Is there any benefit of adding a central nervous system–focused intervention to a manual therapy and home stretching program for people with frozen shoulder? A randomized controlled trial

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Background: Frozen shoulder (FS) is a highly disabling pathology of poorly understood etiology, which is characterized by the presence of intense pain and progressive loss of range of motion. The aim of this study was to evaluate the effect of adding a central nervous system (CNS)–focused approach to a manual therapy and home stretching program in people with FS.
Methods: A total of 34 patients with a diagnosis of primary FS were randomly allocated to receive a 12-week manual therapy and home stretching program or manual therapy and home stretching program plus a CNS-focused approach including graded motor imagery and sensory discrimination training. The Shoulder Pain and Disability Index score, self-perceived shoulder pain (visual analog scale score),

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shoulder range of motion, and the Patient-Specific Functional Scale score were measured at baseline, after a 2-week washout period just before starting treatment, after treatment, and at 3 months' follow-up.

Results: No significant between-group differences in any outcome were found either after treatment or at 3 months' follow-up.

Conclusion: A CNS-focused approach provided no additional benefit to a manual therapy and home stretching program in terms of shoulder pain and function in people with FS.

Level of evidence: Level I; Randomized Controlled Trial; Treatment Study

Frozen shoulder (FS) is one of the most challenging musculoskeletal conditions that physiotherapists face in their clinical practice. It is characterized by a spontaneous onset of shoulder pain, followed by a gradual and generalized decrease in both active and passive range of motion (ROM).[44] In 2011, the American Shoulder and Elbow Surgeons proposed to classify FS into primary or idiopathic FS and secondary FS, with the latter in turn being subclassified into 1 of 3 categories: intrinsic (ie, due to any other shoulder pathology, eg, rotator cuff tear), extrinsic (ie, due to any pathology outside the shoulder, eg, cervical radiculopathy), and systemic (ie, due to diabetes).[44] The underlying physiopathology of FS is still poorly understood, although some mechanisms such as low-grade inflammation and immune system dysregulation have gained scientific interest in recent years.[16,31]

The effectiveness of different interventions in people with FS has been investigated. For instance, a wide variety of mobilization techniques have shown beneficial effects in patients with this clinical condition.[29,30] However, to date, no intervention has demonstrated superiority over the other interventions, except the early use of intra-articular corticosteroid injections in patients with FS of <1 year in duration.[6] Additionally, the effect sizes of currently applied interventions are modest at best, and the natural history of FS does not seem to be influenced by any treatment.[27] This fact has prompted some authors to claim the need for innovative research in the area of management of FS.[41]

In recent years, growing evidence has shown that central pain mechanisms may play a key role in a wide variety of chronic musculoskeletal pain conditions.[14,21,38] Considering the long-lasting nature of FS, it was postulated that this could also be the case for this condition.[41] In line with this, some recent studies have investigated the contribution of altered central pain-processing mechanisms in people with FS. Mena-del Horno et al[23] found that people with FS had reduced tactile acuity and impaired laterality judgment in their affected shoulders when compared with their unaffected shoulders and controls. These results were later replicated by Breckenridge et al.[2] In a case-series study, Louw et al[21] investigated the effects of a brief mirror therapy intervention in subjects with shoulder pain and limited active ROM, including people with FS. Significant improvements in pain intensity, pain catastrophizing, fear avoidance, and shoulder ROM (active flexion) were found after treatment. Similar results were shown by Sawyer et al[38] in a case report of FS after implementing a combined intervention comprising pain neuroscience education, sensory discrimination training, and graded motor imagery (GMI). Because of the small sample sizes, low level-of-evidence study designs (ie, case reports and case series), and short-term follow-up of the aforementioned studies, further research on the role of central nervous system (CNS)–focused interventions in this population seems warranted.

The aim of this study was to investigate the effect of adding a combined CNS-focused intervention including sensory discrimination training and GMI to a manual therapy and home stretching program in people with FS. It was hypothesized that patients receiving the combined peripheral and CNS-focused intervention would report better outcomes than patients receiving only the peripheral-focused intervention (ie, manual therapy and stretching).

