Effective Interventions that Improve Symptoms and Functional Mobility in Adults with Rotator Cuff Injuries: A Systematic Review

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Abstract: This systematic review aimed to evaluate the effectiveness of interventions to improve symptoms and functional outcomes in adults with rotator cuff injuries. A comprehensive search was conducted. This systematic review contributes to the evidence by highlighting effective interventions and synthesizing literature.

Importance: Shoulder joint disorders are estimated to account for 16% of the prevalence of musculoskeletal disorders and can cause pain, decreased muscle strength, numbness, paresthesia, and fatigue (Lee et al., 2024). The lifetime prevalence of shoulder disorders may affect up to 70% of the worldwide population (Pai et al., 2021).

Objective: To identify, evaluate, and synthesize the current literature concerning rotator cuff rehabilitation to determine the efficacy of multiple functional rehabilitation methods.

Data Sources: A literature search occurred between May 6, 2024, and May 29, 2024. Follow up searches were conducted on June 20, 2024. Databases included EBSCO using Hawai'i Pacific University's online library databases. Search terms included: Rotator cuff OR rotator cuff injury AND Occupational Therapy AND noninvasive intervention AND functional mobility, as well as combinations of these terms.

Study Selection and Data Collection: This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Published studies on effective interventions that improve symptoms and functional mobility were included in the systematic review. Data from presentations, non-peer reviewed literature, and dissertations were excluded.

Findings: Six studies were included. Five were of Level I studies, and one was a Level II study according to the American Occupational Therapy Association's Levels of Evidence. The outcomes of these studies indicate evidence that shoulder pain rehabilitation exercise programs and physical agent modalities are effective and potentially beneficial for reducing pain and increasing range of motion in clients with rotator cuff injuries.

Conclusion and Relevance: Rotator cuff treatment interventions are effective, and they improve ROM and pain reduction for adults with rotator cuff injuries.

What this Systematic Review Adds: There are limited high quality studies that evaluate rotator cuff treatments that are effective in increasing ROM and decreasing pain. This systematic review provides a starting point for evaluating the efficacy of these treatments in OT practice. More research is needed to evaluate various treatments and their long-term effects regarding increasing ROM and decreasing pain.

Key Words: Adults, alternative therapy, functional outcomes, occupational therapy, range of motion, rehabilitation, rehabilitation intervention, rotator cuff, symptom management, treatment, ultrasound

Introduction

When considering how rotator cuff injuries develop, one should consider that the rotator cuff is comprised of four muscles which enable the shoulder to abduct, medially rotate, and laterally rotate. The four muscles that make up the rotator cuff include the subscapularis, supraspinatus, infraspinatus, and teres minor. According to May and Garmel (2013), 9.7% of rotator cuff injuries occurred in individuals 20 years and younger, while 62% of rotator cuff injuries occurred in patient's 80 years and older. This highlights the importance of occupational therapists providing patients with effective treatment methods and explaining the role that non-surgical management plays in one's therapy.

It should be noted that subacromial impingement syndrome is the most common disorder and consists of a lifetime prevalence rate of 67% (Varacallo et al., 2023). In addition, Varacallo et al. (2023) shared that prevalence rates increase to over 60% in older adults and rotator cuff injuries afflict individual populations in an age-dependent fashion. Occupational therapists are likely to see patients with rotator cuff injuries and it is important to know the evidence outlying the best practices in treatment methods.

According to Turkmen (2020), rotator cuff tears are prevalent among adults often stemming from tendon degeneration caused by repetitive activities, overloading or traumatic injuries. Effective interventions focused on improving functional outcomes and symptoms in adults with rotator cuff injuries are important due to the significant impact of these injuries on daily life and occupational activities (Pai et al., 2021). This is crucial in the realm of occupational therapy since such injuries result in pain and limited range of motion which can hinder a person's capacity to participate in daily and work-related activities effectively.

