Exercise therapy is effective for improvement in range of motion, function and pain in patients with frozen shoulder : a systematic review and meta-analysis

Title: Exercise therapy is effective for improvement in range of motion, function and pain in patients with frozen shoulder: a systematic review and meta-analysis

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ABSTRACT

Objective: To determine 1) the effect of exercise therapy alone or in combination with other interventions compared to solely exercises and programs with or without exercises? And 2) what kind of *exercise therapy or combination with other interventions* is most effective?

Design: Systematic review and meta-analysis.

Participants: Patients with frozen shoulder.

Intervention: Exercise therapy as sole intervention or combined with other physical therapy interventions.

Outcome measures: Range of motion (ROM), function, disability pain, muscle strength and patient satisfaction.

Results: Thirty-three studies were included in the qualitative and 19 in the meta-analysis. Preliminary evidence was found for supervised exercises to be more beneficial than home exercises for ROM and function. Multimodal programs comprising exercises may result in little to no difference in ROM compared to solely exercises.

Programs comprising muscle energy techniques show little to no difference in ROM when compared to programs with other exercises. Adding stretches to a multimodal program with exercises may increase ROM. There is uncertain evidence that there is a difference between those programs regarding function and pain.

Preliminary evidence was found for several treatment programs including exercises to be beneficial for improvement in both passive and active ROM, function, pain, and muscle strength. No studies used patient satisfaction as an outcome measure.

Conclusion: ROM, function and pain improve with both solely exercises and programs with exercises, but for ROM and pain there was little to no difference between programs and for

function the evidence was uncertain.. Adding exercises improve active ROM compared to a program without exercises, while adding physical modalities has no beneficial effect. Muscle energy techniques are a beneficial type of exercise therapy for improving function compared to other types of exercise. Unfortunately, no conclusion can be drawn about the results in the long-term and most effective dose of exercise therapy.

Key words*: frozen shoulder; exercise therapy; physical therapy; rehabilitation; meta-analysis.*

LIST OF ABBREVIATIONS

FS: frozen shoulder

DM: Diabetes Mellitus

PT: interventions performed by physical therapists

ROM: range of motion

WoS: Web of Science

CENTRAL: Cochrane Central Register of Controlled Trials

PICO: Patient, Intervention, Comparison, Outcome

MD: mean difference

SMD: standardized mean difference

SPADI: shoulder pain and disability index

CMS: Constant Murley score

RC: rotator cuff

CPM: continuous passive motion

PROM: passive range of motion

92 AROM: active range of motion

93 DASH: disabilities of arm shoulder and hand

94 VAS: visual analogue scale

95 ER: external rotation

96

INTRODUCTION

Frozen shoulder (FS) is a common condition characterized by a spontaneous, progressive inflammation and fibrosis of the shoulder joint capsule and the rotator interval, resulting in functional restrictions of both active and passive shoulder range of motion (ROM).[1-5] The non-dominant shoulder is most affected[6-8] and about 6%-34% of those affected will develop a FS in the opposite shoulder.[6, 8-11] FS usually develops between the ages of 40-60 years[6, 8, 10] with the incidence increasing with age.[12] The prevalence of primary FS in the general population is 2-5%[1, 3, 13-16] and usually more women than men are affected.[6, 8-12, 17-19]
Over the last two decades, there has been an increase in the incidence and prevalence of FS, possibly due to an increase in sedentary jobs with physically low activity.[12] It seems that the occurrence of FS is higher in patients with these jobs.[12] Furthermore, up to 39% of patients with Diabetes Mellitus (DM) will develop a FS [16, 20] and they have a 5 to 7 times higher risk of developing a FS.[14]

Interventions performed by physical therapists (PT) are commonly used and often recommended for FS. Treatment of patients with a FS by a physical therapist usually starts when the patient experiences a progressive loss of ROM and persistence of pain. PT are most consistently prescribed to maintain and improve motion and function, but there is a lack of consensus about which PT are most effective.[17, 21-23] Traditional treatment with PT consists of patient education, physical applications (heating or electrotherapy), joint mobilization and exercises.[14, 24] Exercises aim to improve ROM and muscle function by restoring shoulder mobility and stability through range.[25] In general, exercises include any purposeful movement of a joint, muscle contraction or prescribed activity.[26]

In chronic diseases and a range of musculoskeletal conditions, including FS, it has been suggested that exercise therapy is the most effective component of PT, and as effective as medical treatment.[25, 27-32] Exercise therapy (as part of programs including multiple interventions (multimodal protocols)) was found to be effective in reducing pain and disability in several shoulder disorders.[31, 32]

It is proposed that exercise therapy might help to reduce pain and restore the range, coordination and/or control of movements in patients with FS,[33] however, this information might be outdated, not specific for FS, or not systematically reviewed. Hence, it is uncertain what the effects of exercises are, to what extent they work besides or in combinations with other modalities, and which format of exercise therapy is the most effective. Indeed, exercise therapy is usually part of a multimodal program and is often not provided as a single intervention. However, it is interesting to know whether a program with solely exercises is as effective as a multimodal program and what combination of interventions are most effective, in relation to various outcome measures in the short and/or long term.

The research questions regarding patients with FS and the outcome measures ROM, function/disability, pain, muscle strength and patient satisfaction were:

1. What is the effect of *exercise therapy alone or in combination with other interventions* compared to solely exercises and programs with or without exercises?
2. *What kind of exercise therapy or combination with other interventions* is the most effective?

METHOD

147

148 **Design**

149 Systematic review and meta-analysis of randomized controlled trials. The review was not

150 prospectively registered.

151

152 **Identification and selection of studies**

153 PubMed, Web of Science (WoS) and Cochrane Central Register of Controlled Trials

154 (CENTRAL) were searched to identify relevant studies concerning exercise therapy in

155 patients with FS. The search strategy and search terms are based on a Patient, Intervention,

156 Comparison, and Outcomes (PICO) design. The full search strategy for PubMed is presented

157 in Table 1. The search terms for the three different components were combined into one

158 search strategy. The full strategies for WoS and CENTRAL are presented in Supplemental

159 Appendix S1.

160

161 Table 1: Full search strategy for the different elements of the PICO for PubMed. Different

162 elements were combined with AND.

Patient	Intervention	Comparison	Outcome
Frozen shoulder OR Adhesive capsulitis OR Stiff shoulder OR “Periarthritis” [MeSH] OR Periarthritis OR Pericapsulitis	“Rehabilitation” [MeSH] OR “Exercise Therapy” [MeSH] OR "Exercise Movement Techniques"[Mesh] OR "Resistance Training"[Mesh] OR "Plyometric Exercise"[Mesh] OR “High-Intensity Interval Training” [MeSH] OR “Physical Therapy Modalities” [MeSH] OR “Physical Therapy Specialty” [MeSH] OR Exercise therapy OR Exercise training OR Exercise movement techniques OR Muscle strengthening exercises OR Resistance training OR Resistance exercise OR Plyometric training OR Plyometric exercise OR Proprioceptive training OR strength training OR rehabilitation OR aerobic exercise OR anaerobic exercise OR		“Range of motion, articular” [MeSH] OR “Pain” [MeSH] OR “Musculoskeletal Pain” [MeSH] OR “chronic pain” [MeSH] OR “Shoulder Pain” [MeSH] OR "Muscle Strength"[Mesh] OR “activities of daily living” [MeSH] OR “Sports” [MeSH] OR “Quality of life” [MeSH] OR "Patient Satisfaction"[Mesh] OR Pain OR Shoulder pain OR Mobility OR Range of motion OR Muscle strength OR Functionality OR Functional ability OR Activities of daily living OR Sports OR Quality of life OR Patient satisfaction

	high-intensity interval training OR anaerobic training OR aerobic training OR physical therapy		

163

164 The reference lists of included studies and interesting systematic reviews and meta-analyses
165 concerning exercise therapy in patients with FS [11, 13, 14, 17, 21, 25, 26, 33-50] were hand searched
166 additionally. The last search took place on 18 April
167 2019 and was updated 25 May 2021.
168 After searching the three different databases duplicates
169 were removed by the use of Endnote X9. The
170 remaining studies were screened for fulfilling the
171 inclusion criteria (Box 1) on title and abstract by two
172 independent reviewers (MM and LM) with the help of
173 Rayyan.[51] If title and abstract were unclear concerning
174 fulfilling the eligibility criteria, the full text was
175 retrieved and screened together with the remaining
176 studies once more, again by the two independent
177 reviewers. Differences were discussed in a consensus
178 meeting, if consensus could not be reached the last author made the final decision.

Box 1: Inclusion criteria

Design
- Randomized controlled trials

Participants
- Patients with frozen shoulder
- Primary or secondary (systemic and intrinsic) frozen shoulder
- Humans >18 years

Intervention
- Exercise therapy

Outcome measures
- Pain
- Range of motion
- Muscle strength
- Functional ability
- Patient satisfaction

Language
- English or Dutch

179

180 **Quality of evidence**

181 Two reviewers (MM and LM) determined the risk of bias independently by the use of the
182 Risk of Bias 2.0 tool.[52] The ratings of both reviewers were compared and potential differences
183 were discussed in a consensus meeting. If disagreements occurred after the consensus
184 meeting, they were resolved by consulting the last author. A distinction between clinician
185 reported outcome measures, like ROM and patient reported outcome measures, like pain and
186 questionnaires was used to determine the quality of evidence for the different outcome

187 measures. Afterwards, the overall quality of the evidence for each outcome was rated with the
188 GRADE approach by the first author.[53]
189
190 **Data analysis**
191 All included full texts were read and information was extracted about origin, characteristics of
192 study participants, eligibility criteria, characteristics of exercise therapy (exercises, duration,
193 frequency), outcome measures, and main results. Two independent reviewers (MM and LM)
194 performed data extraction in a pre-defined template.
195 The synthesis of results was performed through meta-analysis, with the software Rev Man
196 5.3. Clinical homogenous studies were grouped based on intervention applied and outcome
197 measures used, next the I^2 test determined statistical heterogeneity. With low statistical
198 heterogeneity ($I^2 \leq 50\%$) the fixed effects method was used for data-analysis, else the random
199 effects method was used. Depending on the results in the included studies the mean difference
200 (MD) [95% confidence interval (CI)] was used for outcomes with the same measurement tool,
201 the standardized mean difference (SMD) [95% CI] was used for outcomes with a different
202 measurement tool. Effect measures were determined for ROM, function/disability, pain,
203 muscle strength, and patient satisfaction (if appropriate). If median and range or quartiles
204 were reported, the mean and standard deviation were estimated based on the formulas of Wan
205 et al.[54] When included studies compared three intervention groups, groups were combined, as
206 recommended by the Cochrane Handbook,[55] depending on the comparison. The magnitude of
207 the effect sizes was determined based on the minimal detectable change and minimal
208 clinically important difference if available, otherwise arbitrary borders were determined based
209 on previous literature. Finally, results are presented with their effect in the short (<3 months
210 follow up), mid- (3-9 months follow up) and/or long term (>9 months follow up).
211

212

213 **RESULTS**

214

215

216 **Flow of studies through the review**

217 The study selection process is shown in Figure 1. Finally, 33 studies were included in the
218 qualitative analysis, of which 19 were used in the meta-analysis as well. For the first
219 screening, there was a 96% agreement rate between the two reviewers and for the second
220 screening; there was an 84.1% agreement rate. Full agreement was reached after discussion
221 between the two reviewers.

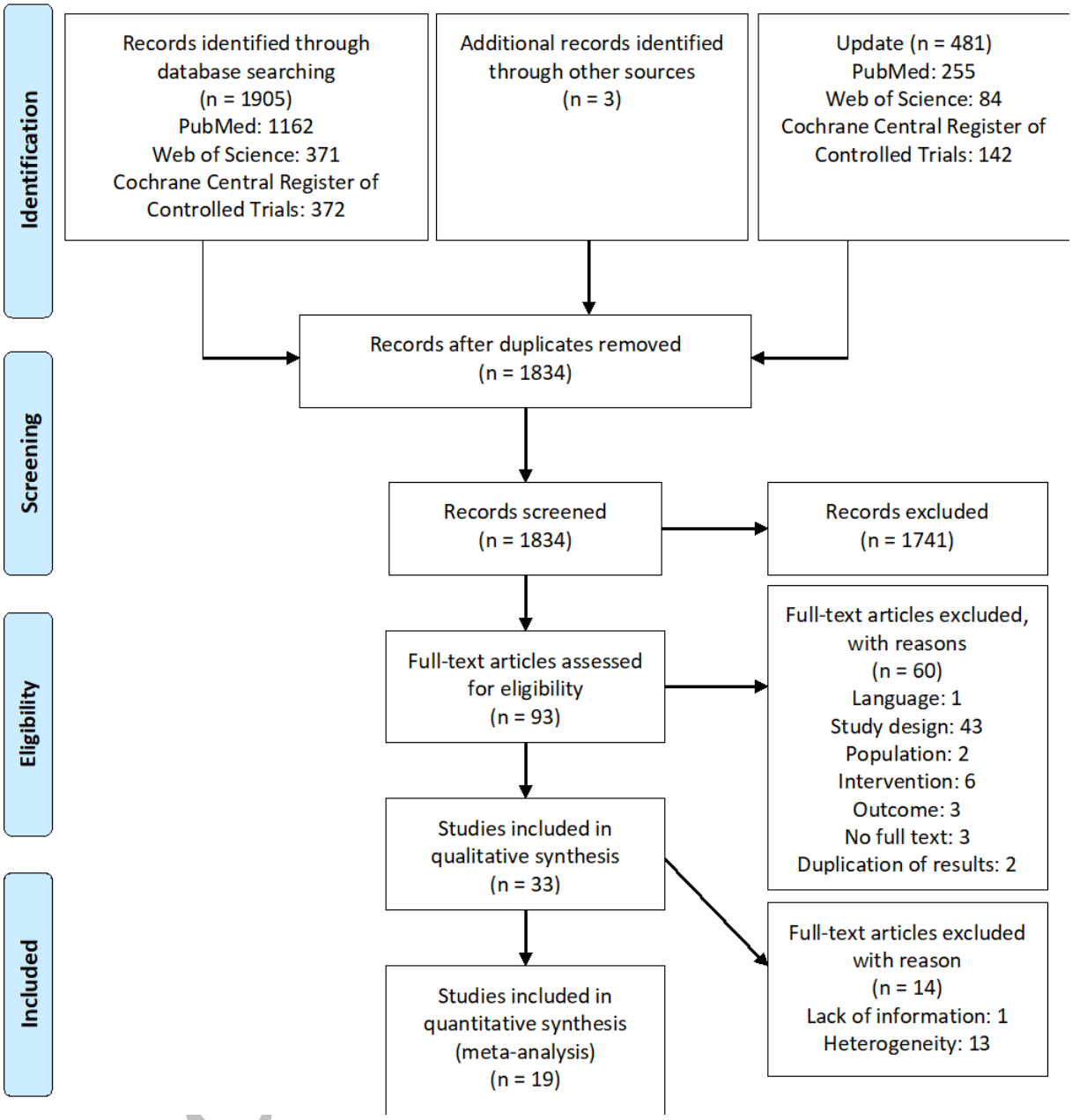


Figure 1. Flowchart of study selection

Quality of evidence

The risk of bias within and between studies is presented in Figure 2. Regarding clinician reported outcome measures, being ROM, muscle strength and scapular position, overall three studies [56-59] had high quality, four studies [59-62] had moderate quality and 20 studies had low quality.[63-83] Regarding the patient reported outcome measures, like pain and self-reported

questionnaires (e.g. Shoulder Pain and Disability Index (SPADI) and Constant Murley Score (CMS)), overall two studies [57-59] had high quality, two studies [59, 60] had moderate quality and 28 studies [61, 62, 64-88] had low quality. Low quality was mainly due to a lack of reporting about adherence to the intervention (domain 'Deviations from intended interventions') in most studies, and lack of blinding participants in studies with patient reported outcome measures. The initial agreement rate between the two reviewers for quality assessment was 77.8%, reaching full agreement after discussing the differences. Most differences occurred in the deviations from the intended interventions, where one reviewer made some assumptions. The reviewing team decided to use only information that was published.