Methods

Study design

We performed a randomized controlled trial analyzing the comparative effectiveness of 2 physiotherapy interventions for FS. This study has been reported following the CONSORT (Consolidated Standards of Reporting Trials) guidelines[25] (Supplementary Appendix S1), and interventions are described in accordance with the Template for Intervention Description and Replication (TIDieR) checklist (Supplementary Appendix S2).[13]

Participants

Participants with primary FS were recruited between October 2017 and March 2020. Participants had to comply with the following inclusion criteria[3]: (1) either loss of passive external rotation in the affected shoulder >50% compared with the unaffected shoulder or >30° of external rotation in the affected shoulder as measured in 0° of shoulder abduction, (2) ROM loss >25% in ≥2 movement planes in the affected shoulder when compared with the unaffected shoulder, and (3) presence of

shoulder pain and restricted ROM that had reached a plateau or had been worsening for ≥1 month. Patients were excluded if they had received shoulder surgery during the past year; had a locked dislocation, arthritis, a fracture, or avascular necrosis; presented difficulties in understanding the written or spoken Spanish language; had any skin or medical condition preventing them from receiving tactile stimuli on the shoulder; had any neurologic or motor disorder (eg, dyslexia); were visually impaired; or had any diagnosis of psychopathology.

Prior to inclusion, none of the participants had received a corticosteroid injection in the affected shoulder or reported satisfactory results from previous physical therapy treatments. All participants were instructed to continue taking any current medications but not to start new medications or initiate new treatments during the treatment period.

Procedure

All participants were interviewed at baseline to collect sociodemographic and clinical information. Then, participants' shoulder ROM and self-perceived shoulder pain were measured, and the Shoulder Pain and Disability Index (SPADI) and Patient-Specific Functional Scale (PSFS) questionnaires were completed.

All assessments were performed by 3 researchers (M.B.-B., L.D., and E.L.), with 20 years, 20 years, and 10 years of clinical experience, respectively, in assessing and treating patients with FS. Prior to study commencement, the researchers practiced all measurements and agreed on them to ensure consistency.

Outcome measures

The primary outcome measure was the SPADI score. Secondarily, self-perceived shoulder pain (visual analog scale [VAS] score), shoulder active and passive ROM, and PSFS score were also measured. All outcomes were recorded at baseline and after a 2-week washout period to evaluate whether changes in participants' clinical condition could occur during a ''non-intervention'' period.[13] Participants again underwent measurements after treatment and at 3 months' follow-up. If no significant differences in outcomes were observed between the baseline and 2-week assessments, any change in the following measurements could be more attributable to the intervention.[10]

Shoulder pain and disability
Participants' shoulder pain and disability were measured with the Spanish version of the SPADI. The SPADI is a 13-item shoulder function index that assesses pain and disability related to shoulder dysfunction.[33] Each item is scored using a numeric scale ranging from 0 (''no pain/no difficulty'') to 10 (''worst pain imaginable/so difficult it required help''). The total score ranges from 0 to 100 points, with higher scores indicating greater disability.

The Spanish version of the SPADI has shown high internal consistency (Cronbach α, 0.916) and excellent test-retest reliability (intraclass correlation coefficient, 0.91).[22] The minimal clinically important difference (MCID) for the SPADI score ranges from 8 to 13 points.[35]

Self-perceived shoulder pain
Participants' self-perceived shoulder pain was assessed with a VAS anchored at 0 (''no pain'') and 100 (''pain as bad as you can imagine''). Participants were asked to indicate their average pain experienced over the 24 hours prior to assessment.[11]

The VAS score has been shown to be a valid and reliable tool to measure pain intensity in people with shoulder pain. The MCID for the VAS score is 30 mm.[17]

Shoulder ROM
Active and passive shoulder flexion and external rotation at 0° of shoulder abduction in the affected shoulder were measured using a Plurimeter-V gravity inclinometer (Plurimeter 164 Dr Rippstein, La Conversion, Switzerland) following previous guidelines.[28,37] For shoulder flexion, participants were standing with the inclinometer placed on the proximal third of the humerus, over the superior portion of the biceps brachii muscle. Participants were first asked to actively elevate the shoulder until either pain or resistance appeared; then, the shoulder was forced passively until pain tolerance or maximum ROM was reached. Inclinometers have shown high responsiveness in measuring change in both passive and active flexion of the shoulder in FS patients, and the minimal detectable change (MDC) for active shoulder flexion is 8° in asymptomatic subjects.[34] In addition, active shoulder flexion in the scapular plane has demonstrated good reliability and validity.[15]

For shoulder external rotation, participants laid supine with the arm entirely supported by a plinth. The arm was placed in 0° of shoulder abduction, 90° of elbow flexion, and neutral forearm prono-supination. The inclinometer was placed on the distal part of the dorsal forearm. Participants were first asked to actively rotate into external rotation until either pain or resistance appeared; then, the shoulder was forced passively until pain tolerance or maximum ROM was achieved. The MDC for active external rotation is 9° in asymptomatic subjects, and good intrarater reliability and inter-rater reliability have been reported for both active and passive external rotation in healthy subjects and patients with shoulder pain disorders.[34]

PSFS score
Participants completed the PSFS questionnaire to assess for changes in the functional status of the affected upper limb after treatment. Participants selected 3-5 activities they had difficulties doing or were unable to do because of their current shoulder problem and rated these activities on an 11-point scale ranging from 0 (''unable to perform the activity'') to 10 (''able to perform the activity at preinjury level''). The total PSFS score was calculated as the sum of the activities' scores divided by the number of limited activities (range, 0-10), with higher scores indicating better performance.

