Department Malliaras, Peter; Monash University Faculty of Medicine Nursing and Health Sciences, Department of Physiotherapy
Keywords:	Rotator Cuff Related Pain, Tendinopathy, Sub-acromial impingement, Resistance Exercise, Shoulder pain

SCHOLARONE™
Manuscripts

Objective: Synthesise evidence regarding effectiveness of progressive and resisted or non-progressive and non-resisted exercise compared with placebo or no treatment, in rotator cuff related pain.

Data sources: English articles, searched in Cochrane CENTRAL, MEDLINE, EMBASE and CINAHL databases up until May 19, 2020.

Methods: Randomised controlled trials in people with rotator cuff related pain comparing either progressive and resisted exercise or non-progressive and non-resisted exercise, with placebo or no treatment were included. Data extracted independently by two authors. Risk of bias appraised with the Cochrane Collaboration tool.

Results: Seven trials (468 participants) were included, four trials (271 participants) included progressive and resisted exercise and three trials (197 participants) included non-progressive or non-resisted exercise. There was uncertain clinical benefit for composite pain and function (15 point difference, 95% CI 9 to 21, 100 point scale) and pain outcomes at >6 weeks to 6 months with progressive and resisted exercise compared to placebo or no treatment (comparison 1). For non-progressive or non-resisted exercise there was no significant benefit for composite pain and function (4 point difference, 95% CI -2 to 9, 100 point scale) and pain outcomes at >6 weeks to 6 months compared to placebo or no treatment (comparison 2). Adverse events were seldom reported and mild.

Conclusions: There is uncertain clinical benefit for all outcomes with progressive and resisted exercise and no significant benefit with non-progressive and non-resisted exercise, versus no treatment or placebo at >6 weeks to 6 months. Findings are low certainty and should be interpreted with caution.

**Effectiveness of Progressive and Resisted and Non-Progressive or Non-Resisted
Exercise in Rotator Cuff Related Shoulder Pain: A Systematic Review and Meta-
analysis of Randomised Controlled Trials**

Josh Naunton, BPhysio, MSportsPhysio¹

Gabrielle Street, BPhysio²

Chris Littlewood BHsc (Hons) Physiotherapy, PhD³

Terrence Haines, PhD⁴

Peter Malliaras, BPhysio(Hons), PhD⁵

¹Monash University.

²Monash University.

³Research Institute for Primary and Health Sciences, David Weatherall Building, Keele University, Staffordshire, ST5 5BG

⁴School of Primary and Allied Health Care, Faculty of Medicine Nursing and Health Sciences, Building G, Peninsula Campus, Monash University, Victoria, Australia, 3199.

⁵Physiotherapy Department, School of Primary and Allied Health Care, Faculty of Medicine Nursing and Health Science, Building B, Peninsula Campus, Monash University, Victoria, Australia, 3199

The study protocol was approved by: NA

Address correspondence to:

Josh Naunton

Department of Physiotherapy

School of Primary and Allied Health Care

Building B, Monash University, Peninsula Campus

Victoria, 3199 Australia

E: josh.naunton@monash.edu

Objective: Synthesise evidence regarding effectiveness of progressive and resisted or non-progressive and non-resisted exercise compared with placebo or no treatment, in rotator cuff related pain.

Data sources: English articles, searched in Cochrane CENTRAL, MEDLINE, EMBASE and CINAHL databases up until May 19, 2020.

Methods: Randomised controlled trials in people with rotator cuff related pain comparing either progressive and resisted exercise or non-progressive and non-resisted exercise, with placebo or no treatment were included. Data extracted independently by two authors. Risk of bias appraised with the Cochrane Collaboration tool.

Results: Seven trials (468 participants) were included, four trials (271 participants) included progressive and resisted exercise and three trials (197 participants) included non-progressive or non-resisted exercise. There was uncertain clinical benefit for composite pain and function (15 point difference, 95% CI 9 to 21, 100 point scale) and pain outcomes at >6 weeks to 6 months with progressive and resisted exercise compared to placebo or no treatment (comparison 1). For non-progressive or non-resisted exercise there was no significant benefit for composite pain and function (4 point difference, 95% CI -2 to 9, 100 point scale) and pain outcomes at >6 weeks to 6 months compared to placebo or no treatment (comparison 2). Adverse events were seldom reported and mild.

Conclusions: There is uncertain clinical benefit for all outcomes with progressive and resisted exercise and no significant benefit with non-progressive and non-resisted exercise, versus no treatment or placebo at >6 weeks to 6 months. Findings are low certainty and should be interpreted with caution.

Key Words: *Rotator cuff related pain, rotator cuff tendinopathy, sub-acromial impingement, resistance exercise, progressive exercise, resistance training, shoulder pain*

1 Shoulder pain affects 15-30% of the population and is the third most common
2 musculoskeletal condition presenting to primary care.^{1, 2} Rotator cuff related pain is the most
3 common cause of shoulder pain, accounting for up to 80% of all cases.³ Up to 50% of people
4 affected experience pain and disability beyond 12 months despite conservative treatment.³
5 Clinical guidelines recommend clinician-guided exercise for rotator cuff related pain.^{4, 5}
6 However, an updated Cochrane review found only one high quality randomised controlled
7 trial (120 participants) out of 60 (3,620 participants) that compared exercise and manual
8 therapy for rotator cuff related shoulder pain to placebo, with no difference in clinical
9 outcomes at 22 weeks.^{6, 7} Two trials (89 participants) of very low quality found similar results
10 in comparison to no treatment.^{8, 9} Other systematic reviews that compare exercise with or
11 without manual therapy to all no-exercise controls found very low quality evidence that
12 exercise was beneficial for pain.¹⁰⁻¹²
13
14 Resistance exercise has previously been shown to be of benefit for knee osteoarthritis,¹³ back
15 pain¹⁴ and is a widely used and recommended treatment modality.^{15, 16} Resistance exercise
16 includes movement against body weight, gravity or by adding load with weight or elastic
17 resistance band (Theraband). Exercise is considered progressive and resisted when the
18 amount of load applied is increased over time as the body adapts to the demand that it is
19 placed under.
20
21 Prior reviews of rotator cuff related pain, including Page et al.⁷ have considered all exercise
22 interventions as equal, without consideration of how the exercise was prescribed (i.e. if there
23 was added resistance that was progressed over time or if resistance was not applied or not
24 progressed).^{7, 17-22} Therefore, it remains unclear whether exercise that is resisted and
25 progressed is more beneficial than placebo or control in treating rotator cuff related pain.

1
2
3 26 Likewise, it is not clear if exercise that is not resisted or not progressed is more effective than
4
5 27 placebo or control in managing rotator cuff related pain. This remains an unanswered
6
7
8 28 important clinical question in determining the most effective type of exercise intervention for
9
10 29 rotator cuff related pain. In a previous narrative review, studies that included progressively
11
12 30 loaded exercise and greater dose appeared to report superior outcomes compared to various
13
14 31 interventions including no treatment, shockwave therapy and therapeutic ultrasound.²³ No
15
16 32 systematic reviews have distinguished between type of exercise for rotator cuff related pain.
17
18
19 33
20
21 34 This systematic review aims to investigate the effectiveness of progressive and resisted
22
23 35 exercise and the effectiveness of non-progressive and non-resisted exercise; compared to
24
25 36 placebo or no treatment in the management of rotator cuff related pain.
26
27
28
29
30

31 38 **Methods**

32
33 39 The methods in this review were similar to methods in the recently updated Cochrane review
34
35 40 of manual therapy and exercise interventions for rotator cuff related pain.⁷ This review was
36
37 41 submitted May 30th 2019 to the International Prospective Register of Systematic Reviews
38
39 42 (PROSPERO; reference CRD42019136513) and registered on August 2nd 2019.
40
41
42
43

44 44 Randomised controlled trials written in any language were included regardless of type.
45
46 45 Participants over 16 years old with a primary complaint of rotator cuff related pain of any
47
48 46 duration were included. Diagnostic criteria included anterolateral shoulder pain (with or
49
50 47 without referral into the arm), preserved passive range of shoulder movement, shoulder pain
51
52 48 with movement or resisted shoulder muscle contraction (e.g. empty/full can tests).
53
54 49 Randomised controlled trials using synonyms for rotator cuff related pain (e.g. subacromial
55
56 50 impingement syndrome, rotator cuff tendinopathy, rotator cuff tendinitis) were included.
57
58
59
60

51

52 Exclusion criteria included participants with a full thickness tear involving more than one
53 rotator cuff tendon (based on clinical presentation or imaging findings, recognizing that some
54 included participants may have undetected rotator cuff tears), gross shoulder instability,
55 significant shoulder trauma, previous shoulder surgery, shoulder osteoarthritis, hemiplegic
56 shoulders, a complex myofascial neck/shoulder/arm pain condition, suspected cervical spine
57 referred pain, or a systemic inflammatory condition (e.g. rheumatoid arthritis), unless data
58 were presented separately for our population of interest.

59

60 In contrast to the review by Page et al. where all exercise was considered equal,⁷ we
61 considered the type of exercise intervention. We included randomised trials with the
62 following comparisons: 1) Progressive and resisted exercise versus placebo or no treatment;
63 2) Non-progressive or non-resisted exercise versus placebo or no treatment. Trials using
64 progressive and resisted exercise were eligible if they explicitly stated within the intervention
65 description how resistance was applied (e.g. theraband, weight), and that there was
66 progression of the volume or the load, or both, over time. Trials using non-progressive or
67 non-resisted exercise were eligible if they explicitly stated that load was not applied or not
68 progressed, or both. Non-progressive or non-resisted exercise could include active movement
69 exercise against gravity or with gravity removed, and trials that progressed range of motion
70 or the type of exercise (e.g. basic static to through range) were excluded if resistance within
71 each exercise was progressed. The comparator group could include placebo interventions
72 (e.g. detuned laser provided as an alternative to ‘physical therapy’) and no treatment. We did
73 not exclude randomised trials that included cointerventions (e.g. manual therapy, advice) as
74 part of the intervention or comparator group, but we planned secondary analyses to determine
75 the effect of these interventions.