Table 2 shows the quality of evidence determined by the GRADE approach for the different research questions with their outcome measures. For several interventions only preliminary evidence is available, these results are shown in Table 3.

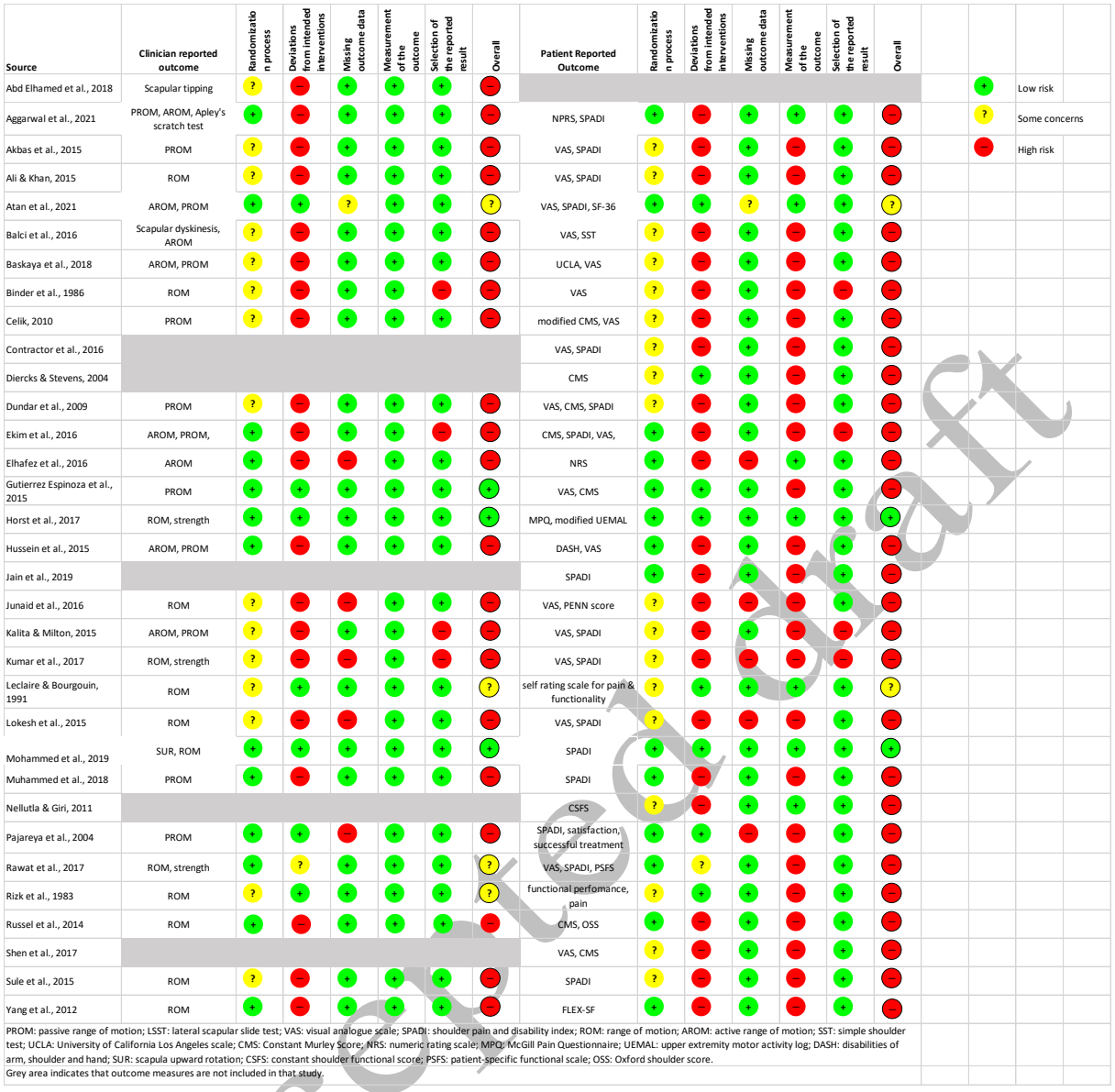


Figure 2. Overview of within and between studies risk of bias for both clinician and patient reported outcome measures.

Table 2 Pooled quality of evidence, based on the GRADE, for the different comparisons and each outcome measure.

Outcome	Result	Weighted (S)MD [95%CI]	Evidence
Multimodal program including exercises compared to solely exercises			
PROM	No difference	-4.91 [-6.76, -3.06]	Low
Function	No difference	0.04 [-0.56, 0.64]	Very low
Pain	No difference	-1.13 [-2.61, 0.35]	Low
MM program including exercises compared to MM program without exercises			
PROM	No difference	4.51 [2.10, 6.91]	High

AROM	MM including exercises more effective	12.83 [6.00, 19.66]	Preliminary
Function	No difference	-0.78 [-2.06, 0.49]	Very low
Pain	No difference	-0.06 [-0.42, 0.30]	Moderate
MM program including MET compared to MM program including other exercises			
PROM	No difference	4.88 [3.24, 6.51]	Moderate
AROM	No difference	6.35 [-8.93, 21.63]	Low
Function	MET more effective	-0.62 [-1.28, 0.04]	Low
Pain	No difference	-0.36 [-1.24, 0.52]	Very low
MM program including static stretching compared to MM program without stretching			
PROM	Static stretching more effective	16.40 [7.41, 25.38]	Very low
Function	No difference	-0.60 [-2.92, 1.72]	Very low
MM program including physical modalities compared to MM program including sham treatment			
PROM	No difference	1.51 [-4.14, 7.16]	Moderate
Pain	No difference	0.10 [-0.26, 0.46]	High
MM: multimodal; PROM: passive range of motion; AROM: active range of motion; MET: muscle energy techniques;			

248

249 Table 3 Overview of results for various treatment programs incorporating exercise
250 therapy, with the mean difference [95% confidence interval] and the effect
251 size.

252

Study	Intervention	MD between groups [95% CI]	Effect size
PROM abduction (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	-6.60 [-13.42, 0.22]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	19.10 [5.47, 32.37]	Moderate
Ekim et al., 2016 [71]	CPM compared to additional stretching	11.00 [0.77, 21.23]	Small
Gutierrez-Espinoza et al., 2015 [56]	Local exercises with US compared to aerobic with mobilization	21.90 [17.65, 26.15]	Moderate
Mohamed et al., 2020[5860]	Scapular recognition exercise compared to placebo exercise	2.29 [-1.63, 6.21]	No effect
Rawat et al., 2017 [61]	Addition of RC strengthening exercises	17.72 [8.36, 27.08]	Moderate
PROM external rotation (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	1.40 [-6.18, 8.98]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	3.10 [-5.82, 12.02]	No effect
Celik, 2010 [69]	Addition of scapulothoracic exercises	2.50 [-4.47, 9.47]	No effect
Ekim et al., 2016 [71]	CPM compared to additional stretching	3.60 [-6.42, 13.62]	No effect
Gutierrez-Espinoza et al., 2015 [56]	Local exercises with US compared to aerobic with mobilization	26.80 [22.75, 30.85]	Moderate
Kumar et al., 2017 [76]	Addition of spray & stretch	19.00 [15.76, 22.24]	Moderate
Mohamed et al., 2020[5860]	Scapular recognition exercise compared to placebo exercise	9.16 [4.58, 13.74]	Small

Rawat et al., 2017 [61]	Addition of RC strengthening exercises	26.05 [18.34, 33.76]	Moderate
Yang et al., 2012 [81] (no values per intervention specified)	Addition of end range mobilization	23.4 [8.2, 37.3]	Moderate
PROM internal rotation (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	-1.40 [-8.04, 5.24]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	3.40 [-6.00, 12.80]	No effect
Celik, 2010 [69]	Addition of scapulothoracic exercises	0.00 [-4.72, 4.72]	No effect
Ekim et al., 2016 [71]	CPM compared to additional stretching	8.90 [-0.05, 17.85]	Small
Rawat et al., 2017 [61]	Addition of RC strengthening exercises	18.43 [13.33, 23.53]	Moderate
Yang et al., 2012 [81]	Addition of end range mobilization	-0.03 [-0.11, 0.05]	No effect
PROM flexion (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	6.20 [-4.59, 16.99]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	22.00 [9.63, 34.37]	Moderate
Celik, 2010 [69]	Addition of scapulothoracic exercises	12.21 [4.39, 20.03]	Small
Ekim et al., 2016 [71]	CPM compared to additional stretching	11.50 [4.33, 18.67]	Small
Gutierrez-Espinoza et al., 2015 [56]	Local exercises with US compared to aerobic with mobilization	37.30 [28.73, 45.87]	Large
Mohamed et al., 2020[5860]	Scapular recognition exercise compared to placebo exercise	10.60 [5.46, 15.74]	Small
Rawat et al., 2017 [61]	Addition of RC strengthening exercises	7.05 [-5.32, 19.42]	Small
AROM abduction (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	-4.90 [-19.42, 9.62]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	21.70 [6.75, 36.65]	Moderate
Ekim et al., 2016 [71]	CPM compared to additional stretching	11.90 [2.47, 21.33]	Small
AROM external rotation (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	2.00 [-5.48, 9.48]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	4.30 [-4.33, 12.93]	No effect
Ekim et al., 2016 [71]	CPM compared to additional stretching	2.50 [-7.49, 12.49]	No effect
AROM internal rotation (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	-0.13 [-7.20, 6.94]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	7.10 [-2.67, 16.87]	Small
Ekim et al., 2016 [71]	CPM compared to additional stretching	7.70 [-1.90, 17.30]	Small
AROM flexion (°)			
Aggarwal et al., 2021[83]	Addition of IASTM	5.20 [-5.64, 16.04]	No effect
Baskaya et al., 2018 [67]	Mirror therapy compared to	24.10 [11.60, 36.60]	Moderate

	no mirror		
Ekim et al., 2016 [71]	CPM compared to additional stretching	11.60 [4.25, 18.95]	Small
Functional ROM (apley's scratch test, overall)			
Aggarwal et al., 2021[83]	Addition of IASTM	-0.02 [-1.61, 1.58]	No effect
Function (diverse)			
Celik, 2010 [69] (modified CMS)	Addition of scapulothoracic exercises	9.00 [2.77, 15.23]	Small
Baskaya et al., 2018 [67] (UCLA)	Mirror therapy compared to no mirror	6.00 [2.48, 9.52]	Moderate
Ekim et al., 2016 [71] (CMS)	CPM compared to additional stretching	7.40 [3.08, 11.72]	Small
Gutierrez-Espinoza et al., 2015 [56] (CMS)	Local exercises with US compared to aerobic with mobilization	20.60 [16.82, 24.38]	Moderate
Kumar et al., 2017 [76] (SPADI)	Addition of spray & stretch	-21.00 [-26.21, -15.79]	Moderate
Mohamed et al., 2020[58]	Scapular recognition exercise compared to placebo exercise	-8.84 [-3.27,-14.41]	No effect
Rawat et al., 2017 [61] (SPADI)	Addition of RC strengthening exercises	-19.62 [-25.56, -13.68]	Moderate
Shen et al., 2017 [88] (CMS)	Yi jin jing compared to functional	3.20 [0.96, 5.44]	No effect
Yang et al., 2012 [81] (FLEX-SF)	Addition of end range mobilization	0.74 [-0.17, 1.66]	No effect
Pain (VAS, unless indicated otherwise)			
Baskaya et al., 2018 [67]	Mirror therapy compared to no mirror	-1.48 [-2.34, -0.62]	Small
Celik, 2010 [69]	Addition of scapulothoracic exercises	-1 (-1.59, -0.41]	Small
Ekim et al., 2016 [71]	CPM compared to additional stretching	-1.10 [-1.90, -0.30]	Small
Gutierrez-Espinoza et al., 2015 [56]	Local exercises with US compared to aerobic with mobilization	-1.00 [-1.50, -0.50]	Small
Junaid et al., 2016 [74]	Addition of mobilization	-0.75 [-1.24, -0.26]	No effect
Kumar et al., 2017 [76]	Addition of spray & stretch	-2.00 [-2.72, -1.28]	Moderate
Leclaire & Bourgouin, 1991 [60]	Addition of electromagnetic therapy	0.10 [-0.26, 0.46] (ordinal scale)	No effect
Rawat et al., 2017 [61]	Addition of RC strengthening exercises	-1.29 [-2.01, -0.57]	Small
Shen et al., 2017 [88]	Yi jin jing compared to functional	-1.80 [-2.46, -1.14]	Small
Muscle strength			
Kumar et al., 2017 [76]	Addition of spray & stretch	32.00 [26.23, 37.77] mmHg	Moderate
Rawat et al., 2017 [61] (multiple directions)	Addition of RC strengthening exercises	2.10 [1.67, 2.52] lb.	Small
Scapular tipping (cm)			
Abd Elhamed et al., 2018 [63]	Addition of lower trapezius strengthening	-3.09 [-4.33, -1.85]	Small
Scapular upward rotation (°)			
Mohamed et al., 2020[58]	Scapular recognition exercise compared to placebo exercise	2.43 [-1.50, 6.36]	No effect

MD: mean difference; CI: confidence interval; PROM: passive range of motion; CPM: continuous passive motion; US: ultrasound; RC: rotator cuff; AROM: active range of motion; VAS: visual analogue scale; cm: centimeter.