The PSFS score has been shown to be a valid, reliable, and responsive outcome measure in people with upper-limb musculoskeletal problems.[12] The MCID for the PSFS score is 1.16 points.[12]

Adherence to treatment
Adherence to home treatment was assessed after each session with a diary in which participants marked their compliance with the assigned home exercises.[26]

Randomization and blinding

Participants were randomized to receive one of two 12-week interventions: a manual therapy and home stretching program or a manual therapy and home stretching program plus a CNS-focused approach including GMI and sensory discrimination training. Randomization was performed via sealed envelopes by a researcher who was blinded to the aim of the study. Additionally, the researchers responsible for all the assessments were blinded to treatment allocation.

Interventions

Manual therapy and home stretching program

Participants in one group received a manual therapy and home stretching program previously described by Dueñas et al.[8] This intervention included 12 sessions of supervised manual therapy applied once a week and a home stretching program performed once a day, 5 days per week, during the whole intervention period. The selection of specific manual therapy and home stretching techniques for each patient was based on individual shoulder ROM impairments[7] and the staged approach for rehabilitation (STAR)-shoulder tissue irritability rating system.[8] Details about how treatment techniques were individualized based on the 2 aforementioned factors can be found elsewhere.[8]

Manual therapy and home stretching program plus CNS-focused approach

Participants in the other group received the same manual therapy and home stretching program plus a CNS-focused approach as previously described by Lluch-Girbés et al.[19] The latter approach included a discussion of the participant's shoulder pain experience from a pain neuroscience perspective, provided in the first session, plus 12 supervised sessions of GMI and sensory discrimination training performed once a week.[20,43] Additionally, participants performed a home exercise program once a day, 5 days per week, consisting of GMI and sensory discrimination training, during the whole intervention. These home sessions lasted approximately 45-60 minutes until task completion. The feasibility of this CNS-focused treatment program for people with FS has recently been demonstrated.[24] The physiotherapist performing all the interventions (S.M.-d.H.) received a postgraduate degree in manual therapy and was trained by 2 experienced researchers (L.D. and E.L.) in the use of these techniques before starting the study.

Sample size calculation

The sample size was calculated using G*Power software (version 3.0.18) based on the SPADI score as the primary outcome measure. On the basis of studies that applied physiotherapy interventions in people with FS (mean SPADI score of 66 points; standard deviation, 16 points),[4] as well as the MDC attained in the study by Tveita et al[42] (17 points), to detect a 17-point between-group difference (standard deviation, 16 points), with 80% power and an α level of .05, a total sample size of 30 patients was estimated (15 per group). An allowance for a 15% dropout rate was made, increasing the sample size to 34 patients (17 per group).

Statistical analysis

Statistical analysis was performed using the R program (R Foundation for Statistical Computing, Vienna, Austria) in accordance with an intention-to-treat approach. Linear mixed models with repeated-measures analysis and random-effect models were used to model the intervention effect over the assessment time points for the primary and secondary outcome measures. We modeled the random effects of individuals and fixed effects of group (manual therapy and home stretching and manual therapy and home stretching plus CNS-focused approach), assessment time point (baseline, after treatment, and at 3 months' follow-up), and group × assessment time point. Pair-wise comparisons with Bonferroni adjustment were used when the interaction effect (ie, group × assessment time point) or the time point was significant and change scores between evaluations at baseline, after treatment, and at 3 months' follow-up were computed to examine whether the MDC or MCID was exceeded.

Results

Fifty-four participants were initially assessed for eligibility, and 34 completed the study (Fig. 1). Both intervention groups were comparable at baseline in terms of patients' characteristics and outcomes (Tables I and II).

Table II shows the results of each outcome for both groups, as well as within- and between-group changes. No time point–by–group interaction was observed for any of the assessed outcomes. A main effect for time point was found for the SPADI score ($P < .001$), with the group receiving manual therapy and home stretching and the group receiving manual therapy and home stretching plus a CNS-focused approach showing similar improvements after treatment (within-group mean difference [MD], −27.36 [95% confidence interval (CI), −40.37 to −14.34] and −28.59 [95% CI, −41.21 to −15.96], respectively) and at 3 months' follow-up (−35.47 [95% CI, −47.63 to −23.30] and −38.32 [95% CI, −50.86 to −25.78], respectively), both exceeding the MCID.