1
2
3 76
4
5
6 77 An a priori decision was made to include composite pain and function shoulder outcomes
7
8 78 and/or pain outcomes given these are patient-important and considered a core outcome domain
9
10 79 by shoulder experts.²⁴ Composite pain and function based on standardised questionnaire was
11
12 80 the primary outcome of interest. When multiple scales were reported, data were extracted
13
14 81 according to the following hierarchy;⁷ 1) Shoulder Pain and Disability Index (SPADI);²⁵ 2)
15
16 82 Croft Shoulder Disability Questionnaire;²⁶ 3) Constant-Murley Score;²⁷ 4) any other shoulder-
17
18 83 specific function scale. Secondary outcomes of interest included overall pain, pain with
19
20 84 activity, and pain at rest (measured on VAS, numerical or categorical rating scale). If overall
21
22 85 pain was not reported, we substituted another pain measure for that analysis in the following
23
24 86 hierarchy, unspecified, rest pain or other pain. Number of participants experiencing an adverse
25
26 87 event (as defined by the authors) were also extracted.
27
28
29
30
31 88
32
33 89 All outcomes times were extracted and grouped to identify short (up to 6 weeks), medium
34
35 90 (longer than 6 weeks and up to 6 months) and long-term (longer than 6 months) effects of the
36
37 91 exercise interventions. The primary time range was longer than 6 weeks and up to 6 months
38
39 92 given this is sufficient time for exercise interventions to have an effect.²⁸ The longest time
40
41 93 point was extracted when multiple time points were reported within the above defined
42
43 94 periods.
44
45
46
47 95
48
49 96 Randomised controlled trials published up to March 2015 were identified from the updated
50
51 97 Cochrane review of manual therapy and exercise interventions for rotator cuff related pain.⁷
52
53 98 The search from the Page et al⁷ 2016 review was repeated excluding search terms for
54
55 99 adhesive capsulitis and manual therapy given these were not relevant for our review
56
57
58
59 100 (Appendix 1).
60

101

102 The search included the following databases: Cochrane Central Register of Controlled Trials
103 (CENTRAL; *The Cochrane Library* May 2020, Issue 5), Ovid MEDLINE (March 2015 to
104 May 2020), Ovid EMBASE (March 2015 to May 2020), and CINAHL Plus (EBSCO, March
105 2015 to May 2020). Gray literature was searched via OpenGray and ongoing trials via the
106 National Institute of Health (clinicaltrials.gov) and the World Health Organisation
107 (<http://www.who.int/ictip>) International Clinical Trials Registries.

108

109 Titles and abstracts were screened independently by two authors (PM, GS), and the full text
110 was reviewed by the same author independently if required to determine eligibility.

111 Consensus on discrepancies was reached via discussion, otherwise a third author (CL or JN)
112 was available to assist if consensus was not reached.

113

114 Data were extracted independently by two authors (PM, GS) to a standard data extraction
115 form, and discrepancies were resolved via discussion, or a third author (CL) was consulted to
116 adjudicate when required. Authors were emailed twice over four weeks to retrieve missing
117 data. All data extraction was checked by a third author (JN). Missing SDs were calculated
118 from standard errors (SEs), 95% CIs or P values, otherwise we planned to impute SDs from
119 other trials in the meta-analyses (median of available SDs) if no measures of variation were
120 reported.²⁹ For the primary outcome of function and pain we calculated the median of
121 available SDs in three studies following the process described above.^{8, 30, 31} For activity pain
122 and rest pain we calculated SDs as above for two studies.^{30, 31} For Giombini et al,³² the
123 reported measure of variability was much lower (by a factor of 4) than all other studies and
124 we assumed it was a standard error (this could not be confirmed by the authors at the time of
125 publication).

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

The data extracted from each randomised trial are shown below:

- Trial characteristics (author name, year published, trial type [e.g. parallel, crossover], country, funding source, trial registration [with number]).
- Participant characteristics (age, gender, duration of symptoms, inclusion/exclusion criteria).
- Exercise intervention characteristics (exercises, sets, repetitions, frequency, duration, how exercises was loaded and progressed, co-interventions, adherence measures, advice about pain).
- Comparator intervention characteristics (details of placebo or no treatment).
- Outcome instrument used and timing.
- Outcome data were extracted according to the following a priori decision rules to minimise bias: 1) preference to data that was adjusted for baseline values (e.g. ANCOVA) and intention-to-treat; 2) follow-up rather than change scores extracted where possible; 3) and data extracted for only the first period of cross-over trials.

The Cochrane Collaboration’s tool was used to assess risk of bias.³³ The results of the risk of bias assessment for all included trials were extracted from Page et al⁷ as no new studies were identified in our updated search.

Dichotomous (relative risk [RR] and 95% confidence intervals [CI]) and continuous measures (mean difference [MD] and 95% CI) of treatment effect were calculated using Review Manager 5.3 (RevMan). For continuous outcomes, MD was used after scores for the Shoulder Rating Questionnaire (17-100) and the Neer Shoulder Score (10-100) were transformed to a 0-100 scale (0 is best).³⁴ We reversed the direction of the Constant-Murley,

1
2
3 151 Neer and Shoulder Rating Questionnaire scores so that zero was best in all scales (to match
4
5 152 the SPADI, the highest outcome in our hierarchy).³⁴ Minimal clinically important difference
6
7 153 was assumed to be 10 on a 100-point scale for composite pain and function outcome,³⁵⁻³⁷ and
8
9 154 15 points on a 100-point scale for pain outcome.³⁸

10
11
12 155

13
14
15 156 Data were pooled in meta-analyses using Review Manager 5.3³⁹ if participants, interventions
16
17 157 and outcome measures were similar. A random effects models was chosen a priori given
18
19 158 heterogeneity is likely. Where data could not be pooled, we summarized findings
20
21 159 descriptively and reported effect estimates and 95% confidence intervals.
22
23

24 160

25
26 161 Assessment of statistical heterogeneity was based on Chi-square statistic and the I^2 statistic.⁴⁰
27
28 162 For the I^2 statistic, we interpreted statistical heterogeneity as not important (<50%), moderate
29
30 163 (50-75%) and high (>75%).⁴⁰

31
32
33 164

34
35 165 A sensitivity analysis was planned to investigate the influence of high risk of bias studies on
36
37 166 treatment outcomes. Subgroup analysis was planned a priori to investigate 1) the effect of
38
39 167 exercise interventions alone versus exercise interventions including co-interventions, and 2)
40
41 168 the effects of exercise setting (e.g. clinician-supervised or home exercise).
42
43

44 169

45
46
47 170 We prepared summary of findings tables for both comparisons and graded the certainty of
48
49 171 evidence using a GRADE approach [Grades of Recommendation, Assessment, Development
50
51 172 and Evaluation Working Group]⁴¹. Level of evidence was downgraded (to moderate, low or
52
53 173 very low) for each of the following: risk of bias, inconsistency of results, indirectness,
54
55 174 imprecision, and publication bias.

56
57
58 175
59
60

1
2
3 176 For dichotomous outcomes (e.g. adverse events), absolute risk difference was expressed as a
4
5 177 percentage and relative percent change was the risk ratio – 1 expressed as a percentage. The
6
7
8 178 NNT_H was calculated using the event rate in the control group and risk ratio.⁴² For
9
10 179 continuous outcomes (e.g. composite pain and function), absolute risk difference was the
11
12 180 mean difference in outcome between the intervention and comparator group expressed as a
13
14 181 percentage. The relative percent change was the mean intervention group difference (absolute
15
16 182 change) divided by the mean at baseline in the control group, expressed as a percentage.
17
18
19 183
20

21 184 **Results**

22
23
24 185 *Study selection*

25
26 186 Nine eligible trials were identified from the Page et al⁷ 2016 systematic review. One trial was
27
28 187 excluded because the control group received a standard exercise instruction pamphlet in
29
30 188 addition to education and therefore is not a true comparison to no treatment or placebo.⁹ The
31
32 189 other excluded trial included physiotherapy treatments as control (heat packs, transcutaneous
33
34 190 electrical nerve stimulation and ultrasound).⁴³ No eligible trials were identified after the
35
36 191 updated search (Figure 1), and screening reference lists of included studies, gray literature
37
38 192 and clinical trials registries. We obtained data from the authors (July 2017) of two trials^{6, 31}
39
40 193 that allowed us to confirm eligibility (Appendix 2). We acknowledge that within the trial
41
42 194 protocol for the randomised trial by Bennell et al.⁴⁴ there was progression of exercise through
43
44 195 range (e.g. external rotation in side lying, to standing in neutral, to elbow supported at 90°
45
46 196 abduction, to unsupported elbow at 45° abduction). However, there was not progression of
47
48 197 load or volume as specified in our eligibility criteria.
49
50
51
52
53
54 198

55
56 199 **Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2009**
57
58 200 **flow diagram for literature search results.**
59
60

201

202 *Trial characteristics*

203 Trial and participant characteristics are shown in Table 1. Seven parallel group randomised
 204 trials (468 participants) were included. Multiple diagnostic labels were used for rotator cuff
 205 related pain but there was overlapping and consistent diagnostic criteria between trials (Table
 206 1). Mean age was between 47 and 61 years, but lower in Giombini et al³² (26 and 29 years).
 207 Men were more prevalent (54-100%) aside from Lombardi et al⁴⁵ (24% men). Baseline
 208 composite pain and function was comparable (33 to 50, 0-100 point scale where 0 is best).