Method

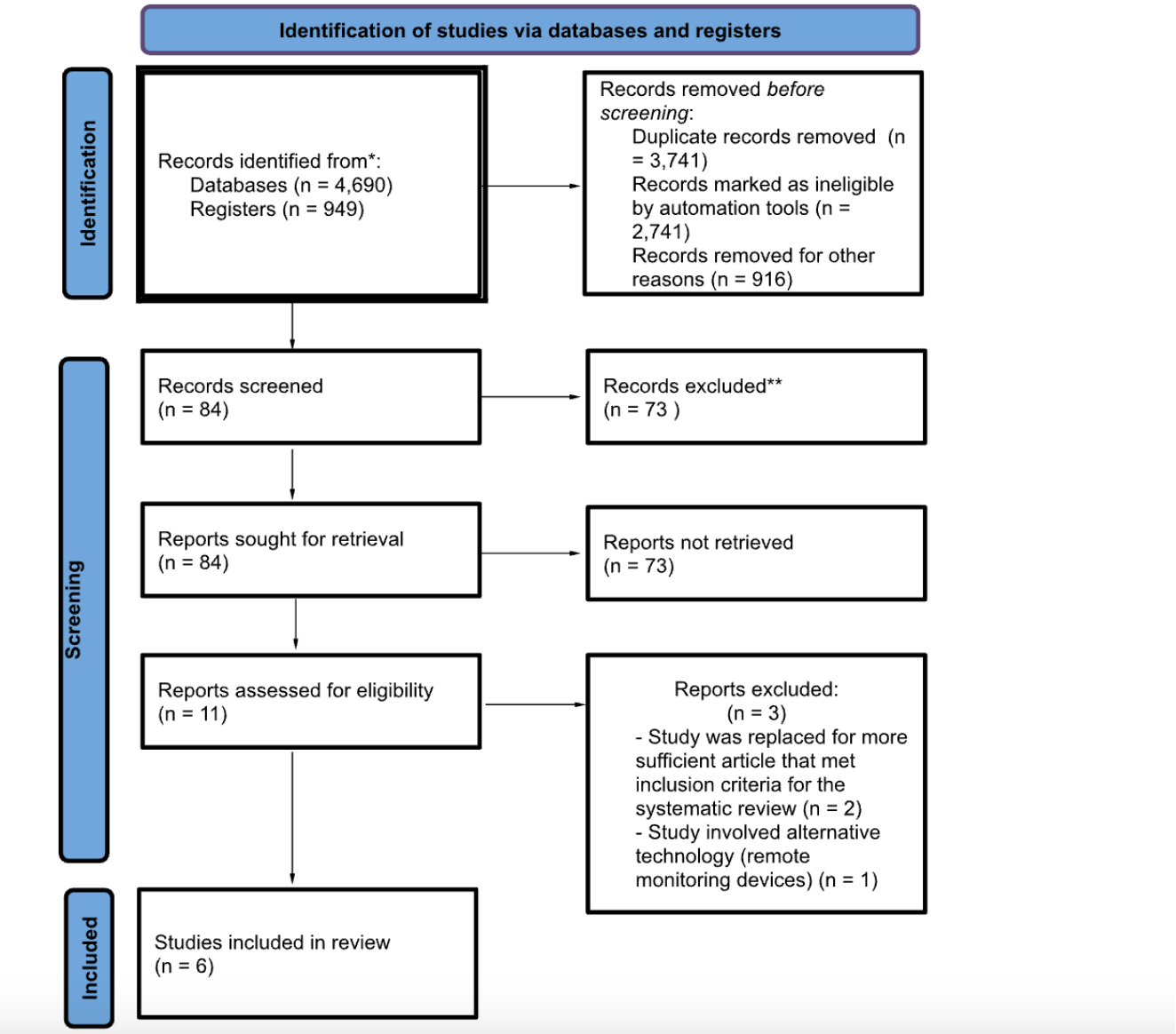
The systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and incorporated recommended processes for conducting a systematic review. The guiding research question for this systematic review was: What OT interventions are most effective to improve symptoms and functional outcomes in adults with rotator cuff injuries?

A broad search of the literature occurred between May 6, 2024, and May 29, 2024. An additional search was conducted June 20, 2024, to ensure all relevant research was included. The inclusion criteria for studies in this systematic review were as follows: peer-reviewed, published in English, and dated between 2019-2024. The exclusion criteria consisted of participants who were not adults, athletes, and outside of the United States. In addition to those studies that did not meet the inclusion criteria, excluded articles were systematic reviews, scoping reviews, dissertations, and presentations. A search for relevant literature was completed using the electronic database EBSCO through Hawai'i Pacific University's online library. Search terms included: Rotator cuff OR rotator cuff injury AND Occupational Therapy AND noninvasive

intervention AND functional mobility, as well as combinations of these terms. Appendix A provides an extensive list of all search terms used for this systematic review. The initial search included six articles related to the research topic (Figure 1). Four independent reviewers completed the screening and selection of the studies, assessed their quality, and extracted the data.

Figure 1

PRISMA Flow Diagram



Results

Six studies met the inclusion criteria. The articles were assessed according to their risk of bias, level of evidence, and quality. This systematic review included six studies that contained relevant information regarding interventions that increased range of motion and lowered pain levels after shoulder surgery. The information from these articles was divided into two themes: Pain Reduction and Increased Range of Motion. An evidence table is provided in Appendix B. The Cochrane risk-of-bias guidelines were used to assess each article and are provided in Appendix C.