A main effect for time point was also observed for the PSFS score ($P < .001$), with both intervention groups showing comparable improvements after treatment (within-group MD, −7.42 [95% CI, −9.50 to −5.11] and −6.05 [95% CI, −8.80 to −4.04], respectively) and at 3 months' follow-up (−8.18 [95% CI, −13.48 to −2.88] and −11.06 [95% CI, −9.60 to 1.31], respectively), which exceeded the MCID. Both groups also showed improvement in the VAS score through the study (main effect for time point, $P < .001$) (within-group MD, −18.58 [95% CI, −34.91 to −2.26] and −33.68 [95% CI, −50.50 to −16.85], respectively) and at 3 months' follow-up (−28.58 [95% CI, −46.03 to −11.14] and −27.93 [95% CI, −45.91 to −9.95], respectively), which exceeded the MCID in the group receiving manual therapy and home stretching plus a CNS-focused approach. Between-group comparisons of PSFS, SPADI, and VAS scores are shown in Figure 2.
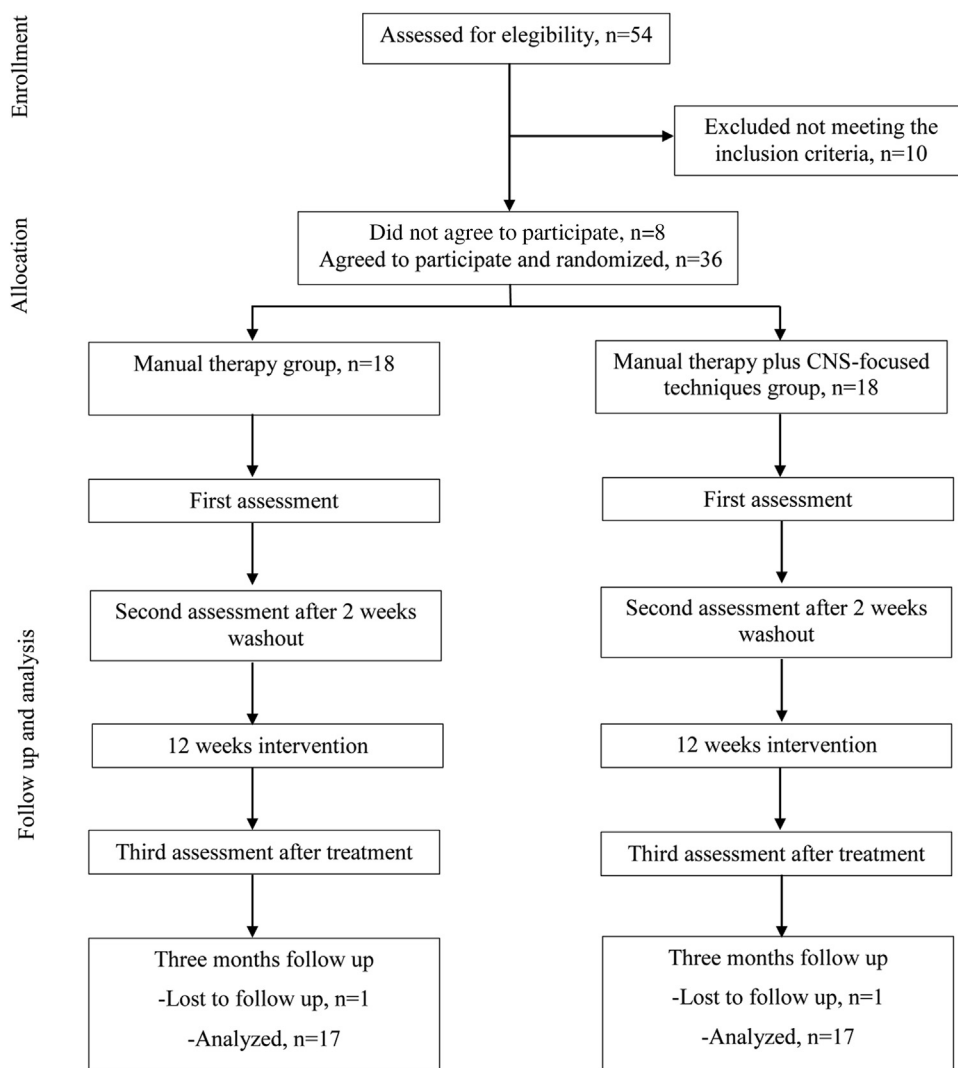
Figure 1 CONSORT (Consolidated Standards of Reporting Trials) diagram showing participant flow through study, from enrollment to allocation, follow-up, and analysis. *CNS*, central nervous system.