253

254 **Study characteristics**

255 The characteristics of the included studies are presented in Table 4-7 and summarized below.

256

257 Table 4 Characteristics of studies comparing solely exercises in different formats

Source & origin	Participants			Experimental intervention	Control intervention	Dose	Follow-up	Outcome measures	Results
	Group composition and patient characteristics	Inclusion	Exclusion						
Russell et al., 2014 [82] United Kingdom	Frozen shoulder 75 T (51.1 (40-65) 25 E ? 26 C ?	• Insidious onset of pain & stiffness • Clinically reduction in ROM, >50% ER • No radiologic abnormalities • At least 3 months complaints	• Other shoulder disorders, surgery or significant trauma • Local CSI or any PT intervention within last 3 months • Bilateral frozen shoulder • Presence of comorbidities • Active medicolegal involvement	HEP + exercise class	HEP	F: 2x/w D: 6 w I: 50 min (class) HEP continued after 6 weeks	6 weeks, 6 months, and 1 year	Function (CMS) Oxford shoulder score ROM (°) - flexion - ER	All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C, All FU: E↑, C↑, E>C, All FU: E↑, C↑, E>C,

T: total group study; E: experimental group; C: control group; ROM: range of motion; ER: external rotation; CSI: corticosteroid injection; PT: physical therapy; HEP: home exercise program; F: frequency; w: week; D: duration; I: intensity; CMS: Constant Murley Score; FU: follow up;

↑: improved
=: not improved
>: improved more than
<: improved less than

258

259 Table 6 Characteristics of studies comparing a physical therapy program including exercises with a program without exercises

Source & origin	Participants: Group composition and patient characteristics	Participants: Inclusion	Participants: Exclusion	Experimental intervention	Control intervention	Dose	Follow-up	Outcome measures	Results
Balci et al., 2016 [66] Turkey	Unilateral adhesive capsulitis stage II 53 T 40 ♀ (75.5%) 13 ♂ (24.5%) 18 E1 (56.7±7.7) 14 ♀ (77.8%) 4 ♂ (22.2%) 18 E2 (58.1±8.4) 15 ♀ (83.3%) 3 ♂ (16.7%) 17 C (58.6±11.3) 11 ♀ (64.7%) 6 ♂ (35.3%)	• Pain in the shoulder for at least 3 months	• History of surgery or MUA • Pain or disorders of the cervical spine, elbow, wrist or hand • Other pathological conditions (including neurologic) involving the shoulder	E1: PT modalities + PNF exercises E2:PT modalities + Classic exercises	PT modalities	F:once D: once I: 1 h	After 1 session	Pain (VAS) Scapular dyskinesis (LSST) AROM (°) - flexion - abduction Function (SST)	E1↑, E2=, C↑, E1=E2=C E1=, E2=, C=, E1=E2=C E1↑, E2↑, C↑, E1=E2=C E1↑, E2↑, C↑, E1=E2=C E1↑, E2↑, C↑, E1=E2=C
Jain et al., 2020 [86]	Frozen shoulder 72 T 41 ♀ (56.9%) 31 ♂ (43.1%) 36 E (49.61±11.27) 20 ♀ (55.6%) 16 ♂ (44.4%)	• Pain & limitation in both active and passive movements of GHJ • Moderate to severe pain and stiffness for 6 months	• Prior history of trauma or arthritis • Bilateral involvement • Major psychiatric problems	Standard care + Supervised SGA (yoga)	Standard care	F: daily D: 4 w I: 30 min (yoga)	After 1, 2, and 4 weeks treatment	Pain & Disability (SPADI) - pain - disability - total	 FFU: E↑, C↑, E=C FFU: E↑, C↑, E=C FFU: E↑, C↑, E=C

	36 C (49.08±11.78) 21 ♀ (58.3%) 15 ♂ (41.7%)								
Muhammed et al., 2018 [78] India	Acute stage adhesive capsulitis 30 T 13 ♀ (43.3%) 17 ♂ (56.7%) 10 E1 (53±6.61) 6 ♀ (60%) 4 ♂ (40%) 10 E2 (50.7±6.34) 3 ♀ (30%) 7 ♂ (70%) 10 C (54.9±5.38) 6 ♀ (60%) 4 ♂ (40%)	• Complaints <3 months • Radiographic evidence for adhesive capsulitis • Reduction shoulder movements	• History of trauma, shoulder dislocation, cervical radiculopathy • Fibromyalgia • Hemiplegic shoulder • RA • Shoulder pain>3 months	E1: PIMR, LLLT and home care program E2: Codman pendulum exercises and LLLT	Maitland mobilization and PT modality	F: 5x/w D: 2 w I: ±20 min	After 2 weeks treatment	Pain & disability (SPADI) PROM (°) - flexion - extension - abduction - ER - IR	E1↑, E2↑, C↑, E1>E2>C E1↑, E2↑, C↑, E1>E2, E1>C, E2=C E1↑, E2↑, C↑, E1=E2=C E1↑, E2↑, C↑, E1>C, E1=E2, E2=C E1↑, E2↑, C↑, E1>C, E2>C, E1=E2 E1↑, E2↑, C↑, E1>C, E2>C, E1=E2
Pajareya et al., 2004 [79] Thailand	Primary adhesive capsulitis 119 T 6 ♀ (60%) 4 ♂ (40%) 60 E (56.3±10.6) 36 ♀ (60%) 24 ♂ (40%) 59 C (57.7±10) 45 ♀ (76.3%)	• Shoulder pain • Limitation of PROM in all directions	• Secondary adhesive capsulitis • Intrinsic and extrinsic causes of shoulder problems • Generalized arthritis • Bilateral involvement • Contra-indication for NSAIDs • Bleeding tendencies	Medication and advice + hospital based PT program (including exercises) and HEP	Medication and advice	Medication: F: daily D: 3 w I: 3x/day PT program F: 3x/w D: 3 w I: ±60 min	3, 6, 12, and 24 weeks (6, 12 and 24 only successful treatment)	SPADI PROM (°) - abduction - ER - IR Treatment satisfaction Successful treatment (self-rated disappearance	3 w: E>C 3 w: E>C 3 w: E=C 3 w: E>C 3 w: E>C 3, 6 w: E>C 12, 24 w: E=C

	14 ♂ (23.7%)							of complaints)	

T: total group study; E: experimental group; C: control group; ♀: female; ♂: male; MUA: manipulation under anesthesia; PT: physical therapy; PNF: proprioceptive neuromuscular facilitation; F: frequency; w: week; D: duration; I: intensity; VAS: Visual Analogue Scale; LSST: lateral scapular slide test; AROM: active range of motion; SST: Simple Shoulder Test; GHJ: glenohumeral joint; SGA: standing group asana; min: minutes; SPADI: Shoulder Pain and Disability Index; FFU: final follow up; RA: rheumatoid arthritis; PIMR: position induced movement re-education; LLLT: low level laser therapy; PROM: passive range of motion; ER: external rotation; IR: internal rotation; HEP: home exercise program;

↑: improved
=: not improved
>: improved more than
<: improved less than

260

261

262 Table 5 Characteristics of studies comparing physical therapy programs including exercises with solely exercises

Source & origin	Participants: Group composition and patient characteristics	Participants: Inclusion	Participants: Exclusion	Experimental intervention	Control intervention	Dose	Follow-up	Outcome measures	Results
Ali & Khan, 2015 [65] Pakistan	Adhesive capsulitis 43 T 22 E (51.31) 11 ♀ (50%) 11 ♂ (50%) 21 C (51.71) unknown	• One sided shoulder involvement • Complaints of pain & shoulder ROM restriction for more than 3 months	• Additional shoulder or cervical pathology • Presence of comorbidities • Severe trauma of fracture • Pregnancy	General exercises + Manual therapy (Maitland mobilization)	General exercises	F: 3x/w D: 5 w I: 45 min	After 5 weeks treatment (pre-post)	Pain (VAS) ROM (°) - abduction - ER - IR Function (SPADI)	E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C
Atan et al., 2021 [59] Turkey	Adhesive capsulitis 31 T 22 ♀ (71.0%) 9 ♂ (29.0%) 11 E1 (56.00±11.63) 7 ♀ (63.6%) 4 ♂ (36.4%) 10 E2 (60.80±8.32) 8 ♀ (80%) 2 ♂ (20%) 10 C (58.50±7.29)	• 18 to 65 years • Passive ER restriction <50% of contralateral shoulder • Normal radiograph finding of the affected shoulder • Complaints of shoulder restriction with severe pain for at least 1 month • Literate and ability to comprehend verbal	• History of bilateral concurrent adhesive capsulitis, shoulder trauma, fracture, shoulder surgery, calcific tendinopathy, GH OA, inflammatory rheumatic diseases, tumor and infection • History of CSI in the shoulder during last 3 months • History of recent lung, breast, or bypass surgery/radiotherapy • History of cervical	E1: Therapeutic exercises + High intensity laser therapy E2: Therapeutic exercises + sham laser	Therapeutic exercises	F: 5x/w D: 3 w I: 25 min. exercises, 15 min. laser/sham	After 3 weeks treatment and at 12 week follow-up	Pain (VAS) Pain and disability (SPADI) Quality of life (SF-36) - PF - RLPH - RLE - EF - EWB	All FU: E1↑, E2=, C=, E1>E2, E1>C, E2=C All FU: E1↑, E2↑, C↑ 3 w: E1=E2=C 12 w: E1>E2, E1>C All FU: E1↑, E2=, C=, E1=E2=C All FU: E1↑, E2=, C=, E1=E2=C All FU: E1↑, E2=, C=, E1=E2=C All FU: E1↑, E2=, C=, E1>E2, E1>C, E2=C All FU: E1↑, E2=, C=, E1=E2=C

	7 ♀ (70%) 3 ♂ (30%)	instructions in our language	radiculopathy/brachial plexus lesion • History of neuromuscular disease • History of physical therapy program for the same shoulder last 6 months					- SF - P - GH - HC AROM (°) - flexion - abduction - ER - IR PROM (°) - flexion - abduction - ER - IR	All FU: E1↑, E2=, C=, E1=E2=C All FU: E1↑, E2=, C=, E1>E2, E1>C, E2=C All FU: E1↑, E2=, C=, E2=C 3 w: E1=E2=C 12 w: E1>E2, E1>C All FU: E1↑, E2=, C=, E1=E2=C All FU: E1↑, E2↑, C↑, E1=E2=C All FU: E1↑, E2↑, C↑, E1=E2=C
Binder et al., 1986 [68] United Kingdom	40 patients with frozen shoulder 40 T (54.8 (45-76)) 24 ♀ (60%) 16 ♂ (40%) 20 E ? 20 C ?	• Painful stiff shoulder at least 1 month • Pain with sleep disturbance • Restricted AROM and PROM with ER at least 50%	• Generalized arthritis, sensory symptoms or signs in the arm or radiation of pain to the neck • Peptic ulceration, serious infection or contra-indications to systemic steroid therapy	HEP + Oral steroid (prednisolone)	HEP	HEP F: every hour D: 6 w I: 2-3 min Steroid F: daily D: 6 w I: 10 mg (4 w), 5 mg (2 w)	Fortnightly for 6 weeks, monthly for a further 6 months	Pain (VAS) - night - movement - rest ROM (°) - total flexion - GH flexion - total abduction - GH abduction - ER	 2, 4, 6 w, 3, 4 m: E>C 5, 6, 7, 8 m: E=C All FU: E=C All FU: E=C All FU: E=C All FU: E=C All FU: E=C All FU: E=C All FU: E=C
Diercks &	Idiopathic frozen	• >50% restriction	• Significant injury to	Standardized PT	Exercises only	F: -	24 months	CMS	All FU: E<C

Stevens, 2004 [85] The Netherlands	shoulder syndrome 77 T 32 E (51±7) 21 ♀ (65.6%) 11 ♂ (34.4%) 45 C (50±6) 26 ♀ (57.7%) 19 ♂ (42.3%)	GHJ in all directions for 3 months or more	ipsilateral shoulder or arm • Surgical procedures on the shoulder, arm, cervical spine, thorax or breast within previous 2 years • Intra-articular deformities, degenerative or inflammatory arthritis • DM	(including exercises)		D: 2 y I: -	with 3 month intervals		
Dundar et al., 2009 [70] Turkey	Primary frozen shoulder phase 1 and/or 2 57 T 29 E (56.3±7.8) 20 ♀ (69.0%) 9 ♂ (31.0%) 28 C (57.1±8.3) 19 ♀ (67.9%) 9 ♂ (32.1%)	• Gradually increasing shoulder pain and stiffness	• Other shoulder disorders or significant trauma • Secondary frozen shoulder	HEP + CPM	HEP + CPT (exercises)	HEP F: daily D: 12 w I: - CPM/CPT F: 5x/w D: 4 w I: 1 h/day	After 4- and 12-weeks treatment	Pain (VAS) - rest - movement - night PROM (°) - flexion - abduction - IR - ER Function - CMS - SPADI ● pain ● disability	 Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E=C Both FU: E↑, C↑, E=C Both FU: E↑, C↑, E=C Both FU: E↑, C↑, E=C Both FU: E↑, C↑, E=C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E=C
Horst et al., 2017 [57] Poland	Frozen shoulder 66 T 25 ♀ (37.9%) 41 ♂ (62.1%) 33 E (44±16) 13 ♀ (31%) 20 ♂ (61%)	• Limited range of motion • Pain in the shoulder region • Prescription for PT by orthopedic surgeon	• Additional symptoms of dizziness and a case history of headaches • Pain and/or limited ROM in the cervical spine and/or temporomandibular joint	Structural oriented (MT & PNF exercises)	Activity oriented (exercise only)	F: 5x/w D: 2 w I: 30 min	After 2 weeks treatment and 3 months	McGill pain questionnaire Function (MUEMAL) ROM (°) - flexion	2 w: E=C 3 m: E<C 2 w: E=C (3/5); E<C (2/5) 3 m: E=C (2/5); E<C (3/5)

	33 C (47±17) 12 ♀ (36%) 21 ♂ (64%)							- extension - IR - ER - abduction - adduction Strength - flexion - extension - IR - ER - abduction - adduction	Both FU: E=C Both FU: E=C Both FU: E<C Both FU: E<C Both FU: E=C Both FU: E<C Both FU: E<C Both FU: E=C Both FU: E<C 2 w: E=C 3 m: E<C Both FU: E<C Both FU: E<C
Kalita & Milton, 2015 [75] India	Frozen shoulder 60 T 30 E 30 C	• Unilateral involvement • Painful stiff shoulder for at least 3 months • Restriction>50% passive ER & restricted overhead reach	• DM • History of surgery on particular shoulder • Other shoulder disorders or surgery	Pendulum exercises + GH end-range mobilization and contract relax technique for GH IR	Pendulum exercises	F: 2x/w D: 4 w I:	After 4 weeks treatment (pre-post)	Pain (VAS) Function (SPADI) - pain - disability - total AROM (°) - ER PROM (°) - ER	- E>C E>C E>C E>C E>C
Russell et al., 2014 [82] United Kingdom	Frozen shoulder 75 T (51.1 (40-65) 25 E1 ? 24 E2 ? 26 C	• Insidious onset of pain & stiffness • Clinically reduction in ROM, >50% ER • No radiologic abnormalities • At least 3 months complaint	• Other shoulder disorders, surgery or significant trauma • Local CSI or any PT intervention within last 3 months • Bilateral frozen shoulder • Presence of comorbidities	HEP + Individual multimodal PT	C1: HEP + Exercise class C2: HEP	F: 2x/w D: 6 w I: 50 min (class) HEP continued after 6 weeks	6 weeks, 6 months, and 1 year	Function (CMS) Oxford shoulder score ROM (°) - flexion	All FU: E↑, C1↑, C2↑, E<C1, E>C2, C1>C2 All FU: E↑, C1↑, C2↑, E<C1, E>C2, C1>C2 All FU: E↑, C1↑, C2↑, E=C1, E>C2, C1>C2,

	?		• Active medicolegal involvement					- ER	All FU: E↑, C1↑, C2↑, E=C1, E>C2, C1>C2,

T: total group study; E: experimental group; C: control group; ♀: female; ♂: male; ROM: range of motion; F: frequency; w: week; D: duration; I: intensity; VAS: Visual Analogue Scale; ER: external rotation; IR: internal rotation; SPADI: Shoulder Pain and Disability Index; SF-36: 36-item short form health survey; PF: physical functioning; RLPH: role limitations due to physical health; RLE: role limitations due to emotional problems; EF: energy/fatigue; EWB: emotional well-being; SF: social functioning; P: pain; GH: general health; HC: health change; AROM: active range of motion; PROM: passive range of motion; HEP: home exercise program; min: minutes; GH: glenohumeral; GHJ: glenohumeral joint; DM: Diabetes Mellitus; PT: physical therapy; CMS: Constant Murley Score; CPM: continuous passive motion; CPT: conventional physical therapy; MT: manual therapy; PNF: Proprioceptive Neuromuscular Facilitation; MUEMAL: Modified Upper Extremity Motor Activity Log; CSI: corticosteroid injection;