209

210 Description of the interventions and comparators are shown in Table 2. Three trials compared
 211 progressive and resisted exercise with no treatment.^{8, 45, 46} One trial compared progressive and
 212 resisted exercise with placebo (detuned laser).³⁰ All progressive and resisted exercise
 213 interventions included scapular and rotator cuff strengthening and progressed the load
 214 (intensity) with theraband or weights.^{8, 30, 45, 46} Prescribed sets and repetitions varied, and only
 215 one study specified exercise intensity (50%-70% of the 6RM).⁴⁵ Three studies included co-
 216 interventions. Brox et al³⁰ included education about pathology, pain and ergonomics, Dickens
 217 et al⁸ included manual therapy, postural advice, taping with or without electrotherapy and
 218 Ludwig et al⁴⁶ included shoulder stretching.

219

220 All three trials (four comparisons) of the non-progressive and non-resisted interventions were
 221 compared with placebo (two ultrasound^{6, 32} and one brace³¹). One non-progressive and non-
 222 resisted exercise trial⁶ targeted scapular and rotator cuff strengthening similar to progressive
 223 and resisted trials. Whereas, Walther et al³¹ assessed static exercise and neck stretching (all
 224 other trials evaluate dynamic exercise) and Giombini et al³² assessed pendular exercise and
 225 shoulder stretching. Load was applied without progression with theraband or 1kg weight in

1
2
3 226 two trials^{6, 31} and no load applied in the remaining trial.³² There were only co-interventions in
4
5 227 Bennell et al⁶ including manual therapy and behavioural strategies (e.g. goal setting, positive
6
7 228 reinforcement).
8
9

10 229
11
12 230 **Table 1: Recruitment and retention, participant characteristics and eligibility criteria**

13
14 231 **Table 2: Exercise characteristics and outcome**

15 232
16
17 233 *Risk of bias in included trials*
18
19 234 Risk of bias assessment was extracted from Page et al⁷ (summarised in Figure 2) as all our
20
21 235 studies were also in this Cochrane review from 2016. Among trials comparing progressive
22
23 236 and resisted exercise or non-progressive and non resisted exercise to placebo or no treatment,
24
25 237 six (86%) were rated high risk of performance and detection bias.^{8, 30-32, 45, 46} Further, two
26
27 238 trials (29%) were at high risk of reporting bias^{31, 32} (uncertain risk in a further four [57%]),^{8,}
28
29 239 ^{30, 45, 46} one trial (14%) was at high risk of attrition bias,³⁰ and there was uncertain risk of
30
31
32 240 selection bias in five (71%) trials.^{8, 30-32, 46}
33
34
35 241
36
37
38
39

40 242 **Figure 2: Risk of bias summary: judgements about each risk of bias item for each**
41
42 243 **included study.**
43
44 244

45
46 245 **Effects of interventions**

47
48 246 **Comparison 1: Progressive and resisted exercise versus placebo or no treatment**

49
50 247 There were four trials with 271 participants that reported composite pain and function,^{8, 30, 45,}
51
52 248 ⁴⁶ three trials^{30, 45, 46} (197 participants) reported overall pain and two trials^{30, 45} (135
53
54 249 participants) reported activity pain and rest pain at >6 weeks to 6 months. No trials reported
55
56 250 adverse events. All outcomes were downgraded twice (low certainty) for risk of bias
57
58
59
60

(performance, detection, reporting and selection).^{8, 30, 46}

There was uncertain clinical benefit (low certainty evidence) in all outcomes with progressive and resisted exercise. For composite pain and function there was a 15.0 point difference (95% CI 8.6 to 21.4; 4 trials, 271 participants, Figure 3, Table 3).^{8, 30, 45, 46} For overall pain there was a 10.7 point difference (95% CI 5.6 to 15.7; 3 trials, 197 participants, Figure 3, Table 3).^{30, 45, 46} For pain with activity there was a 24.7 point difference (95% CI 13.9 to 35.5; 2 trials, 135 participants, Figure 3, Table 3).^{30, 45} For pain at rest there was a 22.8 point difference (95% CI 14.0 to 31.6; 2 trials, 135 participants, Figure 3, Table 3).^{30, 45}

Adverse events

Unclear as no trials of progressive and resisted exercise reported whether adverse events occurred.

Comparison 2: Non-progressive or non-resisted exercise versus placebo and no treatment

Three trials (197 participants) reported composite pain and function, overall pain and pain with activity at >6 weeks to 6 months.^{6, 31, 32} Two trials (174 participants) reported pain at rest at >6 weeks to 6 months.^{6, 31} Two trials (83 participants) reported composite pain and function up to 6 weeks. One trial reported adverse events.⁶ Overall evidence was low certainty for all outcomes (downgraded twice for risk of bias [performance, detection, reporting and selection]).

There was low certainty evidence of no benefit in all outcomes with non-progressive or non-resisted exercise. For function there was a 3.6 point difference (95% CI -2.2 to 9.4; 3 trials, 4

1
2
3 276 comparisons, 197 participants, Figure 4, Table 4).^{6, 31, 32} For overall pain there was a 3.3 point
4
5 277 difference (95% CI -1.5 to 8.1; 3 trials, 4 comparisons, 197 participants, Figure 4, Table 4).^{6,}
6
7
8 278 ^{31, 32} For pain with activity there was a 3.4 point difference (95% CI -5.0 to 11.8; 3 trials, 4
9
10 279 comparisons, 197 participants, Figure 4, Table 4). ^{6, 31, 32} For pain at rest there was a 1.8 point
11
12 280 difference (95% CI -6.6 to 10.2; 2 trials, 3 comparisons, 174 participants, Figure 4, Table 4).^{6,}
13
14
15 281 ³¹

16
17 282
18
19 283 *Adverse events*
20
21 284 One trial reported a short term increase in pain that was greater following exercise
22
23 285 intervention (17/55) compared with placebo (5/61) (RR 4.02, 95% CI 1.56 to 10.37).⁶
24
25
26 286

27
28 287 **Secondary analysis**

29
30 288 Subgroup analysis for co-interventions were similar to the overall effect for all outcomes
31
32 289 (composite pain and function, overall pain, activity pain and rest pain) in both comparisons.
33
34 290 One exception was composite pain and function in comparison 1, where there was benefit of
35
36 291 uncertain clinical importance among the two trials that did not include co-interventions^{25,26}
37
38 292 and clinically important improvement for the two trials^{8, 30} that did. When subgrouping for
39
40 293 supervised versus unsupervised exercise, comparison 1 pain and function outcome showed
41
42 294 clinically important benefit in three trials^{10,28,42} that utilised supervised exercise but uncertain
43
44 295 clinical benefit in one trial⁴⁶ that utilised unsupervised exercise. All other findings were
45
46 296 identical to the overall effect for all outcomes (composite pain and function and overall pain).
47
48 297 There was insufficient data to perform other planned secondary analyses.
49
50
51
52

53 298
54
55 299 **Discussion**
56
57
58
59
60

1
2
3 300 This review identified seven randomised trials (eight comparisons, 468 participants) that
4
5 301 compared exercise (progressive and resisted or not) to placebo or no treatment among people
6
7 302 with rotator cuff related shoulder pain. Four trials^{8, 30, 45, 46} compared progressive and resisted
8
9 303 exercise to no treatment or placebo (comparison 1) and three trials^{6, 31, 32} compared non-
10
11 304 progressive or non-resisted exercise to placebo (comparison 2). For progressive and resisted
12
13 305 exercise, low certainty evidence indicates benefit of uncertain clinical importance in
14
15 306 composite pain and function, overall pain outcomes, pain with activity and pain at rest at >6
16
17 307 weeks to 6 months compared to placebo or no treatment. For non-progressive or non-resisted
18
19 308 exercise, low certainty evidence indicates no benefit for composite pain and function, overall
20
21 309 pain, pain with activity and pain at rest at >6 weeks to 6 months compared to placebo or no
22
23 310 treatment (comparison 2). Adverse events were reported in only one study and included only
24
25 311 mild differences in short term pain after exercise. The trials were heterogeneous (e.g. whether
26
27 312 exercise was supervised, co-interventions used, comparators) so these findings should be
28
29 313 viewed as preliminary and hypothesis generating.
30
31 314
32
33 315 Three (75%)^{8, 30, 45} of the progressive and resisted trials but only one (25%)³¹ of the non-
34
35 316 progressive and non-resisted trials utilised supervised exercise interventions. Three out of
36
37 317 four (75%) progressive and resisted interventions included co-interventions in the exercise
38
39 318 arm (e.g. manual therapy, advice) whereas only one non-progressive and non-resisted
40
41 319 intervention (25%) utilized co-interventions. Further, three trials (75%)^{8, 45, 46} comparing
42
43 320 progressive and resisted exercise were compared to no treatment, whereas all non-progressive
44
45 321 or non-resisted exercise trials were compared with placebo. Therefore, we can only conclude
46
47 322 that progressive and resisted studies, most of which are supervised, may offer benefit of
48
49 323 uncertain clinical importance compared with primarily no treatment comparators.
50
51 324
52
53
54
55
56
57
58
59
60

325

326 All progressive and resisted exercise programs increased load (intensity), only two

327 progressed range of motion, volume or speed. Load progression was based on either

328 achieving a pain response within defined limits (e.g. pain of no more than 4/10 on a 0-10

329 scale) or based on ability (e.g. when the prescribed sets were no longer achieving muscle

330 fatigue). There were important differences in the exercise approaches between the

331 progressive and resisted and non-progressive and non-resisted trials that may have influenced

332 our findings. Two trials that utilized non-progressive and non-resisted exercise prescribed

333 either pendular exercises or isometric (static hold) exercises.^{31, 32} This is in contrast to the

334 dynamic scapular and rotator cuff exercises prescribed in the progressive and resisted trials.