In terms of shoulder ROM, a similar improvement was observed in both groups (no time point–by–group interaction but a significant main effect for time point) for active and passive shoulder flexion ($P < .001$) and active and passive shoulder external rotation ($P < .001$) (the within-group MD for each outcome is shown in Table II). In the group receiving manual therapy and home stretching, active shoulder flexion did not improve after treatment compared with baseline (within-group MD, 13.5°; 95% CI, −0.8° to 27.7°), whereas a significant improvement was observed in the group receiving manual therapy and home stretching plus a CNS-focused approach (within-group MD, 21.6°; 95% CI, 6.9°-36.2°). Significant improvement in active shoulder flexion was observed in the group receiving manual therapy and home stretching between the evaluations after treatment and at 3 months' follow-up (within-group MD, 11.6°; 95% CI, 1.6°-21.7°). Between-group comparisons of shoulder ROM are shown in Figure 3.

Discussion

The aim of this study was to evaluate the additive effect of a CNS-focused approach to a manual therapy and home stretching program in people with FS. Overall, the results indicate that both interventions are equally effective in improving shoulder ROM and reducing shoulder pain and disability, thus suggesting that a CNS-focused approach has no additional benefit to a more peripheral-focused treatment in people with FS.

In recent years, CNS-focused physiotherapy approaches have been successfully implemented, both in isolation or within a multimodal treatment, in people with several chronic musculoskeletal conditions.[1,9,18] Regarding shoulder pain, only a preliminary study and a case report have previously investigated the effect of CNS-focused interventions in FS.[21,38] The improvements in shoulder pain and function in the group receiving the CNS-focused

Table I   Demographic characteristics

Characteristic	Manual therapy (n = 17)	Manual therapy + CNS-focused approach (n = 17)	Total (N = 34)
Sex, n (%)			
Female	9 (52.9)	15 (88.2)	24 (70.6)
Male	8 (47.1)	2 (11.8)	10 (29.4)
Age, yr	53.4 (7.87)	54.2 (7.48)	53.8 (7.57)
BMI	24.2 (3.31)	23.1 (2.28)	23.7 (2.85)
Dominant side, n (%)			
Right	0 (0)	1 (5.9)	1 (2.9)
Left	17 (100)	16 (94.1)	33 (97.1)
Painful side, n (%)			
Left	9 (52.9)	10 (58.8)	19 (55.9)
Right	8 (47.1)	7 (41.2)	15 (44.1)
FS type, n (%)			
Primary adhesive capsulitis	15 (88.2)	11 (64.7)	26 (76.5)
Secondary adhesive capsulitis	2 (11.8)	6 (35.3)	8 (23.5)
Symptom duration, mo	9.82 (8.54)	8.00 (5.41)	8.91 (7.10)
Diabetes, n (%)			
No	14 (82.4)	16 (94.1)	30 (88.2)
Yes	3 (17.6)	1 (5.9)	4 (11.8)
Hypothyroidism or hyperthyroidism, n (%)			
No	15 (88.2)	16 (94.1)	31 (91.2)
Yes	2 (11.8)	1 (5.9)	3 (8.8)

CNS, central nervous system; *BMI*, body max index; *FS*, frozen shoulder.
Data are presented as mean ± standard deviation or frequency (proportion).

intervention group that we observed are in line with the findings of the aforementioned studies. For instance, Louw et al[21] and Sawyer et al[38] reported a mean improvement of 14.5° and 101°, respectively, in active shoulder flexion, whereas a gain of 21.56° in active shoulder flexion after treatment was observed in our CNS-focused group. Similarly, the improvements in the SPADI and shoulder pain scores after treatment (27.36 points and 33.68 points, respectively) observed in the group receiving the CNS-focused approach are comparable to those reported by Sawyer et al for the SPADI score (22 points) and by both Louw et al[21] and Sawyer et al[38] for pain scores on a numerical rating scale (0.48 points and 7 points, respectively).

The positive effects on shoulder pain and function reported in our study by the group receiving manual therapy and home stretching are in accordance with those previously obtained in a case series by our research group[8] and with the recent literature.[29,30,32] However, contrary to our hypothesis, both intervention groups showed comparable improvements in terms of shoulder pain, function, disability, and ROM after treatment and at 3 months' follow-up, suggesting that a CNS-focused approach had no additional benefit to a more peripherally targeted treatment in patients with FS. Several reasons might explain these results. First, we randomly assigned our participants to 1 of 2 intervention groups following a one-size-fits-all approach without establishing their predominant pain mechanism at baseline. Recent evidence has shown that cortical representations were not present in people with shoulder pain