↑: improved
=: not improved
>: improved more than
<: improved less than

263

264 Table 7 Characteristics of studies comparing 2 physical therapy programs both including exercises

Source & origin	Participants Group composition and patient characteristics	Inclusion	Exclusion	Experimental intervention	Control intervention	Dose	Follow-up	Outcome measures	Results
Abd Elhamed, et al., 2018 [63] Egypt	Diabetic frozen shoulder 30 T (40-60) ? 15 E (25.06±3.36) 15 C (26.06±3.39)	• Shoulder pain & restriction in ROM (50% loss of PROM of the shoulder relative to unaffected side in at least 3 directions) for a duration of >3 months • No treatment other than analgesics was prescribed within last 3 months • No abnormal radiographic findings	• Bilateral shoulder involvement • Other GHJ or AC disorders or surgery • Presence of co-morbidities • Pregnancy • Unwillingness to participate	Traditional treatment (including home program) + Strengthening exercises lower fibers trapezius	Traditional treatment (including home program)	F: 3x/w D: 4 w I: ±15 min (w/o exercises)	After 4 weeks treatment (pre-post)	Scapular tipping (A-T distance) - supine - supine with retraction - standing - standing with retraction	 E↑, C=, E>C E↑, C=, E>C E↑, C=, E>C E↑, C=, E>C
Aggarwal et al., 2021 [83] India	Adhesive capsulitis 30 T 23 ♀ (76.7%) 7 ♂ (23.3%) 15 E (52.67±6.25) 10 ♀ (66.7%) 5 ♂ (33.3%)	• Between 35 and 60 years • Showing presence of capsular pattern	• Past UE injuries in last 6 months • History of surgeries of arm • Open wounds, unhealed sutures, hypersensitivity, generalized infections and uncontrolled hypertension	Hydrocollator pack, exercises, Maitland mobilizations (grade III, IV), stretches + IASTM	Hydrocollator pack, exercises, Maitland mobilizations (grade III, IV), stretches	F: 3x/w D: 4 w I: -	After 2 weeks treatment and at 4 weeks FU	Pain (NPRS) Function (SPADI) PROM (°) - flexion - extension - abduction - ER - IR	All FU: E↑, C↑, E=C All FU: E↑, C↑, E=C 2 w: E↑, C↑, E=C 4 w: E↑, C↑, E>C 2 w: E↑, C↑, E=C 4 w: E↑, C↑, E>C All FU: E↑, C↑, E>C 2 w: E↑, C↑, E=C 4 w: E↑, C↑, E>C All FU: E↑, C↑, E>C

	15 C (46.13±8.66) 13 ♀ (86.7%) 2 ♂ (13.3%)							AROM (°) - flexion - extension - abduction - ER - IR Functional ROM (Apley's scratch test) - overhead - behind back - across body	 2 w: E↑, C↑, E=C 4 w: E↑, C↑, E>C 2 w: E↑, C↑, E=C 4 w: E↑, C↑, E>C All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C All FU: E↑, C↑, E=C All FU: E↑, C↑, E=C All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C
Akbas et al., 2015 [64] Turkey	Adhesive capsulitis 36 T (54.35±10.52) 16 ♀ (44.4%) 20 ♂ (55.6%) 18 E (53.94±9.38) 7 ♀ (38.9%) 11 ♂ (61.1%) 18 C (54.81±11.96) 9 ♀ (50%) 9 ♂ (50%)	• Grade 2 or 3 adhesive capsulitis	• Other GHJ disorders or surgery • Being unable to cooperate with exercises	HEP + Before exercises PT modalities + PNF exercises	HEP + Before exercises PT modalities	F: 5x/w D: 3 w I: 25 min (w/o exercises)	After 3 weeks treatment (pre-post)	Pain (VAS) - rest - night - activity PROM (°) - flexion - abduction - ER - IR Functional (SPADI) - pain - disability - total	 E=, C=, E=C E↑, C=, E=C E↑, C↑, E=C E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E>C E↑, C↑, E=C E↑, C↑, E=C
Atan et al., 2021 [59] Turkey	Adhesive capsulitis 21 T 15 ♀ (71.4%)	• 18 to 65 years • Passive ER restriction <50% of contralateral shoulder • Normal radiograph	• History of bilateral concurrent adhesive capsulitis, shoulder trauma, fracture, shoulder surgery,	Therapeutic exercises + High intensity laser therapy	Therapeutic exercises + sham laser	F: 5x/w D: 3 w I: 25 min. exercises, 15 min.	After 3 weeks treatment and at 12 week FU	Pain (VAS) Pain and disability (SPADI)	All FU: E↑, C=, E>C All FU: E↑, C↑, E>C

	6 ♂ (28.6%) 11 E (56.00±11.63) 7 ♀ (63.6%) 4 ♂ (36.4%) 10 C (60.80±8.32) 8 ♀ (80%) 2 ♂ (20%)	finding of the affected shoulder • Complaints of shoulder restriction with severe pain for at least 1 month • Literate and ability to comprehend verbal instructions in our language	calcific tendinopathy, GH OA, inflammatory rheumatic diseases, tumor and infection • History of CSI in the shoulder during last 3 months • History of recent lung, breast, or bypass surgery/radiotherapy • History of cervical radiculopathy/brachial plexus lesion • History of neuromuscular disease • History of physical therapy program for the same shoulder last 6 months			laser/sham		Quality of life (SF-36) - PF - RLPH - RLE - EF - EWB - SF - P - GH - HC AROM (°) - flexion - abduction - ER - IR PROM (°) - flexion - abduction - ER - IR	 All FU: E↑, C=, E=C All FU: E↑, C=, E= C All FU: E↑, C=, E=C All FU: E↑, C=, E>C All FU: E↑, C=, E=C All FU: E↑, C=, E=C All FU: E↑, C=, E>C All FU: E↑, C= 3 w: E=C 12 w: E>C All FU: E↑, C=, E=C All FU: E↑, C↑, E=C All FU: E↑, C↑, E=C
Balci et al., 2016 [66] Turkey	Unilateral adhesive capsulitis stage II 53 T * 40 ♀ (75.5%) 13 ♂ (24.5%) 18 E (56.7±7.7) 14 ♀ (77.8%) 4 ♂ (22.2%)	• Pain in the shoulder for at least 3 months	• History of surgery or MUA • Pain or disorders of the cervical spine, elbow, wrist or hand • Other pathological conditions (including neurologic) involving the shoulder	PT modalities + PNF exercises	PT modalities + Classic group exercises	F:once D: once I: 1 h	After 1 session	Pain (VAS) Scapular dyskinesis (LSST) AROM (°) - flexion - abduction Function (SST)	E↑, C=, E=C E=, C=, E=C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C

	18 C (58.1±8.4) 15 ♀ (83.3%) 3 ♂ (16.7%)								
Baskaya et al., 2018 [67] Turkey	Adhesive capsulitis 30 T (56.63±9.49) 21 ♀ (70%) 9 ♂ (30%) 15 E (54.4±7.6) 9 ♀ (60%) 6 ♂ (40%) 15 C (59.8±10.6) 12 ♀ (80%) 3 ♂ (20%)	• Pain in a single shoulder • <135° shoulder elevation • Limitation shoulder movement only at GHJ	• Hemiplegia • DM • Excessive limitation & pain related to head and neck movements • Strength sensory or reflex deficit in UE • Other GHJ disorders • Major trauma history • History of intra-articular injections in preceding 3 months or PT in preceding 6 months	Exercises with reflecting side of a mirror + Standard PT program (including exercises and a HEP).	Exercises with non-reflecting side of a mirror + Standard PT program (including exercises and a HEP).	F: 10 sessions D: ? I: 1 h	Pre and post treatment	Pain (VAS) AROM (°) - flexion - abduction - IR - ER PROM (°) - flexion - abduction - IR - ER Functional (UCLA)	E↑, C↑, E>C E↑, C↑, E=C E↑, C↑, E=C E=, C=, E=C E=, C=, E=C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E>C
Celik, 2010 [69] Turkey	Frozen shoulder 29 T (52.1 (38-65)) 22 ♀ (75.9%) 7 ♂ (24.1%) 15 E (49.6 (38-62)) 13 ♀ (86.7%) 2 ♂ (13.3%) 14 C (54.78 (42-65))	• ROM ER, abduction & flexion<50% compared to contralateral side • Normal radiography • Secondary frozen shoulder with MRI showing small RC tear • Secondary frozen shoulder with type II SAI	• Radiculopathy • TOS • Rheumatologic disorders • Fractures & tumors of the UE • Neurological disorders causing muscle weakness in the shoulder	PT modalities, NSAID, exercises (including PNF & HEP) + ST exercises	PT modalities, NSAID, exercises (including PNF & HEP)	F: 5x/w D: 6 w I: ±45 min (w/o exercises)	6 & 12 weeks	Function (Modified CMS) Pain (VAS) PROM (°) - flexion - ER - IR	Both FU: E↑, C↑, E=C Both FU: E↑, C↑ 6 w: E>C 12 w: E=C Both FU: E↑, C↑ 6 w: E=C 12 w: E>C Both FU: E↑, C↑, E=C

	9 ♀ (64.3%) 5 ♂ (35.7%)								Both FU: E↑, C↑, E=C
Contractor et al., 2016 [84] India	Adhesive capsulitis 30 T 15 E 15 C	• Having painful stiff shoulder for at least 3 months • Idiopathic adhesive capsulitis • Subjects with DM • Limited ROM abduction & ER • Bi/unilateral adhesive capsulitis	• RC tears • History of RA • Adhesive capsulitis secondary to fracture, dislocation, reflex sympathetic dystrophy, neurological disorder, TOS & peripheral nerve injury	CPT (including exercises) + Muscle Energy Techniques	CPT (including exercises)	F: 3x/wk D: 4 w I: 20 min (w/o exercises)	After 4 weeks treatment (pre-post)	Pain (VAS) Function (SPADI)	E↑, C↑, E=C E↑, C↑, E>C
Ekim et al., 2016 [71] Turkey	Adhesive Capsulitis (phase 2) and DM (w/o complications) 41 T 20 E (60.5±8.1) 13 ♀ (65%) 7 ♂ (35%) 21 C (60.4±6.7) 13 ♀ (61.9%) 8 ♂ (38.1%)	• marked loss of AROM & PROM (>50% ER loss) • shoulder pain and stiffness (phase 2) • pain at extremes of all shoulder motions • normal findings on radiographs • type 2 DM for at least 2 years	• presence of co-morbidities • stiff shoulder due to fracture, dislocation, calcific tendonitis, reflex sympathetic dystrophy • intra-articular injections to the shoulder last 3 months	PT modalities, HEP + CPM treatment	PT modalities, HEP + CPT treatment (exercises)	Supervised F: 5x/w D: 4 w I: 45 min HEP (after 4 weeks): F: - D: 8 w I: - CPM, CPT F: daily D: 4 w I: 1 h	After 4- and 12-weeks treatment	Pain (VAS) - night - rest - movement AROM (°) - flexion - abduction - ER - IR PROM (°) - flexion	 Both FU: E↑, C↑, E>C Both FU:E↑, C↑, E>C Both FU:E↑, C↑ 4 w: E>C 12 w: E=C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E=C Both FU: E↑, C↑, E=C Both FU: E↑, C↑,

								- abduction - ER - IR Function - CMS - SPADI * pain * disability	E>C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E=C Both FU: E↑, C↑ 4 w: E=C 12 w: E>C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E>C Both FU: E↑, C↑, E>C
Elhafez et al., 2016 [72] Egypt	Unilateral Adhesive Capsulitis stage II 45 T (40-60) 15 E1 (50.06±5.3) 8 ♀ (53.3%) 7 ♂ (56.7%) 15 E2 (49.5±4.6) 10 ♀ (67.7%) 5 ♂ (33.3%) 15 C (50.4±5.3) 9 ♀ (60%) 6 ♂ (40%)	• painful, restricted AROM & PROM • capsular pattern of motion restriction • absence of radiologic evidence of GHJ arthritis	• local CSI to the shoulder within last 3 months or current CS therapy • shoulder symptoms due to other causes or history of shoulder surgery • pregnancy • presence of comorbidities	E1: Traditional PT (including laser, supervised exercises & HEP) E2: Traditional PT (including laser, supervised exercises & HEP) & postisometric facilitation technique	Traditional PT (including laser (different region), supervised exercises & HEP)	F: 3x/w D: 4 w I: 30 min (w/o exercises) HEP: F: daily D: 4 w I: 1-2/d Postisometric facilitation F: 3x/w D: 4 w I: 9-13 min	After 4 weeks treatment	Pain (NRS) AROM - flexion - abduction - ER	E1↑, E2↑, C↑, E2>C, E2>E1, E1=C E1↑, E2↑, C↑, E2>C E1↑, E2↑, C↑, E2>C, E2>E1, E1=C E1↑, E2↑, C↑, E2>E1>C
Gutierrez Espinoza et	Primary adhesive capsulitis	• Unilateral adhesive capsulitis	• Secondary to other shoulder	UE cycle ergometer, GH	CPT (including	F: 2 or 3x/w D: 10 sessions	Pre and post treatment	PROM (°) - ER	 E↑, C↑, E>C

al., 2015 [56] Chile	57 T 46 ♀ (80.7%) 11 ♂ (19.3%) 29 E 23 ♀ (79.3%) 6 ♂ (20.7%) 28 C 23 ♀ (82.1%) 5 ♂ (17.9%)		disorders or surgery • High level of irritability • Non-steroid anti-inflammatory drug infiltration or CSI in the last 6 months • Stroke • Previously treated with release technique and/or MUA	posterior mobilization and distraction (Kaltenborn III)	exercises)	I: at least 15 min		- flexion - abduction Pain (VAS) Function (CMS)	E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E>C
Hussein et al., 2015 [73] USA	Adhesive capsulitis stage 3 or 4 60 T 31 ♀ (51.7%) 29 ♂ (48.3%) 30 E (51.9) 30 C (51.2)	• Globally limited GH translation • Loss of PROM >50% compared to non-affected side • No radiographic findings on AP, axillary or scapular y-view shoulder	• Bilateral shoulder involvement • Previous shoulder surgery • Any neuromuscular disorders • DM • CSI previous 6 months • Prior trauma • Any intrinsic GH pathology • CRPS • Pulmonary disease • Contra-indications to treatment	Traditional PT (including HEP) + Static progressive stretching	Traditional PT (including HEP)	Traditional PT: F: 3x/w D: 4 w I: 20 min HEP: F: daily D: 4 weeks I: 3x10 rep Stretching: F: daily D: 4 w I: w 1: 1x30 min. w 2, 3: 2x30 min. w 4: 3x30 min.	After 4 weeks treatment and after 12, 24, 52, 104 weeks	PROM (°) - abduction - ER AROM (°) - abduction Function (DASH) Pain (VAS) - rest	 All FU: E>C All FU: E>C All FU: E>C 4 w E=C All other FU: E>C 4, 12 and 104 w: E=C 24 and 52 w: E>C
Junaid et al., 2016 [74]	Frozen shoulder 52 T (48.90 (30-	• No recent injury, fracture, cancer and no metabolic	• Diabetic patients • Major musculoskeletal	Routine PT (including exercises)	Routine PT (including exercises)	F: 4x/w D: 2 w I: E: 40 min;	After 2 weeks treatment	Pain (VAS) ROM (°)	E=C