335

336 It is possible that mechanisms other than the exercise undertaken explain the findings. For

337 example, giving a patient permission to perform progressive exercise, or do more exercise,

338 may reduce fear of movement and lead to greater general shoulder use in some patients.

339 Adherence and exercise dose parameters were also poorly reported, so we are unable to

340 determine the dose response and actual volume of exercise completed for each intervention.

341 We urge caution in interpreting these findings given the certainty of evidence supporting the

342 findings are generally low using a GRADE approach.

343

344 There have been multiple systematic reviews of exercise interventions for rotator cuff related

345 pain.^{7, 10-12, 47} A recent Cochrane review concluded no benefit of exercise over placebo for

346 rotator cuff related pain,⁷ which contrasts with other systematic reviews.^{10, 12} The difference

347 is the Cochrane review was based on a single (judged by the authors of this review) low risk

348 of bias study. Our findings are broadly consistent with this Cochrane review as most studies

349 using a placebo comparison did not find benefit for exercise (albeit 75% utilized non-

progressive and non-resisted exercise). Future high quality studies investigating whether progressive and resisted exercise is more beneficial than placebo are warranted.

This is the first systematic review with meta-analysis to focus on progressive and resisted exercise or not versus no treatment or placebo. Further, in this review we followed as closely as possible best practice guidelines as outlined by the Cochrane collaboration and PRISMA to minimize potential sources of bias in this review. Inclusion and exclusion criteria were carefully decided a priori and were clearly defined to minimize selection bias.

The main limitation of our review is that there were only 7 trials and 8 comparisons that met our inclusion and exclusion criteria. Potential bias and the limited number of trials identified reduced confidence in our findings, however the findings are consistent with evidence in other tendinopathies around the body and worthy of further investigation.⁴⁸

There are several limitations of the literature we included. There is low certainty evidence for both comparison one and two, only one trial⁶ in this review has a low risk of bias (86% had a high risk of bias, therefore certainty was downgraded two levels, we did not downgrade for inconsistency, indirectness [all interventions reflected clinical practice] or imprecision). This precluded sensitivity analysis including only low risk of bias trials. Further, as discussed, there were more progressive and resisted trials that utilized supervised exercise and co-interventions, and used non-placebo controls, so these factors may have influenced the positive findings reported for this exercise type.

Exercise programs were not described fully. This included characteristics such as pain during loading, exercise adherence, rest between exercise sets and exercise tempo. This limitation is

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

important because exercise dose may contribute to the positive findings and clinicians are unable to implement an exercise program if exercise characteristics are incompletely reported. Limited reporting on exercise programs may also have influenced our decision to classify studies as progressive and resisted or non-progressive and non-resisted. Future trials should consider reporting guidelines (e.g. Consensus on Exercise Reporting Template)⁴⁹ to ensure findings are translatable to practice.

Implications for practice

Progressive resistance exercise may improve function and pain outcomes in rotator cuff related cuff related pain in comparison to placebo or no treatment comparators. The benefit was of uncertain clinical importance and placebo effects were not controlled in 75% of studies. Three quarters of progressive and resisted exercise interventions were supervised and included co-interventions such as manual therapy or advice or shoulder stretching. Clinicians can consider adopting similar progressive and resisted exercise interventions for rotator cuff related pain but the low certainty findings in this review indicate that our findings may change in the future (if there are larger and adequately powered studies addressing the same question). Non-progressive and non-resisted exercise did not demonstrate benefit over primary (75%) placebo comparisons. Our results question the use of non-resisted or non-progressive exercise for rotator cuff related pain.

Future high quality, adequately powered randomised trials should consider the type of exercise prescribed for the intervention, specifically how resistance is added and if it is progressed appropriately throughout the treatment (increasing the intensity of the resistance and also increasing the range at which the exercise is performed).

Clinical Messages

- Progressive and resisted exercise may provide uncertain clinical benefit in pain and function compared with primarily no treatment comparators at >6 weeks to 6 months among people with rotator cuff related pain
- Non-progressive and non-resisted exercise did not demonstrate benefit over placebo at >6 weeks to 6 months among people with rotator cuff related pain

For Peer Review

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Acknowledgments

JN is supported by an Australian Government Research Training Program (RTP) Scholarship.

Author Contributions

- Conceptulisation:** PM, GS and JN
- Data curation:** PM, GS,CL, JN
- Formal anaylsis:** JN, PM
- Methodology:** PM, GS
- Writing - original draft preparation:** JN
- Writing - reviewing and editing:** JN, GS, CL, PM

Competing Interests and Funding Support

There are no known competing interests to declare.
This paper did not receive any funding support.

References

1. Pope DP, Croft PR, Pritchard CM, et al. Prevalence of shoulder pain in the community: the influence of case definition. *J Annals of the Rheumatic Diseases* 1997; 56: 308-312. DOI: 10.1136/ard.56.5.308.
2. Britt H, Miller GC, Henderson J, et al. General practice activity in Australia 2015–16.
3. Ottenheijm RP, Joore MA, Walenkamp GH, et al. The Maastricht Ultrasound Shoulder pain trial (MUST): Ultrasound imaging as a diagnostic triage tool to improve management of patients with non-chronic shoulder pain in primary care. 2011; 12: 154. journal article. DOI: 10.1186/1471-2474-12-154.
4. Therapeutic Guidelines Limited. Rheumatology Expert Group. *Therapeutic guidelines : rheumatology*. Version 3. ed.: West Melbourne, Victoria Therapeutic Guidelines, 2017.
5. Hopman K, Krahe L, Lukersmith S, et al. Clinical practice guidelines for the management of rotator cuff syndrome in the workplace. 2013; 80.
6. Bennell K, Wee E, Coburn S, et al. Efficacy of standardised manual therapy and home exercise programme for chronic rotator cuff disease: randomised placebo controlled trial. *BMJ (Clinical research ed)* 2010; 340. DOI: 10.1136/bmj.c2756.
7. Page MJ, Green S, McBain B, et al. Manual therapy and exercise for rotator cuff disease. *Cochrane Database of Systematic Reviews* 2016. DOI: 10.1002/14651858.CD012224.
8. Dickens VA, Williams JL and Bhamra MS. Role of physiotherapy in the treatment of subacromial impingement syndrome: a prospective study. *Physiotherapy* 2005; 91: 159-164. DOI: <https://doi.org/10.1016/j.physio.2004.10.008>.
9. Kachingwe AF, Phillips B, Sletten E, et al. Comparison of manual therapy techniques with therapeutic exercise in the treatment of shoulder impingement: a randomized controlled pilot clinical trial. *The Journal of manual & manipulative therapy* 2008; 16: 238-247. DOI: 10.1179/106698108790818314.
10. Haik MN, Alburquerque-Sendín F, Moreira RFC, et al. Effectiveness of physical therapy treatment of clearly defined subacromial pain: a systematic review of randomised controlled trials. *British Journal of Sports Medicine* 2016; 50: 1124-1134. DOI: 10.1136/bjsports-2015-095771.
11. Shire AR, Stæhr TAB, Overby JB, et al. Specific or general exercise strategy for subacromial impingement syndrome-does it matter? A systematic literature review and meta analysis. *BMC musculoskeletal disorders* 2017; 18: 158-158. DOI: 10.1186/s12891-017-1518-0.
12. Steuri R, Sattelmayer M, Elsig S, et al. Effectiveness of conservative interventions including exercise, manual therapy and medical management in adults with shoulder impingement: a systematic review and meta-analysis of RCTs. *British Journal of Sports Medicine* 2017; 51: 1340-1347. DOI: 10.1136/bjsports-2016-096515.
13. Latham N and Liu C-j. Strength Training in Older Adults: The Benefits for Osteoarthritis. *Clinics in Geriatric Medicine* 2010; 26: 445-459. DOI: <https://doi.org/10.1016/j.cger.2010.03.006>.
14. Mayer JM, Childs JD, Neilson BD, et al. Effect of Lumbar Progressive Resistance Exercise on Lumbar Muscular Strength and Core Muscular Endurance in Soldiers. *Military medicine* 2016; 181: e1615-e1622. 2016/11/17. DOI: 10.7205/milmed-d-15-00543.
15. Littlewood C, Bateman M, Connor C, et al. Physiotherapists' recommendations for examination and treatment of rotator cuff related shoulder pain: A consensus exercise. *Physiotherapy Practice and Research* 2019; 40: 87-94. DOI: 10.3233/PPR-190129.
16. Liu CJ and Latham NK. Progressive resistance strength training for improving physical function in older adults. *Cochrane Database of Systematic Reviews* 2009. DOI: 10.1002/14651858.CD002759.pub2.