with a primary nociceptive pain mechanism.[5] Most of our sample could have consisted of patients with a dominant nociceptive pain mechanism, thus explaining why they did not show the expected benefit with an additional CNS-focused approach. Second, it cannot be discarded that the theoretically summative therapeutic effect of the combined peripheral and CNS-focused intervention might have been annulated owing to participants in this group perceiving a contradictory message between the 2 treatments.[9] Additionally, better outcomes may have been obtained by adding CNS-focused interventions other than those used in this study (eg, pain neuroscience education). Furthermore, pain and functional limitations in people with FS are largely related to pathophysiological changes occurring at the peripheral tissue level (eg, inflammation and subsequent capsular contracture).[16,36] This may be the reason CNS approaches such as GMI, sensory discrimination training, or pain neuroscience education would have not added any value to the manual therapy and exercise treatment, as no influence on the pathologic changes reported in the joint capsule and related structures may be expected after implementing the aforementioned CNS-focused interventions.

Study limitations

This study has several limitations that need to be acknowledged. First, the lack of a control group without intervention prevents us from establishing firm conclusions

Table II Results of each outcome for both groups and within- and between-group changes

Outcome	Manual therapy	Manual therapy + CNS-focused approach	Between-group change score
Active shoulder flexion, °			
Baseline	112.6 ± 5.9	103.1 ± 6.1	
After treatment	126.1 ± 5.1	124.6 ± 5.3	1.4 (−13.5 to 16.4)
Within-group change from baseline to after treatment	13.5 (−0.8 to 27.7)	21.6 (6.9-36.2)	
3-mo follow-up	137.7 ± 5.4	134.3 ± 5.6	3.4 (−12.5 to 19.3)
Within-group change from baseline to 3-mo follow-up	25.1 (12.2-38.1)	31.3 (17.9-44.6)	
Within-group change from after treatment to 3-mo follow-up	11.6 (1.6-21.7)	9.7 (−0.7 to 20)	
Passive shoulder flexion, °			
Baseline	122.5 ± 6.3	119.0 ± 6.5	
After treatment	139.1 ± 5.6	134.8 ± 5.8	4.3 (−12.2 to 20.8)
Within-group change from baseline to after treatment	16.5 (3.9-29.2)	15.8 (2.7-28.8)	
3-mo follow-up	147.0 ± 5.7	145.4 ± 5.8	1.6 (−15 to 18.2)
Within-group change from baseline to 3-mo follow-up	24.5 (12.3-36.6)	26.4 (13.9-39)	
Within-group change from after treatment to 3-mo follow-up	7.9 (−2.3 to 18.2)	10.687 (0.2-21.2)	
Active shoulder external rotation, °			
Baseline	10.1 ± 2.9	13.1 ± 2.9	
After treatment	23.4 ± 4.3	26.5 ± 4.3	−3.1 (−15.4 to 9.2)
Within-group change from baseline to after treatment	13.3 (4.8-21.9)	13.4 (4.8-21.9)	
3-mo follow-up	30.2 ± 4.8	32.6 ± 4.8	−2.4 (−16.1 to 11.4)
Within-group change from baseline to 3-mo follow-up	20.1 (10.3-29.9)	19.4 (9.6-29.3)	
Within-group change from after treatment to 3-mo follow-up	6.8 (−0.4 to 14)	6.1 (−1.2 to 13.3)	
Passive shoulder external rotation, °			
Baseline	16.8 ± 3.2	20.7 ± 3.3	
After treatment	37.6 ± 6.1	36.8 ± 6.3	0.8 (−17 to 18.6)
Within-group change from baseline to after treatment	20.9 (8-33.8)	16.1 (2.8-29.4)	
3-mo follow-up	42.1 ± 5.1	40.8 ± 5.3	1.3 (−13.6 to 16.3)
Within-group change from baseline to 3-mo follow-up	25.3 (14.1-36.5)	20.1 (8.5-31.6)	
Within-group change from after treatment to 3-mo follow-up	4.4 (−4.2 to 13)	3.9 (−4.9 to 12.8)	
SPADI score (0-100)			
Baseline	57.6 ± 4.4	61.2 ± 4.5	
After treatment	29.0 ± 5.3	33.8 ± 5.5	−4.8 (−20.4 to 10.7)
Within-group change from baseline to after treatment	−28.6 (−41.2 to −16)	−27.4 (−40.4 to −14.3)	
3-mo follow-up	22.1 ± 4.8	22.9 ± 4.9	−0.8 (−14.7 to 13.2)
Within-group change from baseline to 3-mo follow-up	−35.5 (−47.6 to −23.3)	−38.3 (−50.9 to −25.8)	
Within-group change from after treatment to 3-mo follow-up	−6.9 (−17.9 to 4.2)	−11.0 (−22.4 to 0.4)	
PSFS score[*]			
Baseline	38.6 ± 4	37.5 ± 4.2	
After treatment	31.2 ± 3.2	31.1 ± 3.3	0.1 (−9.3 to 9.5)