Pakistan	60)) 26 ♀ (50%) 26 ♂ (50%) 26 E 26 C	diseases	problems • Red flags • History of shoulder trauma or prolonged immobilization due to neurologic disorder • Suffering with Neuralgia/hemiplegia • Bilateral frozen shoulder	+ Kaltenborn mobilization		C: 25 min.		- abduction - flexion - extension - IR - ER Function (PENN shoulder scale)	E>C E>C E>C E>C E>C E>C
Kumar et al., 2017 [76] India	Primary Adhesive Capsulitis 30 T 15 E 15 C	• Primary idiopathic adhesive capsulitis with trigger points in subscapularis • Painful stiff shoulder >3 months • Male/female • Unilateral condition with 50% ROM compared to unaffected side	• Previous shoulder surgeries to affected shoulder, neck, elbow • Secondary adhesive capsulitis • Other comorbidities) • CSI in affected shoulder in preceding 4 weeks • Other inflammatory conditions • Allergic to spray	conservative management (including exercises) + Spray & stretch technique	Conservative management (including exercises)	F: 4x/w D: - I: -	Pre-posttreamtent	Pain (VAS) ROM (°) - ER Function (SPADI) Muscle strength - ER	E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E>C
Leclaire & Bourgouin, 1991 [60] France	Periarthritis of the shoulder 47 T (58±6.9) 29 ♀ (61.7%) 18 ♂ (38.3%)	• Shoulder pain >2 months • Limited AROM and PROM • Pain on resisted abduction, IR or ER • Impaired GHJ	• Presence of co-morbidities • RC rupture • X-ray calcification • Severe adhesive capsulitis	PT modalities and exercises + Electromagnetic therapy	PT modalities and exercises + Sham therapy	F: 3x/w (exercises daily) D: 12 w I: 35 min (supervised), 20 min	After 4, 8, and 12 weeks treatment	ROM (°) - flexion - extension - abduction - adduction - ER - IR	 All FU: E↑, C↑, E=C All FU: E=, C=, E=C All FU: E↑, C↑, E=C All FU: E=, C=, E=C All FU: E↑, C↑, E=C All FU: E↑, C↑, E=C

	22 E 25 C	motion	(flexion<100°, abduction<90° or global rotations <20°) • Receiving anticoagulants or anti-inflammatory drugs or received CSI			(exercises)		Pain (ordinal scale) - rest - motion - lying down Self-rating disability scale - functional - pain	 4 w: E↓, C↑, E<C Other FU: ↑, C↑, E=C All FU: E↑, C↑, E=C All FU: E↑, C↑, E=C All FU: E↑, C↑, E=C All FU: E↑, C↑, E=C
Lokesh et al., 2015 [77] India	Periarthritis shoulder 30 T (40-60) ? E ? C	• Capsular pattern of restriction • History of pain for 3-18 months	• Shoulder trauma or disorders • Neurological disorders • Radiating pain • Neoplastic conditions	HEP and CPT + muscle energy techniques.	HEP and CPT	F: 6x/w D: 2 w I: -	After 2 weeks treatment Before 3rd, 6th, 9th and 12th treatment session	ROM (°) - flexion - abduction - IR - ER Pain (VAS) Function (SPADI) - pain - disability - total	 FFU: E↑, C↑, E>C FFU: E↑, C↑, E>C FFU: E↑, C↑, E>C FFU: E↑, C↑, E>C FFU: E↑, C↑, E>C FFU: E↑, C↑, E>C FFU: E↑, C↑, E>C FFU: E↑, C↑, E>C
Mohamed et al., 2020 [58] Egypt	Unilateral adhesive capsulitis 60 T 26 ♀ (43%) 34 ♂ (57%) 30 E (51.93±6.16) 12 ♀ (40%) 18 ♂ (60%)	• Inability to elevate the arm above 100 degrees in the plane of the scapula • Limitation in both active and passive shoulder ROM • Presence of pain interfering with activities of daily living	• Presence of any shoulder condition that is a contraindication for exercising the shoulder joint • No signs of scapular dyskinesis	Hot pack and scapular mobilization + Dynamic scapular recognition exercise	Hot pack and scapular mobilization + Placebo active shoulder exercise with uninvolved shoulder	F: 3x/w D: 2 months I: 40 min	After 2 weeks, 2 and 6 months	Scapular upward rotation (°) ROM (°) - flexion - abduction - ER Pain and disability	2 w: E↑, C=, E>C 2, 6 m: E↑, C↑, E>C 2 w: E↑, C=, E>C 2, 6 m: E↑, C↑, E>C 2 w: E↑, C=, E>C 2, 6 m: E↑, C↑, E>C 2 w: E=, C=, E=C 2 m: E↑, C↑, E>C 6 m: E↑, C=, E>C 2 w: E↓, C↓, E<C

	30 C (50.06±5.87) 14 ♀ (47%) 16 ♂ (53%)							(SPADI)	2 m: E↓, C↓, E<C 6 m: E↓, C=, E<C
Muhammed et al., 2018 [78] India	Acute stage adhesive capsulitis 30 T * 13 ♀ (43.3%) 17 ♂ (56.7%) 10 E (53±6.61) 6 ♀ (60%) 4 ♂ (40%) 10 C (50.7±6.34) 3 ♀ (30%) 7 ♂ (70%)	• Complaints <3 months • Radiographic evidence for adhesive capsulitis • Restricted shoulder movements	• History of trauma, shoulder dislocation, cervical radiculopathy • Fibromyalgia • Hemiplegic shoulder • RA • Shoulder pain>3 months	PIMR, LLLT and home care program	Codman pendulum exercises and LLLT	F: 5x/w D: 2 w I: ±20 min	After 2 weeks treatment	Pain & disability (SPADI) PROM (°) - flexion - extension - abduction - IR - ER	E↑, C↑, E1>C E↑, C↑, E>C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C
Nellutla & Giri, 2011 [87] India	Chronic frozen shoulder 40 T 56.15±8.71 16 ♀ (60%) 24 ♂ (40%) 20 E 6 ♀ (60%) 4 ♂ (40%) 20 C 6 ♀ (60%) 4 ♂ (40%)	• Restricted ROM • Limitations in ADL • Pain score 10 or 15 on CMS	• none	PT modality, mobilizations (GH, AC, SC, ST) + PNF	PT modality, mobilizations (GH, AC, SC, ST) + Conventional free exercises (including HEP)	Conventional F: 6x/w D: 3 w I: ±20 min (w/o exercises) PNF F: daily D: 3 w I: 3x/day HEP F: daily D: 3 w I: 2x/d	After 3 weeks treatment (pre-post)	CMS	E↑, C↑, E=C
Rawat et al., 2017 [61]	Adhesive capsulitis	• 1-3 months onset of pain & stiffness • ROM restriction in	• OA or signs of bony damage • Hypermobility	HEP + PT modality,	HEP + PT modality,	F: 3x/w D: 4 w I: -	After 4 weeks treatment (pre-post)	Pain (VAS) ROM (°)	E>C

India	42 T 45 ♀ (76.3%) 14 ♂ (23.7%) 21 E (56.00±10.42) 11 ♀ (52.4%) 10 ♂ (47.6%) 21 C (54.19±8.33) 7 ♀ (33.3%) 14 ♂ (66.7%)	ER, abduction & flexion <50% compared to contralateral side • Pain during sleep • Difficulty with grooming, dressing and reaching to shoulder level, behind the back and overhead	and instability • Neurological disorder causing muscle weakness • Any local or systemic disease • Upper limb nerve tension testing reproduces the symptoms	mobilization + RC muscle strengthening	mobilization			- flexion - abduction - IR - ER Function - PSFS - SPADI Muscle strength - flexors - extensors - abductors - adductors - IR - ER	E=C E>C E>C E>C E>C E>C E=C E>C E>C E>C E>C E>C
Rizk et al., 1983 [62] USA	Adhesive capsulitis 50 T (56 (40-70)) 32 ♀ (64%) 18 ♂ (36%) 24 E ? 26 C ?	• Pain on resisted abduction and/or IR or ER • Localization of impaired movement to GHJ exclusively • Maximum PROM < 110° abduction, 50° ER, 70° IR and 140° flexion	• Bony or neurological disorders • Polyarthritis	HEP + PT modality combined with traction	HEP + CPT (including exercises)	HEP: F: daily D: ? I: 5 3x/d Supervised PT F: 4x/w - 3x/w D: 4 w - 4 w I: E: 2 h; C: -	Monthly up to 8 m Weekly for 8 weeks, monthly for 6 m.	ROM (°) - IR - ER - flexion - extension - adduction - abduction Function Night pain	 All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C All FU: E↑, C↑, E>C 1 m: E=, C=, E=C 2, 3 m: E↑, C=, E>C 4, 5, 6, 7, 8 m: E↑, C↑, E>C 1, 2, 3, 4 m: E↑, C=, E>C All other FU: E↑, C↑, E>C
Shen et al., 2017 [88] China	Scapulohumeral periarthritis 30 T	• Chronic onset • History of injury • Deficiency of qi and blood coupled with	• Experienced acute inflammation of the shoulder • Shoulder injury or	Tuina treatment (mobilization, manipulation)	Tuina treatment (mobilization, manipulation)	Tuina: F: 3-4x/w D: 1 month I: 20 min.	After 1-month treatment (pre-post)	Pain intensity (VAS) Function (CMS)	E↑, C↑, E>C E↑, C↑, E>C

	15 E (55.3±6.7) 10 ♀ (67.7%) 5 ♂ (33.3%) 15 C (57.6±8.7) 8 ♀ (53.3%) 7 ♂ (46.7%)	external contraction of wind, cold and dampness • Shoulder pain, aggravate at night • Induced by weather change or fatigue • Limited shoulder joint movement • Incidence of shoulder muscle atrophy • Pressing pain on shoulder • Negative X-ray • Did not receive therapy last 2 months	bone fracture • Shoulder tumor • Severe heart, brain or kidney diseases • History of mental disorder	+ Yi jin jing (exercises)	+ Shoulder joint functional exercise	Exercises: F: daily D: 1 month I: -			
Sule et al., 2015 [80] India	Adhesive capsulitis (subacute & chronic stage) 30 T (56.27±5.20) 15 E 15 C	• Prediagnosed adhesive capsulitis • Subacute & chronic stage • Both male & female • Having at least 90° shoulder abduction and elbow flexion	• History of uncontrolled DM • Recent fracture upper limb • Elbow pathology restricting ROM • Cervical radiculopathy	CPT (including exercises) + Sleepers stretch	CPT (including exercises)	F: 5x/w D: 2 w (10 d) I: -	After 2 weeks treatment (at 10th day)	ROM - flexion - extension - abduction - IR - ER - horizontal adduction - horizontal abduction SPADI - pain - function	E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E=C E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E>C E↑, C↑, E=C E↑, C↑, E=C E↑, C↑, E=C
Yang et al., 2012 [81] Taiwan	Frozen shoulder syndrome 34 T	• >50% loss of PROM in 2 or more directions • Duration of	• History of stroke with residual upper extremity involvement	E1: Standardized treatment (including exercises)	Standardized treatment (including exercises)	F: 2x/w D: 3 months I: -	After 4 and 8 weeks of treatment	FLEX-SF	4 w: E1=E2, E1=C, E2=C 8 w: E1>E2, E1=C, E2<C

	10 E1 (56.8±7.2) 7 ♀ (70%) 3 ♂ (30%) 12 E2 (54.9±10.3) 10 ♀ (83.3%) 2 ♂ (16.7%) 10 C (54.3±7.6) 5 ♀ (50%) 5 ♂ (50%)	complaints >3 months	• Presence of co-morbidities • Other shoulder disorders or surgery • Pain or disorders of the cervical spine, elbow, wrist or hand	+ End range mobilization & scapular mobilization E2: Standardized treatment (including exercises) + Passive mid-range mobilization **				ROM (°) - IR - ER	All FU: E1>E2, E1=C, E2<C 4 w: E1=E2, E1=C, E2<C 8 w: E1>E2, E1=C, E2<C

* study with 3 experimental groups, only the relevant groups for this comparison are shown.
** patients with less kinematics as 8° scapular posterior tipping, 97° humeral elevation & 39° humeral ER during elevation received E1 or E2, patients with larger kinematic received the control intervention.

T: total group study; E: experimental group; C: control group; ROM: range of motion; PROM: passive range of motion; GHJ: glenohumeral joint; AC: acromioclavicular; F: frequency; w: week; D: duration; I: intensity; min.: minutes; w/o: without: A-T: acromion-table; ♀: female; ♂: male; UE: upper extremity; IASTM: instrument assisted soft tissue mobilization; NPRS: numeric pain rating scale; SPADI: Shoulder Pain and Disability Index; ER: external rotation; IR: internal rotation; AROM: active range of motion; FU: follow up; HEP: home exercise program; PT: physical therapy; PNF: Proprioceptive Neuromuscular Facilitation; VAS: Visual Analogue Scale; SF-36: 36-item short form health survey; PF: physical functioning; RLPH: role limitations due to physical health; RLE: role limitations due to emotional problems; EF: energy/fatigue; EWB: emotional well-being; SF: social functioning; P: pain; GH: general health; HC: health change; MUA: manipulation under anesthesia; h: hour; LSST: lateral scapular slide test; SST: Simple Shoulder Test; DM: Diabetes Mellitus; UCLA: University of California Los Angeles scale; RC: rotator cuff; SAI: subacromial impingement; TOS: thoracic outlet syndrome; ST: scapula-thoracic; CMS: Constant Murley Score; RA: rheumatoid arthritis; CPT: conventional physical therapy; CPM: continuous passive motion; CSI: corticosteroid injection; GH: glenohumeral; AP: anterior-posterior; CRPS: complex regional pain syndrome; DASH: Disabilities of Arm, Shoulder and Hand; FFU: final follow up; PIMR: position induced movement re-education; LLLT: low level laser therapy; ADL: activities of daily living; SC: sternoclavicular; OA: osteoarthritis; PSFS: patient specific functional score; m: months

↑: improved
=: no change
↓: detoriated
>: scored better than
<: scored worse than

Study population

FS patients included in the studies were termed as adhesive capsulitis,[56, 58, 59, 61, 62, 64-67, 72, 73, 76, 78-80, 83, 84] FS,[57, 68-70, 74, 75, 82, 86, 87] FS syndrome,[81, 85] periarthritis of the shoulder,[60, 77] diabetic FS,[63] diabetic adhesive capsulitis,[71] and scapulohumeral periarthritis.[88] Twenty-one studies did not specify the FS phase,[56-59, 61-65, 67-69, 74, 79, 81-86, 88] while [7870]seven studies included phase 2[60, 66, 71, 72, 75-77] and one study included acute phase FS,[78] phase 1 and/or 2,[70] phase 3 or 4,[73] chronic phase[87] and subacute and chronic phase.[80]

Treatments

One study compared supervised group exercises with home exercises,[82] whereas eight studies compared a multimodal program including exercises with solely exercises.[57, 59, 65, 68, 70, 75, 82, 85] Four studies compared a multimodal program including exercises, with a multimodal program without exercises,[66, 78, 79, 86] and 24 studies compared two multimodal programs (identical PT modalities) including different exercises with each other.[56, 58-64, 66, 67, 69, 71-74, 76-78, 80, 81, 83, 84, 87, 88]

Treatment period varied from 1 session[66] to 2 years[85], with 4 weeks[61, 63, 72, 73, 75, 84, 86, 88, 89] as most common period. Other treatment durations were 2 weeks,[57, 74, 77, 78, 80] 3 weeks,[59, 64, 79, 87] 5 weeks,[56, 65] 6 weeks,[68, 69, 82] 8 weeks[58, 62] and 12 weeks.[60, 70, 71, 81] Most studies used the same follow up period as their treatment period,[56, 60, 61, 63-66, 70-72, 74, 75, 77, 78, 80, 83, 84, 86-88] however, some studies used a longer follow up period up to 3 months,[57, 59, 69] 24 weeks,[79] 6 months,[58, 62] 8 months,[68] 1 year,[82] and 2 years.[73, 85] In addition, one study used a shorter follow up period of 8 weeks.[81] The treatment frequency in the included studies varied from 2 to 6 times a week for supervised treatment, home exercises were usually daily recommended.