17. Desmeules F, Cote CH and Fremont P. Therapeutic exercise and orthopedic manual therapy for impingement syndrome: a systematic review. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine* 2003; 13: 176-182. 2003/06/07. DOI: 10.1097/00042752-200305000-00009.
18. Grant HJ, Arthur A and Pichora DR. Evaluation of interventions for rotator cuff pathology: a systematic review. *J Hand Ther* 2004; 17: 274-299. 2004/05/27. DOI: 10.1197/j.jht.2004.02.013.
19. Green S, Buchbinder R and Hetrick SE. Physiotherapy interventions for shoulder pain. *Cochrane Database of Systematic Reviews* 2003. DOI: 10.1002/14651858.CD004258.
20. Hanratty CE, McVeigh JG, Kerr DP, et al. The Effectiveness of Physiotherapy Exercises in Subacromial Impingement Syndrome: A Systematic Review and Meta-Analysis. *Seminars in arthritis and rheumatism* 2012; 42: 297-316. DOI: 10.1016/j.semarthrit.2012.03.015.
21. Kromer TO, Tautenhahn UG, de Bie RA, et al. Effects of physiotherapy in patients with shoulder impingement syndrome: a systematic review of the literature. *Journal of rehabilitation medicine : official journal of the UEMS European Board of Physical and Rehabilitation Medicine* 2009; 41: 870-880. 2009/10/21. DOI: 10.2340/16501977-0453.
22. Kuhn JE. Exercise in the treatment of rotator cuff impingement: a systematic review and a synthesized evidence-based rehabilitation protocol. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]* 2009; 18: 138-160. 2008/10/07. DOI: 10.1016/j.jse.2008.06.004.
23. Littlewood C, Malliaras P and Chance-Larsen K. Therapeutic exercise for rotator cuff tendinopathy: a systematic review of contextual factors and prescription parameters. *International Journal of Rehabilitation Research* 2015; 38: 95-106. 2015/02/26. DOI: 10.1097/mrr.0000000000000113.
24. Buchbinder R, Page MJ, Huang H, et al. A Preliminary Core Domain Set for Clinical Trials of Shoulder Disorders: A Report from the OMERACT 2016 Shoulder Core Outcome Set Special Interest Group. *J Rheumatol* 2017; 44: 1880-1883. 2017/01/17. DOI: 10.3899/jrheum.161123.
25. Roach KE, Budiman-Mak E, Songsiridej N, et al. Development of a shoulder pain and disability index. *Arthritis care and research : the official journal of the Arthritis Health Professions Association* 1991; 4: 143-149. 1991/12/01.
26. Croft P, Pope D, Zonca M, et al. Measurement of shoulder related disability: results of a validation study. *Annals of the rheumatic diseases* 1994; 53: 525-528. 1994/08/01.
27. Constant CR and Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res* 1987: 160-164. 1987/01/01.
28. Bird SP, Tarpenning KM and Marino FEJSM. Designing Resistance Training Programmes to Enhance Muscular Fitness. 2005; 35: 841-851. journal article. DOI: 10.2165/00007256-200535100-00002.
29. Ebrahim S, Akl EA, Mustafa RA, et al. Addressing continuous data for participants excluded from trial analysis: a guide for systematic reviewers. *Journal of clinical epidemiology* 2013; 66: 1014-1021.e1011. 2013/06/19. DOI: 10.1016/j.jclinepi.2013.03.014.
30. Brox JI, Staff PH, Ljunggren AE, et al. Arthroscopic surgery compared with supervised exercises in patients with rotator cuff disease (stage II impingement syndrome). *BMJ (Clinical research ed)* 1993; 307: 899-903.
31. Walther M, Werner A, Stahlschmidt T, et al. The subacromial impingement syndrome of the shoulder treated by conventional physiotherapy, self-training, and a shoulder brace: results of a prospective, randomized study. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]* 2004; 13: 417-423. 2004/06/29. DOI: 10.1016/s1058274604000485.

32. Giombini A, Di Cesare A, Safran MR, et al. Short-term effectiveness of hyperthermia for supraspinatus tendinopathy in athletes: a short-term randomized controlled study. *Am J Sports Med* 2006; 34: 1247-1253. 2006/04/26. DOI: 10.1177/0363546506287827.
33. Higgins JPT, Altman DG, Gøtzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ (Clinical research ed)* 2011; 343: d5928. DOI: 10.1136/bmj.d5928
34. Thorlund K, Walter SD, Johnston BC, et al. Pooling health-related quality of life outcomes in meta-analysis-a tutorial and review of methods for enhancing interpretability. *Res Synth Methods* 2011; 2: 188-203. 2011/09/01. DOI: 10.1002/jrsm.46.
35. Angst F, Schwyzer H-K, Aeschlimann A, et al. Measures of adult shoulder function: Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and Its Short Version (QuickDASH), Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Society Standardized Shoulder Assessment Form, Constant (Murley) Score (CS), Simple Shoulder Test (SST), Oxford Shoulder Score (OSS), Shoulder Disability Questionnaire (SDQ), and Western Ontario Shoulder Instability Index (WOSI). 2011; 63: S174-S188. DOI: doi:10.1002/acr.20630.
36. Roy J-S, MacDermid JC and Woodhouse LJ. Measuring shoulder function: A systematic review of four questionnaires. 2009; 61: 623-632. DOI: doi:10.1002/art.24396.
37. Roy J-S, Macdermid JC, Goel D, et al. What is a Successful Outcome Following Reverse Total Shoulder Arthroplasty? *The open orthopaedics journal* 2010; 4: 157-163. DOI: 10.2174/1874325001004010157.
38. Hawker GA, Mian S, Kendzerska T, et al. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). 2011; 63: S240-S252. DOI: doi:10.1002/acr.20543.
39. Review Manager 5 (RevMan 5). Copenhagen: Nordic Cochrane Centre, The Cochrane Collaboration, 2014.
40. Higgins JPT and Thompson SG. Quantifying heterogeneity in a meta-analysis. 2002; 21: 1539-1558. DOI: doi:10.1002/sim.1186.
41. Schünemann H, Oxman AD, Vist G, et al. Chapter 12: Interpreting results and drawing conclusions. In: Higgins J and Green S, (eds.). *Cochrane handbook for systematic reviews of interventions Version 5.10*. The Cochrane Collaboration, 2011.
42. Cates C. Visual Rx NNT Calculator. 2.0. 2004.
43. Bae YH, Lee GC, Shin WS, et al. Effect of Motor Control and Strengthening Exercises on Pain, Function, Strength and the Range of Motion of Patients with Shoulder Impingement Syndrome. *Journal of Physical Therapy Science* 2011; 23: 687-692. DOI: 10.1589/jpts.23.687.
44. Bennell K, Coburn S, Wee E, et al. Efficacy and cost-effectiveness of a physiotherapy program for chronic rotator cuff pathology: a protocol for a randomised, double-blind, placebo-controlled trial. *BMC musculoskeletal disorders* 2007; 8: 86-86. DOI: 10.1186/1471-2474-8-86.
45. Lombardi I, Jr., Magri AG, Fleury AM, et al. Progressive resistance training in patients with shoulder impingement syndrome: a randomized controlled trial. *Arthritis and rheumatism* 2008; 59: 615-622. 2008/04/29. DOI: 10.1002/art.23576.
46. Ludewig PM and Borstad JD. Effects of a home exercise programme on shoulder pain and functional status in construction workers. *Occupational and environmental medicine* 2003; 60: 841-849. 2003/10/24.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

47. Bury J, West M, Chamorro-Moriana G, et al. Effectiveness of scapula-focused approaches in patients with rotator cuff related shoulder pain: A systematic review and meta-analysis. *Man Ther* 2016; 25: 35-42. 2016/07/17. DOI: 10.1016/j.math.2016.05.337.

48. Malliaras P, Barton CJ, Reeves ND, et al. Achilles and patellar tendinopathy loading programmes : a systematic review comparing clinical outcomes and identifying potential mechanisms for effectiveness. *Sports medicine (Auckland, NZ)* 2013; 43: 267-286. 2013/03/16. DOI: 10.1007/s40279-013-0019-z.

49. Slade SC, Dionne CE, Underwood M, et al. Consensus on Exercise Reporting Template (CERT): Explanation and Elaboration Statement. *British Journal of Sports Medicine* 2016; 50: 1428-1437. DOI: 10.1136/bjsports-2016-096651.

For Peer Review

Table 1. Recruitment and retention, participant characteristics and eligibility criteria