(*continued on next page*)

Table II   Results of each outcome for both groups and within- and between-group changes   (*continued*)

Outcome	Manual therapy	Manual therapy + CNS-focused approach	Between-group change score
Within-group change from baseline to after treatment	−7.4 (−9.5 to −5.1)	−6.1 (−8.8 to −4)	
3-mo follow-up	30.4 ± 2.6	33.3 ± 3	−2.9 (−11.4 to 5.5)
Within-group change from baseline to 3-mo follow-up	−8.2 (−13.5 to −2.9)	−11.1 (−9.6 to 1.3)	
Within-group change from after treatment to 3-mo follow-up	−0.8 (−9.8 to −5.1)	5.0 (−1.3 to 5.9)	
VAS score			
Baseline	41.6 ± 5.5	49.3 ± 5.6	
After treatment	23.1 ± 5	15.6 ± 5.2	7.4 (−7.3 to 22.1)
Within-group change from baseline to after treatment	−18.6 (−34.9 to −2.3)	−33.7 (−50.5 to −16.9)	
3-mo follow-up	13.1 ± 5.1	21.4 ± 5.2	−8.3 (−23.2 to 6.5)
Within-group change from baseline to 3-mo follow-up	−28.6 (−46 to −11.1)	−27.9 (−45.9 to −10)	
Within-group change from after treatment to 3-mo follow-up	−10.0 (−23.3 to 3.3)	5.7 (−8 to 19.5)	

CNS, central nervous system; *SPADI*, shoulder pain and disability index; *PSFS*, Patient-Specific Functional Scale; *VAS*, visual analog scale.
Data are presented as mean ± standard error or mean difference (95% confidence interval).
* The total score is calculated as the sum of the activities' scores divided by the number of activities (range, 0-10).
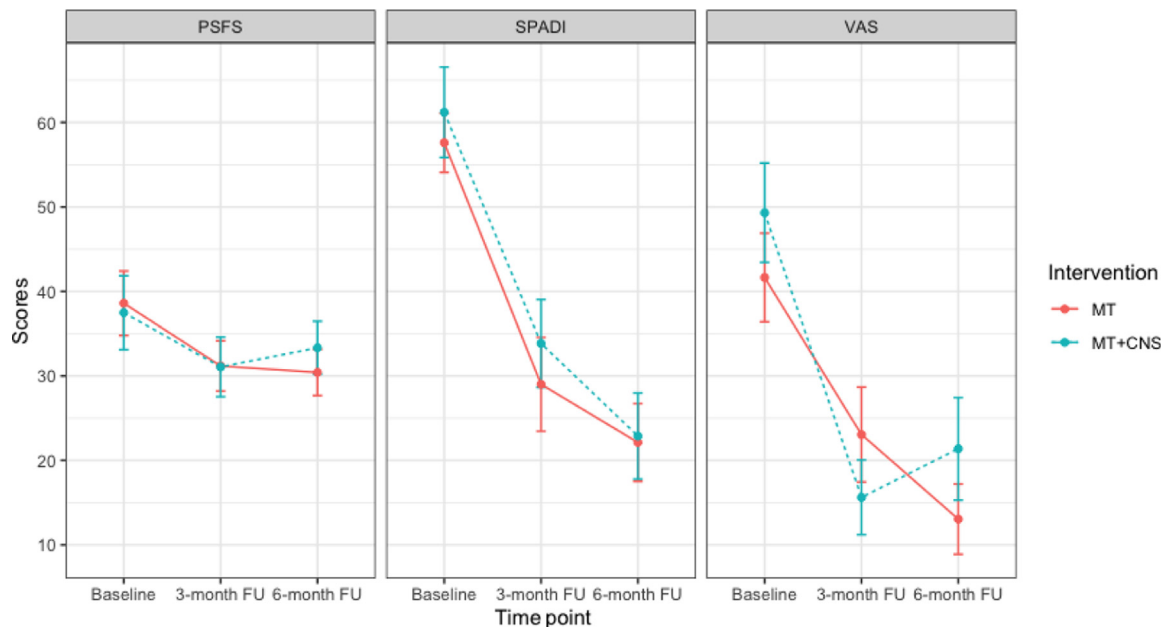

Figure 2   Between-group comparisons of Patient-Specific Functional Scale (PSFS), Shoulder Pain and Disability Index (SPADI), and visual analog scale (VAS) scores throughout study. *MT*, manual therapy and home stretching program; *MT+CNS*, manual therapy and home stretching program plus central nervous system–focused approach; *FU*, follow-up.