Exercises

As part of the multimodal program or solely, most common types of exercises were isometric or strengthening exercises of rotator cuff (RC), trapezius, scapular, and glenohumeral muscles,[56, 61, 63, 66, 67, 74, 76, 80] muscle energy technics (e.g. Proprioceptive Neuromuscular Facilitation (PNF)),[57, 64, 66, 69, 72, 75, 77, 84, 87] wand/wall exercises,[62, 64, 66, 76, 83, 84] (Codman) pendulum exercises,[56, 59, 62, 65-67, 70-72, 75-78, 80, 83-85, 87] and stretching exercises.[60, 65, 67, 69, 71, 74, 80, 84]

ROM exercises,[59, 67, 69, 71] functional exercises (e.g. daily activities),[57, 88] scapulothoracic exercises,[58, 69] cycle ergometer exercise,[56] yoga,[86] position induced movement re-education,[78] exercise circuit (combination of various exercises),[82] and not further defined active exercises[81] were less common.

Several studies incorporated a home exercise program,[61, 62, 67-73, 79, 82, 85] that included various of the above-mentioned exercises, like pendulum, ROM, wall, and scapular exercises.

Treatment programs

The multimodal programs with and without exercises consisted of combinations of the following interventions: thermotherapy,[58, 60, 62, 64, 66, 69, 71, 73, 74, 77-80, 82-84] ultrasound,[56, 63, 64, 66, 67, 71, 72, 87] electrotherapy,[61, 62, 66, 67, 69, 71, 76, 77] manual therapy,[56-58, 61-63, 65, 73-79, 81-83, 85, 87] oral medication,[68, 69, 79, 86] continuous passive motion (CPM),[70, 71] laser therapy,[59, 72, 78] infrared therapy,[67] a progressive stretch device,[73] spray and stretch technique,[76] electromagnetic therapy,[60] tuina (kind of manual therapy),[88] sleepers stretch,[80] and not further defined physical modalities.[81]

Outcome measures

Both passive and active ROM (PROM and AROM) were measured with a goniometer in all included studies. Apley's scratch test was used as an alternative measurement for AROM in

one study.[83] Scapular dyskinesis was assessed in only two studies and they used different outcome measures: scapular tipping [63] and the lateral slide test.[66]

The included studies used various outcome measures for function/disability and pain. For function/disability the following outcome measures were used SPADI,[58, 59, 61, 64, 65, 70, 71, 75-80, 83, 84, 86] CMS,[56, 69-71, 82, 85, 87, 88] Simple Shoulder Test,[66] Modified Upper Extremity Motor Activity Log,[57] University of California Los Angeles scale,[67] Oxford Shoulder Score,[82] Disabilities of Arm, Shoulder and Hand (DASH),[74] PENN score,[74] patient-specific functional scale,[61] and FLEX-SF.[81] Most common used measures for pain were Visual Analogue Scale (VAS) [56, 59, 61, 64-71, 73-77, 84, 88], Numeric Rating Scale,[72, 83] and McGill Pain Questionnaire.[57] In some studies the outcome measure for pain and functional ability was an ordinal scale[60] or a self-constructed measure.[62]

Muscle strength was used in only two studies[61, 76] as an outcome measure and they used a sphygmomanometer[76] and a handheld dynamometer.[61]

Effect of intervention

Supervised exercises compared to unsupervised exercises

Only one study[82] compared supervised and unsupervised exercise interventions, class versus home exercises, for ROM and function in the long term. There is preliminary evidence that an exercise class increases *ROM* (MD: 10.96° [7.54°, 14.37°]) and *function/disability* (MD: CMS, 16.10 [10.25, 21.95] points) compared to a home exercise program.

Exercises in a multimodal program compared to solely exercises

Eight included studies [57, 59, 65, 68, 70, 75, 82, 85] evaluated exercises in a multimodal program compared to solely exercises in the short and long term. Unfortunately, one study [75] could not be used in the meta-analysis because of a lack of information in the study and upon

information request (not answered). Figure 3-5 show the results of the meta-analysis for these interventions on PROM, function/disability, and pain, respectively.

Four studies found that solely exercises may result in little to no difference in*PROM* into flexion (MD: -3.32 [-7.23, 0.58])[57, 59, 68, 70] and slightly increase internal rotation (MD: -7.64 [-11.548, -3.75])[57, 59, 65, 70] compared to exercises in a multimodal program in the short term. Five studies [57, 59, 65, 68, 70] found that exercises in a multimodal program may result in no difference in PROM into abduction (MD: -1.06 [-4.92, 2.80]) and external rotation (ER, MD: -6.86 [-10.13, -3.58]) compared to solely exercises. The excluded study[75] for meta-analysis preliminary showed that exercises in a multimodal program improve active and passive ER ROM compared to solely exercises.

The efficacy of exercises in a multimodal program versus solely exercises on *function/disability* and *pain* in the short and long term was investigated by four[59, 70, 82, 85] and three[59, 65, 70] studies, respectively. The evidence is uncertain about the effect of exercises in a multimodal program on *function/disability* (SMD: -0.04 [-0.56, 0.64]) compared to solely exercises. In addition, exercises in a multimodal program may not reduce *pain* (MD: -1.13 [-2.61, 0.35]) compared to solely exercises. The excluded study[75] for meta-analysis preliminary showed that exercises in a multimodal program improve function/disability compared to solely exercises.

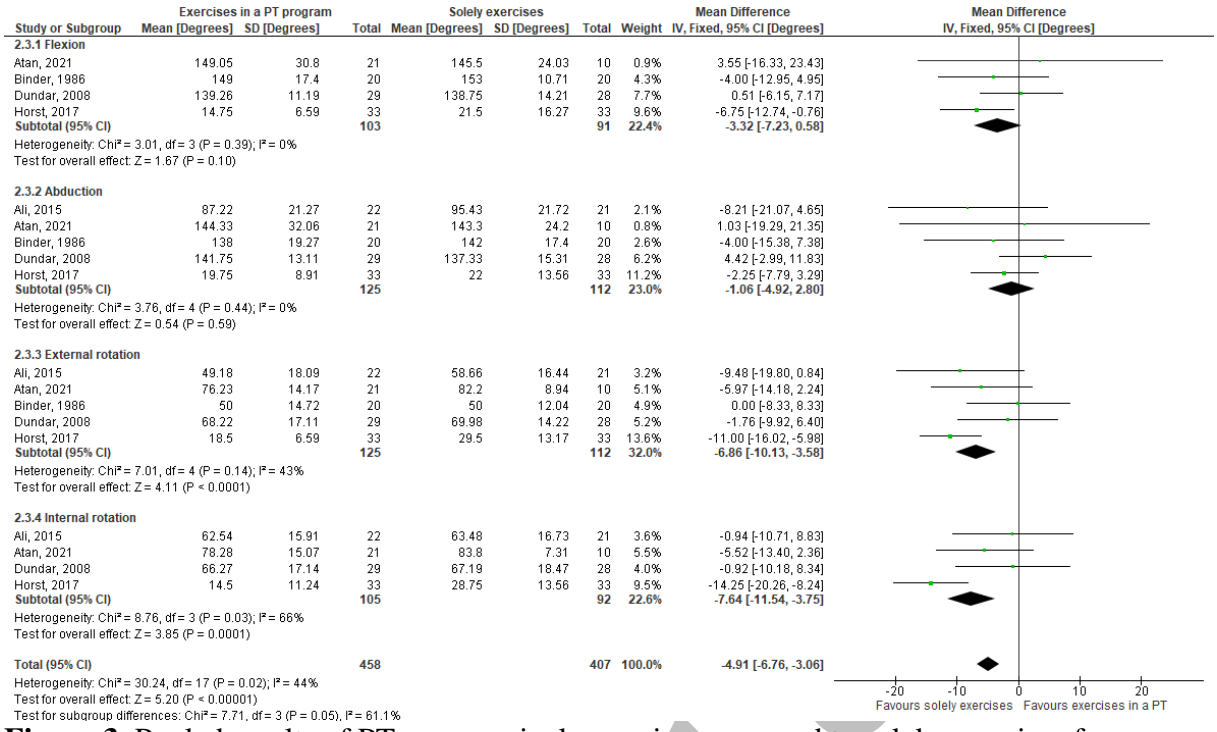


Figure 3. Pooled results of PT program incl. exercise compared to solely exercises for *PROM*.

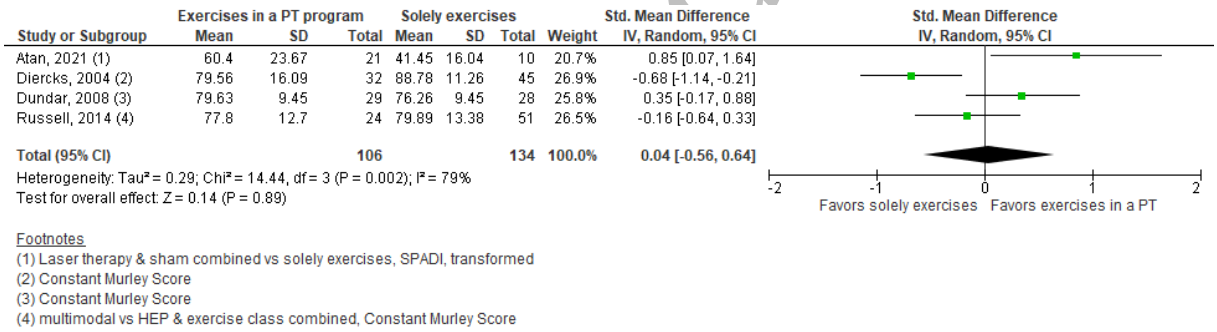


Figure 4. Pooled results of PT program incl. exercise compared to solely exercises for *function*.

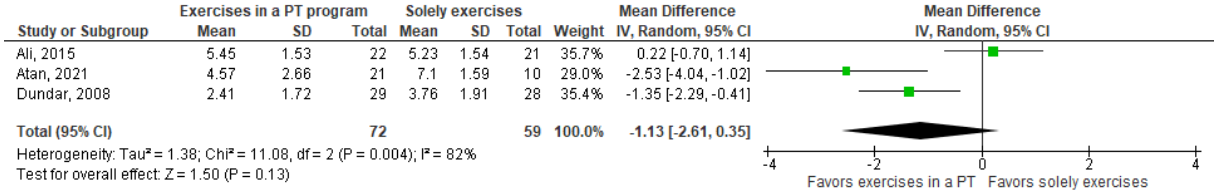


Figure 5. Pooled results of PT program incl. exercise compared to solely exercises for *pain* (VAS).

<u>Exercises in a multimodal program compared to a multimodal program without exercises</u>

Four included studies[66, 78, 79, 86] evaluated exercises in a multimodal program and compared it to a multimodal program without exercises in the short and midterm. Figure 6-9 show the

results of the meta-analysis for these interventions on PROM, AROM, function, and pain, respectively.

Two studies[78, 79] found that exercises in a multimodal program results in little to no difference in *PROM* into abduction (MD: 6.12 [2.96, 9.28]) and ER (MD: 4.53 [2.22, 6.83]) compared to a program without exercises. In addition, preliminary evidence[78] was found that in the short term programs comprising exercises slightly increase flexion (MD: 10.35 [6.20, 14.50]) ROM, but not internal rotation (MD: 2.85 [0.83, 4.87]) and extension (MD: 0.10 [-2.45, 2.56]) ROM compared to a program without exercises.

For *AROM* only preliminary evidence[66] was found that a program with exercises increases flexion (MD: 16.00 [14.07, 17.93]) and slightly increases abduction (MD: 9.00 [4.38, 13.62]) ROM, compared to a program without exercises.

The efficacy of these treatment programs on *function/disability* and *pain* was investigated by three[66, 78, 86] and two[66, 86] studies, correspondingly. The evidence is uncertain about the effect of a program with exercises compared to one without exercises on function/disability (SMD: -0.78 [-2.06, 0.49]), while programs comprising exercises probably do not reduce pain (SMD: -0.06 [-0.42, 0.30]) compared to one without exercises.

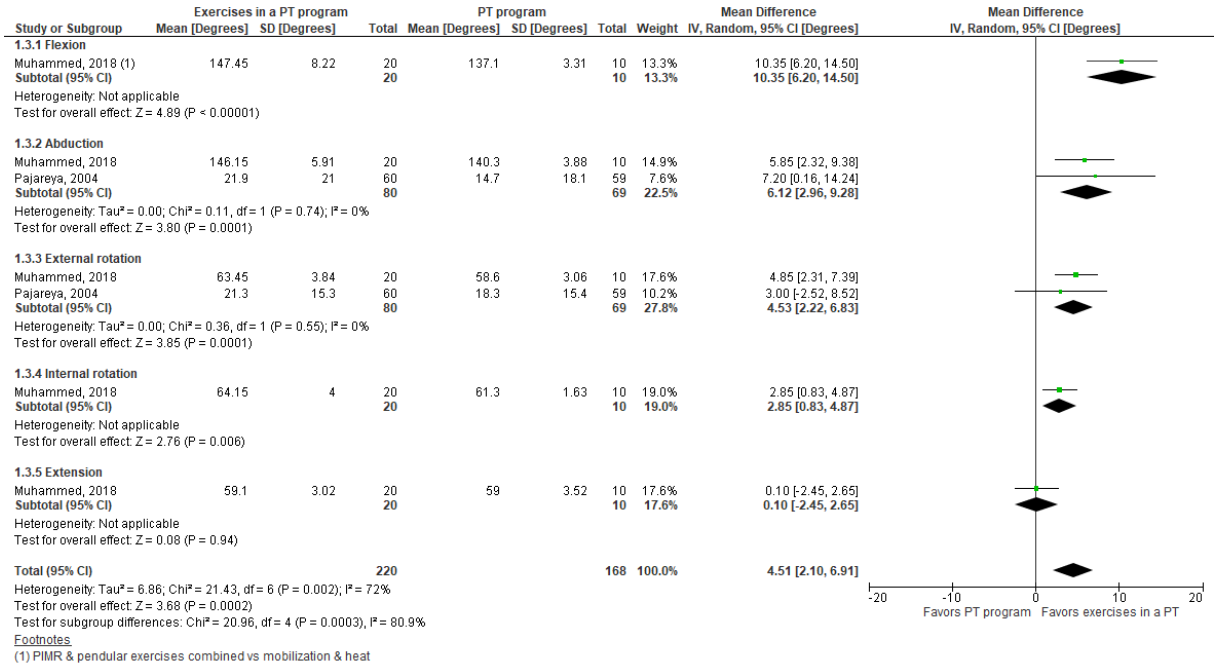


Figure 6. Pooled results of PT program incl. exercise compared to a PT program without exercise for *PROM*.