Author, year, diagnostic label	Participants Number screened, number randomised total, per group, number available at follow-up	Mean age, function/pain, symptoms duration	Duration of pain	Pain on active movement	+ve resisted or orthopaedic tests	Dx imaging	Dx injection	Exclusion criteria
Progressive and resisted exercise versus placebo or no treatment								
Brox et al. 1993, rotator cuff disease	195 screened, 125 randomised, 30 placebo laser, 50 supervised exercises, 45 arthroscopic surgery not included in this review, follow up 79	Supervised exercise group: 47 years, 44% men, 66 (10-100, 100 best), overall pain 15 (0-100, 0 best), 24 months Placebo Laser group: 48 years, 50% men, 65 (10-100, 100 best), overall pain 14.8 (0-100, 0 best), 20 months	>3 months	Abduction	Abduction (0, 30 degrees), external rotation, positive impingement test	Not reported	Yes (LA)	Restricted passive range of motion, arthritis acromioclavicular joint, cervical syndrome, rotator cuff rupture, glenohumeral instability, bilateral pain and tenderness/decreased ability to relax shoulder, neck and temporomandibular joints
Dickens et al. 2005, subacromial impingement syndrome	Number screened not reported, 85 randomised, 40 no treatment, 45 non-progressive physiotherapy exercises, follow up 73	No treatment group: 54 years, 55% men, 56 (0-100, 100 best), overall pain not reported, duration of symptoms not reported Non-progressive physiotherapy exercise group: 55 years, 58% men, 52 (0-100, 100 best), overall pain not reported, duration of symptoms not reported	Not reported	Dx based on clinical exam (not described)	Dx based on clinical exam (not described)	Not reported	Yes (3 steroid in 6 weeks)	Cervical radiculopathy, adhesive capsulitis, 'clinically obvious' rotator cuff tear, grade III subacromial spur on x-ray, previous physiotherapy treatment
Lombardi et al. 2008, shoulder impingement syndrome	Number screened not reported, 60 randomised, 30 no treatment (physiotherapy waiting list), 30 progressive resistance exercise, follow up 56	No treatment group: 55 years, 17% men, 47 (0-100, 0 best), overall pain 44 (0-100, 100 best), 14 months Progressive resistance exercise group: 56 years, 30% men, 50 (0-100, 0 best), overall pain 43 (0-100, 100 best), 14 months	>2 months	Arc of movement that produces the greatest shoulder pain	Neer, Hawkins-Kennedy	Not reported	Not reported	Shoulder fractures or dislocation history; cervical radiculopathy; degenerative glenohumeral joint disease; shoulder, back, or thorax surgery; inflammatory arthropathy; shoulder injection in previous 3 months; people undergoing any physical interventions for the shoulder
Ludwig et al. 2003, shoulder impingement syndrome	110 screened, 92 randomised, 33 no treatment, 34 progressive resistance exercise, 25 asymptomatic subjects not included in this review, follow up 62	No treatment group: 49 years, 100% male, 73 (17-100, 100 best), overall pain 5 (0-10, 0 best), duration of symptoms not reported Progressive resistance exercise group: 48 years, 100% male, 66 (17-100, 100 best), overall pain 5 (0-10, 0 best), duration of symptoms not reported	Not reported	Abduction painful arc	Neer, Hawkins-Kennedy, Yocum, Jobe, and Speeds tests (≥ 2 positive). Resisted abduction, flexion, internal or external rotation.	Not reported	Not reported	Less than 130 degrees shoulder elevation; cervical spine or periscapular pain; shoulder symptoms reproduced by cervical spine assessment; previous rotator cuff surgery or glenohumeral dislocation or other traumatic injury

								Tenderness on palpation of biceps or rotator cuff tendons
Non-progressive or non-resisted exercise versus placebo or no treatment								
Bennell et al. 2010, rotator cuff disease	438 screened, 120 randomised, 59 active intervention non-progressive exercise group, 61 placebo sham ultrasound group, follow up 114	Active intervention non-progressive exercise group: 59 years, 58% men, 43 (0-100, 0 best), overall pain 48 (0-100, 0 best), 24 months Placebo sham ultrasound group: 61 years, 49% men, 44 (0-100, 0 best), overall pain 48 (0-100, 0 best), 14 months	>3 months	Abduction or external rotation >3/10 pain	Quick test for shoulder impingement	Not reported	Not reported	Shoulder pain severity >7/10 at rest, suspected complete rotator cuff tear (+ve drop arm test, substantial shoulder weakness, high riding humeral head on xray), prior surgery or fracture, inflammatory arthritis, osteoarthritis or calcification on xray, neoplastic disorder, >50% reduction range of motion in 2 or more planes, pain referred from vertebral structures, complex regional pain syndrome, active interventions last 3 months (e.g. injection, physiotherapy), anti-inflammatories previous 2 weeks
Giombini et al. 2006, supraspinatus tendinopathy	159 screened, 37 randomised, 12 ultrasound control group, 11 non-progressive exercise, 14 hyperthermia group not included in this review, follow up 23	Ultrasound control group: 29 years, 67% men, 59 (0-100, 100 best), overall pain 6.3 (0-10, 0 best), 5 months (mean both groups) Non-progressive exercise group: 26 years, 82% male, 59 (0-100, 100 best), overall pain 6.1 (0-10, 0 best), 5 months (mean both groups)	3-6 months	Not reported	Hawkin's sign or impingement in 90 degrees forward flexion & +ve empty can test	Non-homogeneous signal intensity without a tear	Not reported	Restricted passive range of motion, traumatic onset, severe neck pain, frozen shoulder, calcific tendinopathy, degenerative joint disease of the acromioclavicular or glenohumeral joint; prior intra-articular or subacromial injection of corticosteroids; clinical or ultrasonographic diagnosis of a rotator cuff tear; previous shoulder surgery on the affected or contralateral shoulder
Walther et al. 2004, subacromial impingement syndrome	Number screened not reported, 60 randomised, 20 functional brace (placebo), 20 self-training non-progressive exercise group, 20 physiotherapy non-progressive exercise group, follow up	Functional brace (placebo) group: 49 years, 70% men, 63 (0-100, 100 best), overall pain 50 (0-100, 0 best), 27 months Self training non-progressive exercise group: 52 years, 45% male, 58 (0-100, 100 best), overall pain 47 (0-100, 0 best), 23 months Physio non-progressive exercise grouping: 52 years, 55% male, 60 (0-100, 100 best), overall pain 54 (0-100, 0 best), 32 months	Not reported	Dx based on clinical exam (not described)	Neer test	X-ray and ultrasound (measures not described)	Yes (LA)	Cervical radiculopathy, frozen shoulder, full-thickness tear of the rotator cuff, acromioclavicular pathology; glenohumeral joint arthritis; calcifying tendinitis, shoulder instability, posttraumatic disorders, pending workers' compensation claim

Table 2. Exercise characteristics and outcomes

Author, year, trial type, country, funding, trial registration	No treatment or placebo group description, frequency, duration	Exercise group intervention description, exercise type, additional interventions	Home or supervised exercise, follow up sessions	Sets x repetitions or time, frequency, duration, total sessions, time under tension, rest time, repetitions per week	How load was applied, progression criteria	Advice about pain during exercise	Adherence	Outcomes, extracted outcomes
Progressive and resisted exercise versus placebo or no treatment								
Brox et al. 1993, RCT, Norway, Norwegian Research Council, no trial registration	Advice about pathology, pain, ergonomics, detuned laser 12 sessions in 6 weeks	Advice about pathology, pain, ergonomics, shoulder rotation, then flexion-extension, then abduction-adduction	Supervised twice weekly and daily home exercise on other days, 12-26 weeks	?, daily for one hour, 12-26 weeks, ?, ?, ?, incalculable	Load 'added gradually', did not specify how, did not specify criteria	Not reported	Not reported	Outcomes: Composite pain and function with Neer shoulder score (10-100, 100 is best), activity, rest and night pain with NRS (1-9, 9 worst possible pain) Outcomes extracted: composite pain and function, overall pain, activity pain, rest pain Note: Overall pain assumed from Neer pain item. We reversed the direction of the function score and converted to a 0-100 scale for consistency with other studies. We estimated SD as a median of the available SDs
Dickens et al. 2005, RCT, UK, Physiotherapy Research Council, no trial registration	Surgical waiting list, maintain normal ADLs	Manual therapy, postural advice, strapping +/- electrotherapy and exercises (not specified) for scapularthoracic muscles including trapezius and serratus anterior and rotator cuff muscles	Supervised 1-2 x per week and home, progressed 'regularly'	Sets/ reps not specified, twice daily, 26 weeks, ?, ?, ?, incalculable Isometric, then inner range, through range, outer range, functional positions. Resistance and speed of exercises progressed	Range, load (theraband), and speed were progressed 'regularly' based on ability to perform exercise	Not reported	Not reported	Outcomes: Composite pain and function with Constant score (0-100, 100 is best) Outcomes extracted: composite pain and function Note: We reversed the direction of the function score for consistency with other studies. We estimated SD as a median of the available SDs
Lombardi et al. 2008, RCT, Brazil, no funding reported, no trial registration	Physiotherapy waitlist	Flexion, extension, medial and lateral rotation	Supervised, 4 sessions in 8 weeks (fortnightly)	2x8 (50% [1 st set] to 70% [2 nd set] of 6 repetition maximum load), twice weekly, 8 weeks, 4 sec, 2 minutes, 128/wk	Pulley system progressed, based on 6 repetition maximum reassessment	Painfree	Not reported	Outcomes: Composite pain and function with disability of arm and shoulder score (laborious function component and activities of daily living component) (0-100, 0 better), quality of life short form SF-36, activity and rest pain with VAS (0-10, 10 worse pain) Outcomes extracted: composite pain and function (laborious function), overall, activity and rest pain

Note: Overall pain assumed from the SF-36 pain item. We reversed the direction of the SF-36 pain score for consistency with other studies.