about the superiority of the 2 studied interventions over natural history. Second, as previously mentioned, no stratification of participants was performed at baseline in terms of pain mechanisms, so interventions were not individually tailored. Future studies could classify participants with FS at baseline in terms of predominant pain mechanisms[39,40] to establish more specific inclusion criteria before treatment.
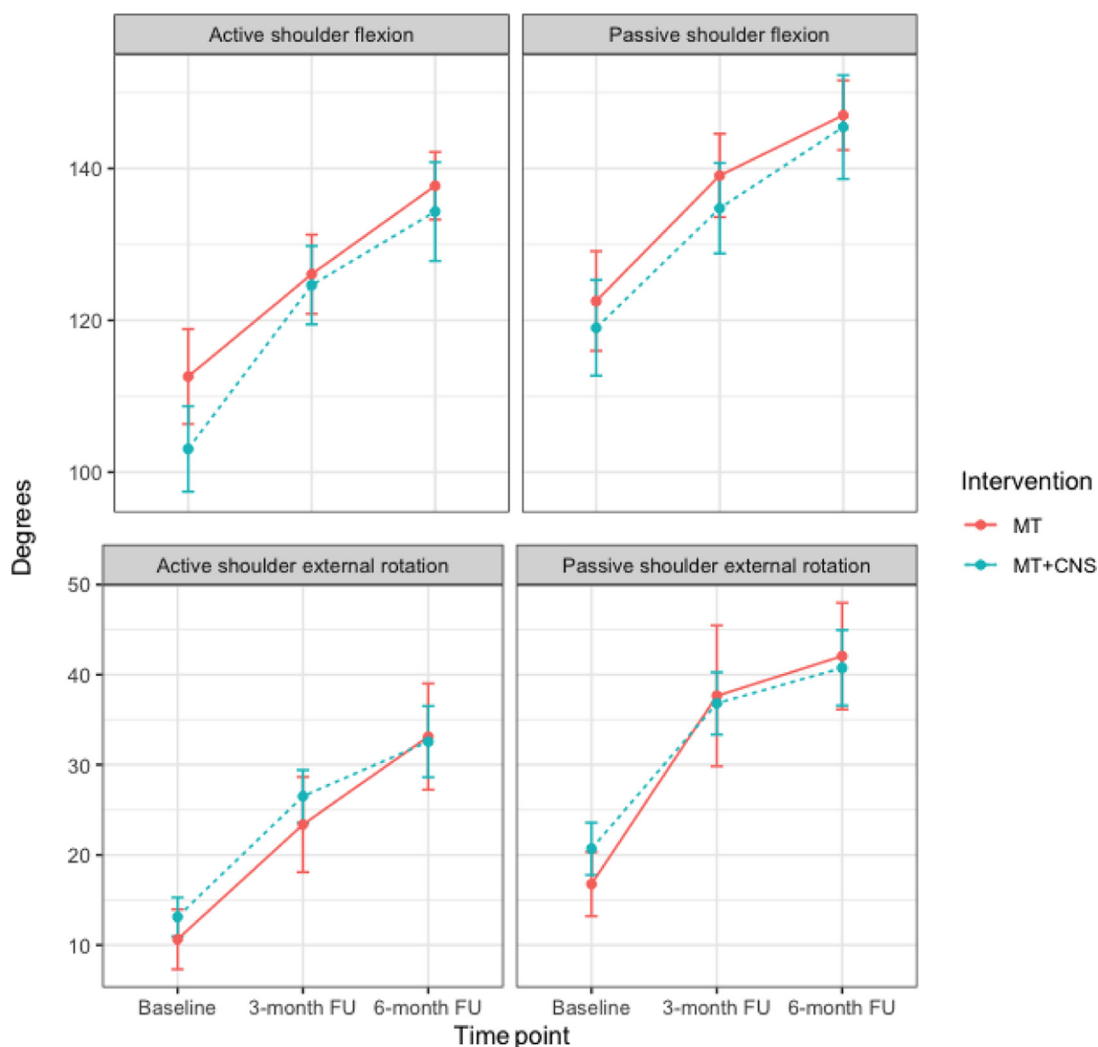
Figure 3 Between-group comparisons of shoulder range of motion throughout study. *MT*, manual therapy and home stretching program; *MT+CNS*, manual therapy and home stretching program plus central nervous system–focused approach; *FU*, follow-up.

Conclusion

A CNS-focused approach provided no additional benefit to a manual therapy and home stretching program in terms of shoulder pain and function in people with FS. Future studies should evaluate the effectiveness of CNS-focused interventions in people with FS with a predominant nociplastic pain mechanism to assess their potential benefits.

Acknowledgment

Disclaimers:

Supplementary data

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