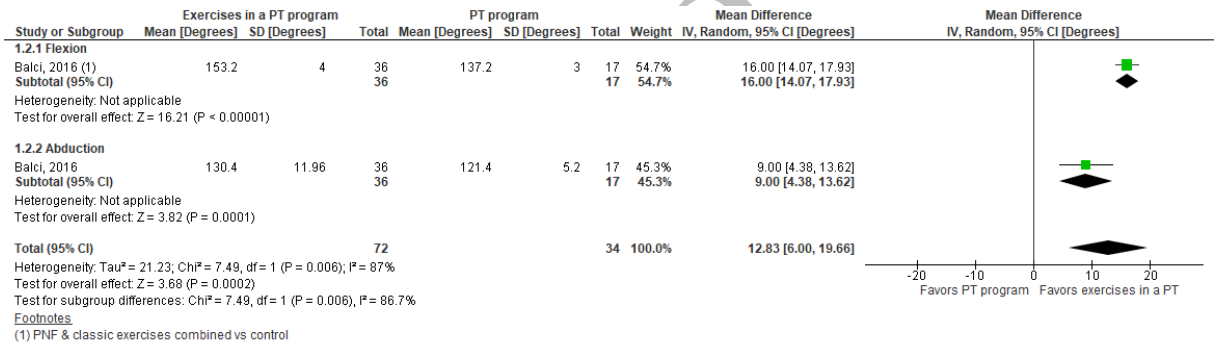


Figure 7. Pooled results of PT program incl. exercise compared to a PT program without exercise for *AROM*.

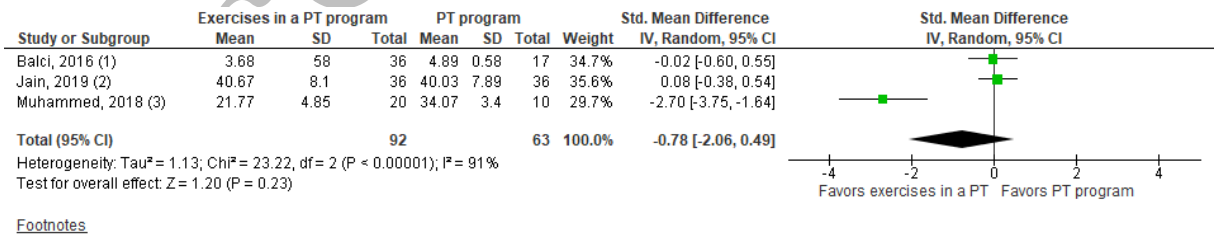


Figure 8. Pooled results of PT program incl. exercise compared to a PT program without exercise for *function*.

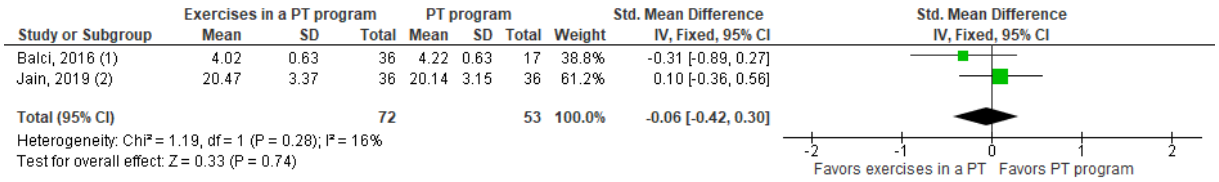


Figure 9. Pooled results of PT program incl. exercise compared to a PT program without exercise for *pain***.**

Exercises in a multimodal program compared to different exercises in a multimodal program

Twenty-four studies [56, 58-64, 66, 67, 69, 71-74, 76-78, 80, 81, 83, 84, 87, 88] compared various exercises in different programs with each other. Due to heterogeneity in outcome measures and exercise programs, only a meta-analysis could be performed for studies comparing muscle energy techniques (e.g. PNF) with other types of exercises, for studies comparing programs with and without static stretching and programs comparing physical modalities with sham treatment.

Muscle energy techniques compared to different exercises in a treatment program

Seven studies [64, 66, 72, 77, 78, 84, 87] compared a type of muscle energy techniques with another type of exercise for PROM, AROM, function and pain in the short term. The results of the meta-analysis for these outcome measures are shown in Figure 10-13, respectively.

Based on three studies[64, 77, 78] it is likely that muscle energy techniques have similar effects for *PROM* (MD: 4.88° [3.24-6.51°]) and *AROM* (MD: 6.35 [-8.83, 21.63]),[66, 72]compared to other types of exercises. Muscle energy techniques [66, 72] may improve *function/disability* (SMD: -0.62 [-1.28, 0.04]),[64, 66, 77, 78, 84, 87] compared to other exercises. Furthermore, the evidence[64, 66, 72, 77, 84] is uncertain about the effect of muscle energy techniques on *pain* (SMD: -0.36 [-1.24, 0.52]) compared to other exercises.

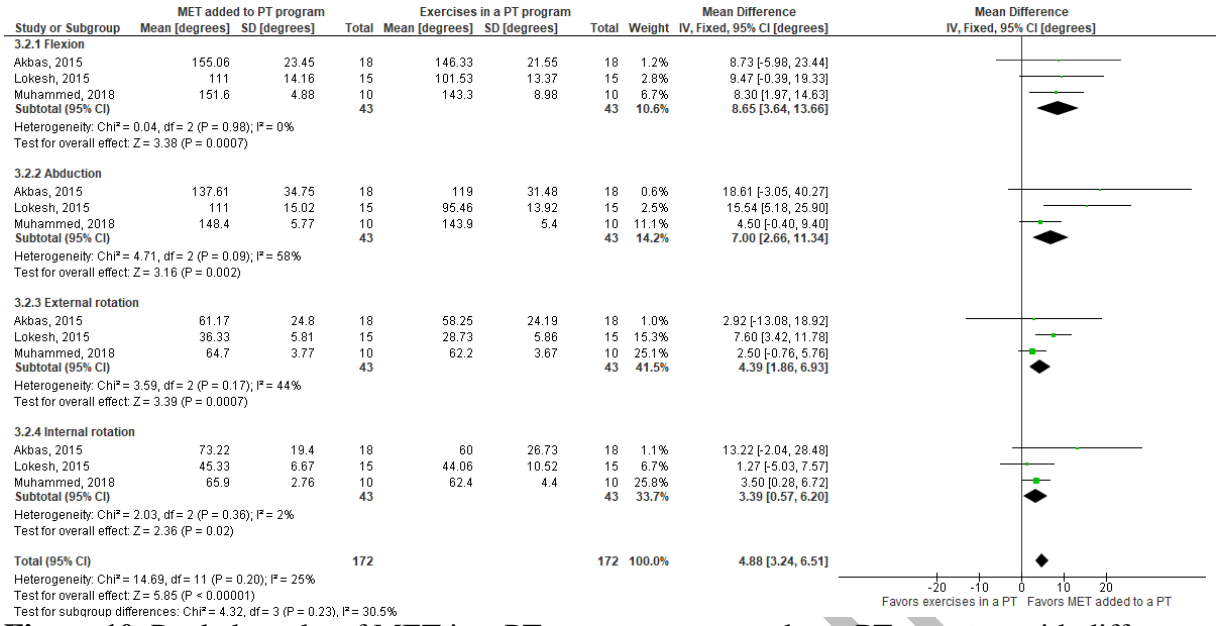


Figure 10. Pooled results of MET in a PT program compared to a PT program with different exercises for *PROM*.

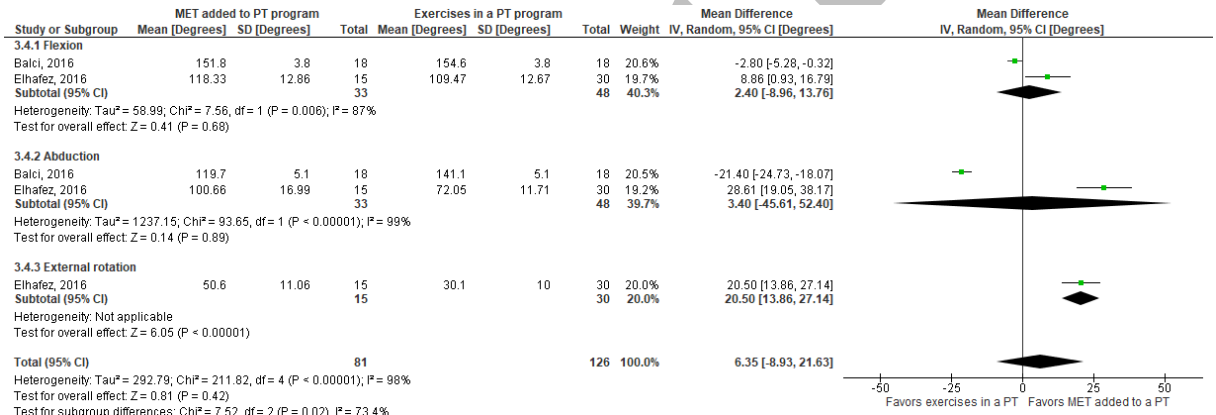
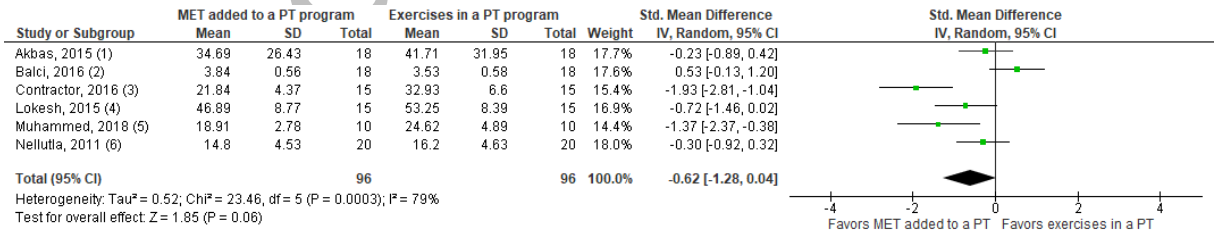


Figure 11. Pooled results of MET in a PT program compared to a PT program with different exercises for *AROM*.



Footnotes
(1) SPADI
(2) SST, (transformed low=high)
(3) SPADI
(4) SPADI
(5) SPADI
(6) CMS (transformed, low=high)

Figure 12. Pooled results of MET in a PT program compared to a PT program with different exercises for *function*.

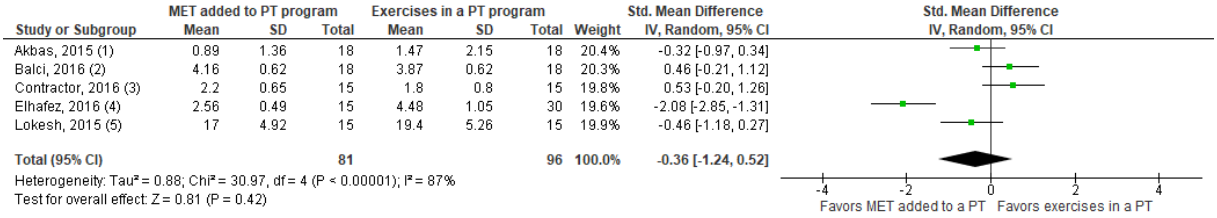


Figure 13. Pooled results of MET in a PT program compared to a PT program with different exercises for *pain***.**

Static stretching combined with exercise vs exercises in a multimodal program

Two studies [73, 80] compared adding static stretching to a multimodal program (including thermotherapy and home exercises) to the same program without static stretching in the short and long term. The results of the meta-analysis for PROM and function are shown in Figure 14 and 15, respectively.

The evidence is uncertain about the effect of adding stretches to a multimodal program on *PROM* (MD: 16.40 [7.41, 25.38]) and *function/disability* (SMD: -0.60 [-2.92, 1.72]) compared to the same program without stretching.

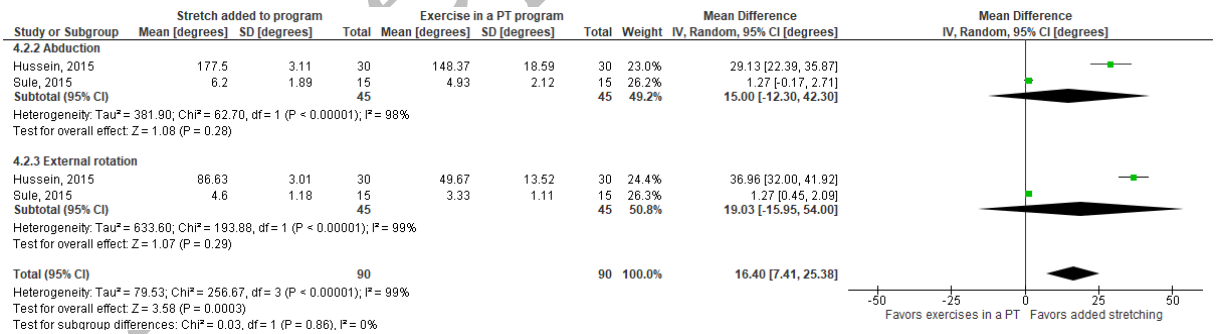


Figure 14. Pooled results of stretching added to a PT program including exercises compared to the same PT program for *PROM***.**

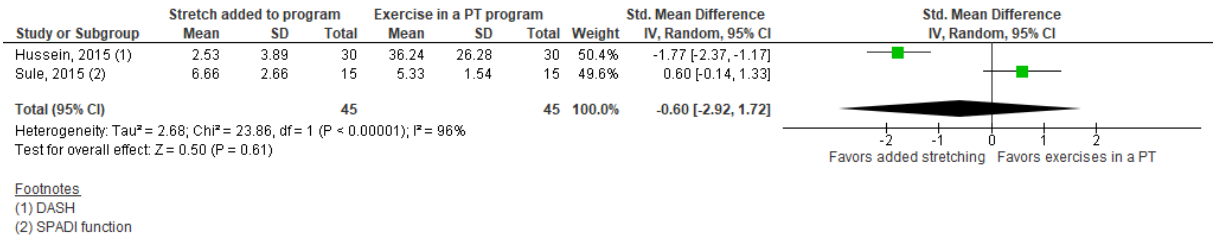


Figure 15. Pooled results of stretching added to a PT program including exercises compared to the same PT program for *function*.

Physical modalities combined with exercises compared to sham with exercises

Two studies[59, 60] compared physical modalities combined with exercises with sham treatment in the short term. The results of the meta-analysis for PROM and pain are shown in Figure 16 and 17, respectively.

Physical modalities do not improve *PROM* (Overall MD: 1.51 [-4.14, 7.16]) and *pain* (MD: 0.10 [-0.26, 0.46]).