Ludwig et al. 2003, RCT, USA, Centre to protect worker' rights, the public health service and the University of Iowa, no trial registration	No treatment	Anterior and posterior shoulder stretches, abduction active movement, and external rotation in neutral and in abduction progressive resisted exercise	Home, 1 in person and 1 phone or in person (if required) over 10 weeks Initial, at 1 week, phone/optional at 4 weeks	Stretches 30secx5/day & active movement 5x/day, progressive exercise 3x10 – 20 (by 3 rd week), 3x/week, 10 weeks, ?, ?, 540/wk	Theraband, based on ability to perform exercise	'No increased shoulder pain' (not clear if increased their baseline or no pain)	Exercise log (27% completed 75% or more of prescribed exercise	Outcomes: Composite pain and function with shoulder rating questionnaire (17-100, 100 is better), work related shoulder pain, work related disability Outcomes extracted: composite pain and function, overall pain Note: Overall pain assumed from work related pain item. We reversed the direction of the function score and converted to a 0-100 scale for consistency with other studies. SE reported and used to calculate SD.
---	--------------	---	--	---	---	---	--	--

Non-progressive or non-resisted exercise versus placebo or no treatment

Bennell et al. 2010, RCT, Australia, National Health and Medical Research Council, no NCT00415441	Sham ultrasound, no instruction to do any home exercises, no instruction in exercise technique 10 sessions in 10 weeks	Education, goal setting, manual therapy and home exercise program including dynamic scapular control, strengthening scapular stabiliser and rotator cuff muscles, improving shoulder and thoracic posture and increasing range of motion of thoracic extension	Home, 10 sessions over 10 weeks. Then instructed to continue daily exercises for further 12 weeks.	Variable sets/reps (2x10 repetitions or 5 sec x 5 or 1-3 minute hold), twice daily for first week, daily after that to 10 weeks, ?, ?, incalculable	Theraband, not progressed	Not reported	Exercise log (participant s completed 82% of prescribed exercise at 11 weeks, 70% at 22 weeks)	Outcomes reported: Composite pain and function, and overall pain with SPADI (both 0-100, 0 is best), activity and rest pain with NRS (0-10, 10 worse), quality of life using SF-36 Outcomes extracted: composite pain and function, overall, activity and rest pain
---	---	--	--	---	---------------------------	--------------	--	--

Giombini et al. 2006, RCT, Italy, no funding reported, no trial registration	Therapeutic ultrasound	Pendular flexion and extension in prone and passive glenohumeral stretching	Home, weekly, 4 weeks	Sets/reps not specified (5 minutes), twice daily, 4 weeks, ?, ?, incalculable	No load applied	'To tolerance'	Not reported	Outcomes reported: Composite pain and function with Constant-Murley score (0-100, 100 is best), mean pain using a 10cm VAS, pain on resisted movement (4 point scale, 0 is best), Pain on active abduction 40-120 (4 point scale, 0 is best) Outcomes extracted: composite pain and function, overall pain, pain during movement
--	------------------------	---	-----------------------	---	-----------------	----------------	--------------	---

Note: Overall pain assumed from mean pain. Reversed the direction of the function score for consistency with other studies.								
Walther et al. 2004, RCT, Germany, ?, no trial registration	Shoulder brace	Group a) Physiotherapy: Isometric shoulder retraction, abduction, external rotation, and rowing with elbow bent and straight, cervical lateral flexion stretch, pendular exercises, isometric adduction with self protraction mobilisation Group b) Self-training: as above	Group a supervised, 30 sessions in 12 weeks Group b home, 4 sessions in 12 weeks	Isometric 10x10sec, stretch 2x15sec, pendular 3-5 mins, adduction & distraction 3x15sec, group a 5x/wk; group b 2-3x/week, 12 weeks, ?, ?, incalculable Group b 5xper week for 10-15 mins.	Theraband or 1kg weight, no progression	Not reported	Not reported	Outcomes reported; Composite pain and function and with Constant-Murley (0-100, 100 is best), activity, night and rest pain (0-100, 100 maximum pain) Outcomes extracted: composite pain and function, overall pain, activity and rest pain Note: Overall pain assumed from night pain. We reversed the direction of the function score for consistency with other studies. We estimated SD as a median of the available SDs.

Note: ?=data missing; rep=repetitions, repetitions/week is the average over intervention period if weekly repetitions vary

Table 3. Summary of Findings: Progressive and resisted exercise compared to placebo for rotator cuff related pain

Patient or population: rotator cuff related pain						
Setting: Primary care patients (Norway), patients on surgery waiting list (UK), physiotherapy waiting list University hospital (Brazil), construction workers (USA)						
Intervention: 8-26 weeks of progressive resisted exercise						
Comparison: placebo (detuned laser) or no treatment						
Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk Placebo	Corresponding risk Progressive and resisted exercise				
Function Assessed with Constant-Murley (0-100, 100 is best), Neer (10-100, 100 is best) or SRQ (17-100, 100 is best) or the DASH (0-100, 0 is best) Follow-up: 8 to 26 weeks	The mean function in the control group was 44.2¹	The mean function in the intervention group was 15.0 points better (8.6 to 21.4 better)	-	271 (4 RCTs)	⊕⊕○○ LOW ³	Statistically significant but uncertain clinical benefit ² Absolute change 15% better (9% better to 21% better); relative change 32% better (18% better to 45% better) ⁴
Overall pain Assessed with SF36 (0-100, 0 is best), Neer (10-100, 0 is best) or VAS (0-100, 0 is best) Follow-up: 8 to 26 weeks	The mean overall pain in the control group was 53.3¹	The mean overall pain in the intervention group was 10.7 points better (5.6 to 15.7 better)	-	197 (3 RCTs)	⊕⊕○○ LOW ³	Statistically significant but uncertain clinical benefit ² Absolute change 11% better (6% better to 16% better); relative change 19% better (10% better to 28% better) ⁴
Pain with activity Assessed with VAS (0-100; 0 is best) Follow-up: 8 to 26 weeks	The mean pain with activity in the control group was 71.0¹	The mean pain with activity in the intervention group was 24.7 points better (13.9 to 35.5 better)	-	135 (2 RCTs)	⊕⊕○○ LOW ³	Statistically significant but uncertain clinical benefit ² Absolute change 25% better (14% better to 36% better); relative change 35% better (20% better to 50% better) ⁴
Pain at rest Assessed with VAS (0-100; 0 is best) Follow-up: 8 to 26 weeks	The mean pain at rest in the control group was 43.0¹	The mean overall pain in the intervention group was 22.8 points better (14.0 to 31.6 better)	-	135 (2 RCTs)	⊕⊕○○ LOW ³	Statistically significant but uncertain clinical benefit ² Absolute change 23% better (14% better to 32% better); relative change 58% better (36% better to 81% better) ⁴
Adverse events	-	-	-	-	-	-

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95%CI).
CI: Confidence interval; SRQ: shoulder rating questionnaire; DASH: disability of the arm, shoulder and hand; VAS: visual analogue scale; NRS: numerical rating scale

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

This table summarises data from the Brox 1993, Dickens 2005, Lombardi 2008, Ludwig 2003 trials.
¹Lombardi was used as the control group risk
²We assumed a clinically important improvement in function of 10 points on a 100-point scale (or 10%) and a clinically important improvement in pain of 15 points on a 100-point scale (or 15%)
³Downgraded (-2) for risk of bias. Participants and outcome assessors were not blinded (risk of performance, detection and selection bias). Not all measured outcomes were reported
⁴Relative changes calculated as absolute change divided by mean at baseline in the control group from Lombardi: Mean SD values were 47.4 (24.7) for function on a 0-100 point DASH scale; 56.1 (19.2) for overall pain on 0-100 point SF36 scale; 7.1 (1.5) for activity pain on 0-10 point VAS; 3.9 (2.6) for rest pain on 0-10 point VAS

Table 4. Summary of Findings: Non-progressive and non-resisted exercise compared to placebo for rotator cuff related pain**Patient or population:** rotator cuff related pain**Setting:** Primary care patients (Australia), University hospital (Germany) and athletes in University setting (Italy)**Intervention:** 4 to 12 weeks of non-progressive and non-resisted exercise**Comparison:** placebo (detuned laser, ultrasound, brace)

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Placebo	Non-progressive and non-resisted exercise				
Function Assessed with the Constant-Murley (0 to 100, 100 is best) or SPADI total score scales (0 to 100, 0 is best) Follow-up: 10 to 22 weeks	The mean function in the control group was 28.3¹	The mean function in the intervention group was 3.6 points better (2.2 worse to 9.4 better)	-	197 (3 RCTs)	⊕⊕○○ LOW ²	No significant benefit ³ Absolute risk difference 4% better (2% worse to 9% better); relative change 8% better (5% worse to 21% better) ⁴
Overall pain Assessed with the SPADI pain (0-100, 0 is best), mean pain VAS (0-100, 0 is best), night pain (0-100, 0 is best) Follow-up: 10 to 22 weeks	The mean overall pain in the control group was 31¹	The mean overall pain in the intervention group was 3.3 points better (1.5 worse to 8.1 better)	-	197 (3 RCTs)	⊕⊕○○ LOW ²	No significant benefit ³ Absolute risk difference 3% better (1% worse to 8% better); relative change 7% better (3% worse to 17% better) ⁴
Pain with activity Assessed with VAS (0-100, 0 is best) or NRS (0-100, 0 is best) Follow-up: 10 to 22 weeks	The mean pain with activity in the control group was 33¹	The mean pain with activity in the intervention group was 3.4 points better (5.0 worse to 11.8 better)	-	197 (3 RCTs)	⊕⊕○○ LOW ²	No significant benefit ³ Absolute risk difference 3% better (5% worse to 12% better); relative change 7% better (10% worse to 24% better) ⁴
Pain at rest Assessed with VAS (0-100, 0 is best) or NRS (0-100, 0 is best) Follow-up: 12 to 22 weeks	The mean pain at rest in the control group was 16¹	The mean pain at rest in the intervention group was 1.8 points better (6.6 worse to 10.2 better)	-	174 (2 RCTs)	⊕⊕○○ LOW ²	No significant benefit ³ Absolute risk difference 0.2% better (0.7% worse to 1% better); relative change 9% better (31% worse to 49% better) ⁴
Adverse events Follow-up: 10-11 weeks	Study population 82 per 1000	 309 per 1000 (122 to 782)	RR 3.77 (1.49 to 9.54)	116 (1 RCT)	⊕⊕⊕⊕ HIGH	Absolute risk difference 23% (9% to 37% more); relative percentage change 277% (49% to 854% more) NNTH 5 (26 to 2). Adverse events were mild and included short-term pain after exercises

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95%CI).

CI: Confidence interval; VAS: visual analogue scale; NRS: numerical rating scale; RR: Relative Risk; SPADI: Shoulder Pain and Disability Index

GRADE Working Group grades of evidence**High certainty:** We are very confident that the true effect lies close to that of the estimate of the effect**Moderate certainty:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different**Low certainty:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect**Very low certainty:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

This table summarises data from the Bennell 2010, Walther 2004 and Giombini 2006 trials.