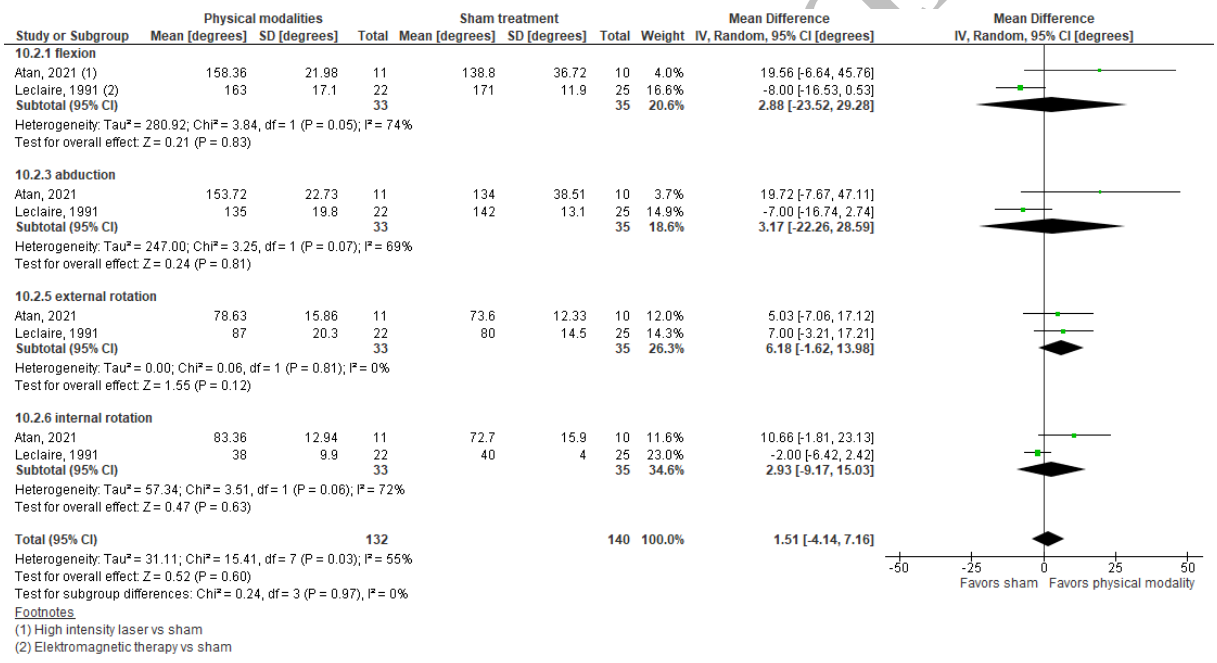


Figure 16. Pooled results of physical modalities compared to sham treatment added to a PT program including exercises for *PROM*.

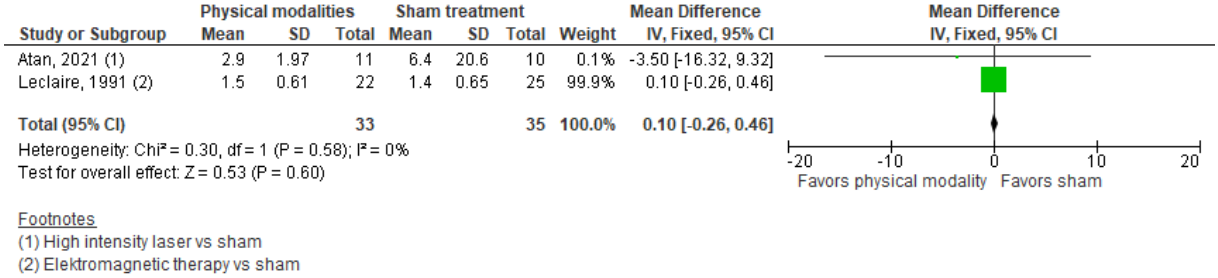


Figure 17. Pooled results of physical modalities compared to sham treatment added to a PT program including exercises for *pain*.

Various exercises in a treatment program

Thirteen studies [56, 58, 61-63, 67, 69, 71, 74, 76, 81, 83, 88] compared different types of exercises with each other on various outcome measures. An overview of these preliminary results is shown in Table 3 and summarized below. The results show the effect of the treatment programs in the short term, unless indicated otherwise.

For local exercises with US a large increase in *PROM* in flexion was found.[56] Adding instrument-assisted soft-tissue massage,[83] RC strengthening exercises,[61] spray and stretch technique,[76] dynamic scapular recognition exercise[58] and end-range mobilizations,[81] mirror therapy[67] and local exercises with US[56 61765881]improve PROM (in at least one direction), and [83]CPM[71] and adding instrument-assisted soft-tissue massage[83] and scapulothoracic exercises[69] slightly improve PROM (in at least one direction) compared to a control intervention with exercises. [60]

Mirror therapy[67] increases *AROM* (in at least one direction), while adding instrument-assisted soft-tissue massage[83] and CPM[71] slightly increases AROM (in at least one direction) compared to a control intervention with exercises.

Compared to a control intervention with exercises, an increase in *function/disability* was found with mirror therapy,[67] local exercises with US[56] and adding spray and stretch technique[76] and RC strengthening exercises.[61] In addition, a slight increase in function was found with adding scapulothoracic exercises[69] and CPM[71], while no effect was found with yi jin jing[88] and additional instrument-assisted soft-tissue massage,[83] scapular recognition exercise[58] and end-range mobilization.[81]

For *pain* as an outcome, only adding spray and stretch techniques showed a decrease compared to an intervention without spray and stretch.[76] Furthermore, a slight decrease in pain was found with mirror therapy,[67] adding scapulothoracic exercises[69]and RC strengthening exercises,[61] CPM,[71] local exercises with US[56 61]and yi jin jing,[88] while no effect

was found for additional instrument-assisted soft-tissue massage[83] and additional mobilizations[74 60]

Adding spray and stretch technique[76] was found to increase *muscle strength*, and additional RC strengthening exercises[61] slightly increased muscle strength compared to a control intervention without these interventions. Furthermore, adding lower trapezius exercises to a program already containing exercises[63] slightly decreased *scapular tipping*. Finally, *functional ROM* was changed after additional instrument-assisted soft-tissue massage,[83] however, the magnitude was unclear and *scapular upward rotation* did not change with an additional scapular recognition exercise.[58]

DISCUSSION

The first aim of the current study was to determine the effect of solely exercise or combined with other interventions in patients with FS. Preliminary evidence shows an improvement in ROM and function/disability of an exercise class compared to a home exercise program. Furthermore, solely exercises may result in little to no difference in PROM and pain compared to a multimodal program including exercises and the evidence for function/disability is uncertain. Adding exercises to a multimodal program results in little to no difference in PROM, probably do not reduce pain, and the evidence is uncertain about the effects of these programs on function/disability.

The second aim was to determine what kind of exercise therapy or combined with other interventions is most effective on ROM, function/disability, pain, muscle strength, and patient satisfaction in these patients. It is likely that the type of exercises (muscle energy techniques

versus other type) do not result in a difference in PROM and AROM, while function/disability may improve with muscle energy techniques. Finally, the evidence for the effect on pain of different types of exercises is uncertain. Adding static stretches to multimodal programs including exercises may increase ROM, but the evidence is uncertain about the effect on function/disability.

Clinical and research implications

The results from this review implicate that exercises improve ROM, function/disability and pain and that the type of exercise has little or no influence on this. Although the latter can only be concluded for muscle energy techniques compared to other exercise types. For strength training or ROM exercises not sufficient data was available to draw any conclusions. Adding (physical) modalities to exercises has no benefit for treatment outcome. Due to heterogeneity of modalities added to the exercises no specific modalities can be excluded. However, exercises can be performed in a home program or combined with an exercise class, this seems to be effective as well and is more efficient and cost-effective. Although the effect of exercise class with home program should be confirmed in future research.

Programs with exercises result in larger AROM gains than programs without exercises, no difference was found for other outcomes. In these programs the exercises comprised mostly of supervised exercises. The effect of a home program compared to a program without exercises should be confirmed in future research.

The evidence for additional static stretches is uncertain, the effect on PROM is promising, but should be confirmed with higher quality studies. Passive stretching was not included in this review and a more extensive comparison of the effect of stretching compared to exercises was not possible and should be investigated in future research.

Our results are in line with several other reviews, that indicate that exercises are an effective intervention.[14, 38, 48, 50] However, in most reviews, exercises were part of a multimodal program and a more extensive comparison is not possible.

Limitations included evidence

These results were influenced by several factors, including methodological issues and substantive differences between studies. In the next section the influence of the quality of evidence, differences in patient characteristics, applied treatment programs, and selected outcome measures will be discussed.

Quality of evidence

In studies with modalities as intervention and subjective outcome measures, several challenges need to be countered to blind participants.[90] In addition, an intervention as exercise therapy is difficult to compare to a placebo exercise, because the placebo exercise needs to have the same characteristics as the 'real' exercise.[90] Therefore in many cases this will result in a high risk of bias. As a consequence of these results, the quality of evidence according to the GRADE will be downgraded with one or two levels.

Another difficulty within our review was the consideration of publication bias. After the creation of homogenous groups, the number of studies was not sufficient (5-10 is recommended) to create a funnel plot for detection of publication bias. Which also might have influenced the quality of evidence.

Finally, we believe that it is not fair to determine the GRADE for comparisons that include only one study, because few domains (inconsistency, imprecision) cannot be scored correctly. Therefore we did not rate these studies with a certainty level, but we proposed them as preliminary evidence.

Patient characteristics

Comparison of the results between studies based on patient characteristics is difficult for various reasons. First, there is moderate evidence of early recovery that slows with time.[91] So studies that included patients in an earlier phase could have found larger benefits of the intervention compared to studies that included patients in a later phase. Although diagnosing disease stage is difficult, comparability of patients could be done with tissue irritability levels. Second, there is conflicting evidence whether patients with FS and DM have a worse prognosis for recovery[34, 92-95] and therefore it is uncertain whether these studies can be compared to each other.

Treatment programs

There is a large heterogeneity in type of exercise (e.g. supervised, home, strength training, ROM exercises) and dose between studies that provided exercise programs solely or as part of a treatment program. In addition, not in all studies the dose of exercises is clearly described. These limitations make comparison between studies difficult and insufficient to prove the most effective dose for exercise therapy. Furthermore, the heterogeneity in content and dose of the multimodal programs prevent to provide evidence for the most effective multimodal program as well.

Most studies use short treatment and follow up periods. Since FS is a chronic disorder with an average disease duration of 1 to 3 years[8] and time to greatest improvement from 12 to 48 months[91] these short time frames may not be sufficient for realizing effective treatments. As a consequence of these short treatment periods and time to greatest improvement from at least 12 months,[91] a large improvement in most studies cannot be expected.

Outcome measures

Not all outcome measures may be valid for the FS population. In the included studies, the CMS is one of the most commonly used outcome measures regarding function/disability. However, its use is (up to now) only advised for patients with subacromial shoulder disorders[96] and it is only validated in English.[97] If patients are unable to achieve 90° abduction (which is the case in many patients with FS) they should receive the score zero and this might not reflect the actual strength of this patient, but more the restriction of ROM.[97, 98] In addition, pain is measured in two elements, during self-report and as factor within pain-free ROM.[97] As a consequence of these constructs the CMS is not valid in patients with FS, because the majority of these patients are not able to abduct their shoulders sufficient to lift the weight reliably [99] and might move their shoulder beyond pain free range as well. This might be a reason for not finding a difference between treatment programs regarding function/disability. For patient reported outcome measures in patients with FS, it is recommended to use the DASH, the American Shoulder and Elbow Surgeons shoulder scale, or the SPADI.[14] Clinical relevant changes for ROM, function/disability (SPADI), and pain (VAS 0-100) were suggested to be at least 15°,[100] 8-13,[101] and 12 mm,[102] respectively. However, not for all outcome measures minimal detectable change and minimal clinically important difference values are present. Therefore, for some outcome measures (e.g. CMS, muscle strength) it was difficult to determine effect sizes.

Finally, another shortcoming is the limited studies about the effect of exercises regarding the outcomes muscle strength and patient satisfaction. Both outcomes should be more emphasized in future studies.

<u>Strengths</u>

This study had several strengths, first a comprehensive set of search terms was used to search three databases for relevant studies. Second, a hand search was performed to prevent overlooking of relevant studies. Third, two independent reviewers performed the screening, risk of bias assessment, and data extraction. Fourth, there was sufficient homogeneity between studies to perform a meta-analysis.

Study limitations

Due to the lack of multiple studies investigating solely exercise programs and the heterogeneity of the other studies comparing exercises in a multimodal program no meta-analysis could be performed for these studies. In addition, we might have overlooked some relevant studies, despite our comprehensive set of search terms and searching three databases. We only selected studies written in English or Dutch, we did not search for gray literature, and we could have searched additional databases. Finally, the GRADE assessment was only performed by one reviewer, which could have resulted in bias.

Conclusion

In conclusion, exercises (in a program or on their own) improve ROM, function/disability and pain. However, only little to no difference was found in PROM and pain between the programs and the effects in function/disability are uncertain. Adding physical modalities to exercises has no benefit for treatment outcome. Compared to a program without exercises, adding exercises improve the AROM. Regarding type of exercise can be concluded that muscle energy techniques only improve function/disability more than other exercise types, while no difference was found for other outcomes.

Future research should focus on the effect of exercises on muscle strength and patient satisfaction as outcomes and results in the long term should be investigated. Moreover, the

effect of solely exercises (as class, home program or combined) should be confirmed. Finally, the dose of exercises should be standardized to draw a conclusion.

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Supplemental Appendix S1: search strategies other databases

Web of Science, advanced search:

TS = ((Frozen shoulder OR Adhesive capsulitis OR Stiff shoulder OR Periarthritis OR Pericapsulitis) AND (Exercise therapy OR Rehabilitation OR Exercise training OR Exercise movement techniques OR Muscle strengthening exercises OR Resistance training OR Resistance exercise OR Plyometric training OR Plyometric exercise OR Proprioceptive training OR strength training OR high-intensity interval training OR physical therapy modalities OR physical therapy specialty OR physical therapy OR physiotherapy OR aerobic exercise OR anaerobic exercise OR aerobic training OR anaerobic training OR interval training) AND (Pain OR Shoulder pain OR Mobility OR Articular range of motion OR Muscle strength OR Functionality OR Functional ability OR Activities of daily living OR Sports OR Quality of life OR Patient satisfaction))

Publication type: article

Cochrane trials, advanced search on title, abstract, keyword:

(Frozen shoulder OR Adhesive capsulitis OR Stiff shoulder OR Periarthritis OR Pericapsulitis) AND (Exercise therapy OR Rehabilitation OR Exercise training OR Exercise movement techniques OR Muscle strengthening exercises OR Resistance training OR Resistance exercise OR Plyometric training OR Plyometric exercise OR Proprioceptive training OR strength training OR high-intensity interval training OR physical therapy modalities OR physical therapy specialty OR physical therapy OR physiotherapy OR aerobic exercise OR anaerobic exercise OR aerobic training OR anaerobic training OR interval

946 training) AND (Pain OR Shoulder pain OR Mobility OR Articular range of motion OR
947 Muscle strength OR Functionality OR Functional ability OR Activities of daily living OR
948 Sports OR Quality of life OR Patient satisfaction)