¹Placebo group score in Bennell 2010 was used as assumed control group risk

²Downgraded (-2) for risk of bias. Participants and outcome assessors not blinded (risk of performance, detection and selection bias). Not all measured outcomes were reported in two studies with the lowest weighting

³We assumed a clinically important improvement in function of 10 points on a 100-point scale (or 10%) and a clinically important improvement in pain of 15 points on a 100-point scale (or 15%)

⁴Relative changes calculated as absolute change divided by mean at baseline in the control group from Bennell: Mean SD values were 43.9 (17.5) for function on a 0-100 point SPADI scale; 48.4 (17.5) for overall pain 0-100 point scale SPADI pain; 49 (18) for activity pain on 0-100 VAS, 21 (18) for rest pain on 0-100 point VAS

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2009 flow diagram for literature search results.

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Figure 2. Risk of bias summary: judgements about each risk of bias item for each included study (from Page et al).

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bennell 2010	+	+	+	+	+	+	+
Brox 1993	+	?	-	-	-	?	+
Dickens 2005	?	?	-	-	+	?	+
Giombini 2006	+	?	-	-	+	-	+
Lombardi 2008	+	+	-	-	+	?	+
Ludewig 2003	+	?	-	-	+	?	+
Walther 2004	?	?	-	-	+	-	+

Figure 3. Comparison One - Effects of progressive and resisted exercise versus placebo or no treatment on composite pain and function, overall pain, activity pain and rest pain

Figure 4. Comparison Two - Effects of non-progressive or non-resisted exercise versus placebo or no treatment on composite pain and function, overall pain, activity pain and rest pain

Composite Pain and Function

Overall Pain

Activity Pain

Rest Pain

Appendix 1

Search strategy for CENTRAL:

1. MeSH descriptor: [Shoulder Pain] explode all trees
2. MeSH descriptor: [Shoulder Impingement Syndrome] explode all trees
3. MeSH descriptor: [Rotator Cuff] explode all trees
4. MeSH descriptor: [Bursitis] explode all trees
5. ((shoulder* in AllText or rotator* in AllText) and (bursitis in AllText or impinge* in AllText or tendonitis in All Text or tendonitis in All Text or tendinopathy in AllText or pain* in All Text))
6. "rotator cuff" in AllText
7. #1 or #2 or #3 or #4 or #5 or #6
8. MeSH descriptor: [Rehabilitation] explode all trees
9. MeSH descriptor: [Physical Therapy Modalities] explode all trees
10. MeSH descriptor: [Exercise Movement Techniques] explode all trees
11. MeSH descriptor: [Ultrasonography, Interventional] explode all trees
12. rehabilitat* in All Text or physiotherapy* in AllText or "physical therap*" in AllText or "manual therap*" in All Text or exercis* in All Text
13. (ultrasound in All Text or ultrasonograph* in All Text or tns in AllText or tens in All Text or shockwave in All Text or electrotherap* in All Text or mobili* in AllText)
14. #9 or #10 or #11 or #12 or #13
15. #8 and #15

Search strategy for MEDLINE (Ovid):

1. shoulder pain/
2. shoulder impingement syndrome/
3. rotator cuff/
4. exp bursitis/
5. ((shoulder\$ or rotator cuff) adj5 (bursitis or impinge\$ or tendinitis or tendonitis or tendinopathy or pain\$)).mp.
6. rotator cuff.mp.
7. or/1-7
8. exp rehabilitation/
9. exp physical therapy techniques/
10. exp musculoskeletal manipulations/
11. exp exercise movement techniques/
12. exp ultrasonography, interventional/
13. (rehabilitat\$ or physiotherap\$ or physical therap\$ or manual therap\$ or exercis\$ or ultrasound or ultrasonograph\$ or TNS or TENS or shockwave or electrotherap\$ or mobili\$). mp.
14. or/9-13
15. clinical trial.pt
16. random\$.mp.
17. ((single or double) adj (blind\$ or mask\$)).mp.
18. placebo\$.mp.
19. or/16-18
20. 7 and 14 and 19

Search strategy for EMBASE (Ovid):

1. 'shoulder pain'/exp
2. 'shoulder impingement syndrome'/exp
3. 'rotator cuff'/exp

4. 'bursitis'/exp
5. ((shoulder* OR rotator*) AND('bursitis'/de OR impinge* OR 'tendonitis'/de OR 'tendinitis'/de OR 'tendinopathy'/ de OR pain*))
6. 'rotator cuff'
7. #1 OR #2 OR #3 OR #4 OR #5 OR #6
8. 'rehabilitation'/exp
9. 'physiotherapy'/exp
10. 'kinesiotherapy'/exp
11. 'endoscopic echography'/exp
12. rehabilitat* OR physiotherapy* OR 'physical therapy'OR 'manual therapy'OR kinesiotherap* OR exercis*
13. 'ultrasound'/de OR ultrasonograph* OR 'transcutaneous nerve stimulation' OR 'transcutaneous electricalnerve stimulation' OR shockwave OR electrotherap*OR mobili*
14. #9 OR #10 OR #11 OR #12 OR #13 OR #13
15. 'randomized controlled trial'/exp
16. #7 AND #14 AND #15

Search strategy for CINAHL Plus (EBSCO):

- S1 MH "shoulder pain"
- S2 MH "shoulder impingement syndrome"
- S3 MH "rotator cuff"
- S4 MH bursitis+
- S5 TX (shoulder* N5 bursitis) or TX(shoulder* N5 impinge*) or TX(shoulder* N5 tend?nitis) or TX(shoulder* N5 tendinopathy) or TX(shoulder* N5 pain*)
- S6 TX (rotator cuff N5 bursitis) or TX(rotator cuff N5 impinge*) or TX(rotator cuff N5 tend? nitis) or TX(rotator cuff N5 tendinopathy) or TX(rotator cuff N5 pain*)
- S7 TX rotator cuff
- S8 S1 or S2 or S3 or S4 or S5 or S6 or S7
- S9 MH Rehabilitation+
- S10 MH physical therapy+
- S11 MH Manual Therapy+
- S12 MH Therapeutic Exercise+
- S13 MH Ultrasonography+
- S14 TX rehabilitat* or physiotherapy* or physical therap*or manual therap* or exercise* or ultrasound or ultrasonograph* or TNS or TENS or shockwave or electrotherapy*or mobili*
- S15 S10 or S11 or S12 or S13 or S14 or S15
- S16 PT clinical trial
- S17 TX random*
- S18 TX(single blind*) or TX(single mask*)
- S19 TX(double blind*) or TX(double mask*)
- S20 placebo*
- S21 S17 or S18 or S19 or S20 or S21
- S22 S8 and S15 and S21

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Appendix 2

Email correspondence from Markus Walther clarifying if there was progression of resistance within each exercise.

Hi,
All did the same exercises.
The Theraband stayed the same - we did not change to a harder one.
Regards,
Markus Walther

Email correspondence from Kim Bennell clarifying if there was progression of resistance within each exercise.

Hi Peter,
Sounds like an interesting project.
No the resistance band wasn't changed in each exercise ... the program itself was progressive so the exercises were changed along the way to make them increasingly harder.
The exercises were checked by the physio for form particularly around correct posture.
However, if the physio felt that they weren't able to progress to the more difficult exercise or they were having pain etc, they could stay at the easier exercise level. I did manage to find the therapist handbook
Hope that helps – it was a long time ago!
Regards,
Kim

Note: Our eligibility and exclusion criteria states progressive and resisted trials needed to state how load was applied (e.g. Theraband or weight) AND that there was progression of volume or load or both. Non-progressive or non-resisted trials could include progression of range or from static to through range. We specifically required that resistance or load was progressed within each exercise to be classified as progressive and resisted.

Appendix 3

Included Studies

1. Brox JI, Staff PH, Ljunggren AE, et al. Arthroscopic surgery compared with supervised exercises in patients with rotator cuff disease (stage II impingement syndrome). *BMJ (Clinical research ed)* 1993; 307: 899-903.
2. Bennell K, Wee E, Coburn S, et al. Efficacy of standardised manual therapy and home exercise programme for chronic rotator cuff disease: randomised placebo controlled trial. *BMJ (Clinical research ed)* 2010; 340. DOI: 10.1136/bmj.c2756.
3. Dickens VA, Williams JL and Bhamra MS. Role of physiotherapy in the treatment of subacromial impingement syndrome: a prospective study. *Physiotherapy* 2005; 91: 159-164. DOI: <https://doi.org/10.1016/j.physio.2004.10.008>.
4. Giombini A, Di Cesare A, Safran MR, et al. Short-term effectiveness of hyperthermia for supraspinatus tendinopathy in athletes: a short-term randomized controlled study. *Am J Sports Med* 2006; 34: 1247-1253. 2006/04/26. DOI: 10.1177/0363546506287827.
5. Lombardi I, Jr., Magri AG, Fleury AM, et al. Progressive resistance training in patients with shoulder impingement syndrome: a randomized controlled trial. *Arthritis and rheumatism* 2008; 59: 615-622. 2008/04/29. DOI: 10.1002/art.23576.
6. Ludewig PM and Borstad JD. Effects of a home exercise programme on shoulder pain and functional status in construction workers. *Occupational and environmental medicine* 2003; 60: 841-849. 2003/10/24.
7. Walther M, Werner A, Stahlschmidt T, et al. The subacromial impingement syndrome of the shoulder treated by conventional physiotherapy, self-training, and a shoulder brace: results of a prospective, randomized study. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]* 2004; 13: 417-423. 2004/06/29. DOI: 10.1016/s1058274604000485.