Pain Reduction

Five of the six studies on the topic discussed the efficacy of the physical agent modalities and shoulder pain rehabilitation exercise programs, extracorporeal shock-wave therapy (ESWT), dry needling (DN), shoulder rehabilitation exercises, and conventional physiotherapy. Five of these studies were Level I studies, and one research article was a Level II study (see Appendix B). All studies provided evidence that physical agent modalities and shoulder pain rehabilitation exercise programs are effective and potentially beneficial for reducing pain in clients with rotator cuff injuries.

One Level 1 study and one Level 2 study conducted ESWT interventions for individuals with Chronic Rotator Cuff Tendonitis (CRCT) and Rotator Cuff Calcific Tendinitis (RCCT). According to Li et al. (2017), extracorporeal shock-wave therapy demonstrated greater efficacy for decreasing the intensity of shoulder pain for individuals with RCCT. Utilizing the Numeric Rating Scale (NRS) score and the Constant-Murley score (CMS) and Simple Shoulder Test (SST) score for measuring shoulder function, extracorporeal shock-wave therapy significantly decreased shoulder pain intensity at 4 weeks ($P < .05$) and 8 weeks ($P < .01$) post treatment.

According to Duymaz and Sindel (2019), while all parameters in both groups of the patients improved significantly, patients in the extracorporeal shock wave therapy (rESWT) group had an improvement that was statistically significant for range of motion ($p<0.001$), pain ($p<0.001$), and Disabilities of the Arm, Shoulder and Hand questionnaire (Quick Dash) scores ($p<0.001$). The Quick Dash scores of the patients regarding overall functional status was fully improved in the rESWT group.

According to Momenzadeh et al. (2021), dry needling is a newer intervention and has been shown to have a positive effect on the reduction of pain in people with chronic shoulder pain. Dry needling works by increasing the blood circulation and oxygen levels. Dry needling stimulates the central nervous system to release peripheral opioid analgesia and activates the dorsal tracts.

As stated by Lee et al. (2024), 11 shoulder rehabilitation exercise programs were designed using a wearable IMU sensor for patients diagnosed with shoulder diseases. A 92.5%

accuracy was found for effectively providing appropriate feedback, therefore deep learning in patient monitoring and rehabilitation has an important role in bringing innovative changes using IMU sensor data.

Pai et al. (2021) found that one single session of dry needling resulted in significant pain reduction. The study suggested a sustained persistent analgesic effect in the active dry needling group only during this period and not at other points in their nonintervention shoulder pain treatment.

Limitations of the Studies on Pain Reduction

Li et al. (2017) performed an experimental study on the effect of extracorporeal shock-wave therapy for treating patients with chronic rotator cuff tendonitis. Although this study had a positive effect when it came to ESWT having an encouraging effect on treating patients with CRCT it did have some limitations. One limitation was the results of the study being affected because of a small sample size. The second limitation consisted of the study only being conducted at a single center and having their participants only being one ethnicity, which was Chinese Han. Duymaz and Sindel (2019) conducted a study that compared radial extracorporeal shock wave therapy and traditional physiotherapy in the treatment of rotator cuff calcific tendinitis. Duymaz and Sindel (2019) identified several limitations. Duymaz and Sindel (2019) explained that patients in their study had been evaluated twice at the beginning and at the end of treatment, but they did not assess a long-term follow-up to see the success of the therapy. Another limitation being that the success of the treatment was only captured by functionality, range of motion, and assessment of shoulder pain not including the amount of calcification or imaging techniques. Post-needling soreness, a frequent event after dry needling, should be considered as a factor that may influence pain intensity and sensitivity (Momenzadeh, 2021). It is also recommended that a sham group be included in any future dry needling studies. The subject group in the study from Lee et al. (2024) was comprised only of patients with shoulder joint diseases with shoulder pain, therefore it limits the study by not gathering data for other shoulder conditions. There is a need for further research to categorize exercise programs more specifically for different shoulder diagnosis. Pai et al. (2021) noted some limitations including that the participants were only assessed in three face-to-face visits and that the researchers stopped their assessment on the seventh day after dry needling. Pai et al noted that they do not know the analgesic effect's exact time duration. The analgesic effects persisted for at least 7 days after the procedure, and this may impact the dosing in the next study.

Increasing Range of Motion

Three of the six studies discussed the efficacy of physical agent modalities and shoulder pain rehabilitation exercise programs on increasing range of motion for individuals with rotator cuff injuries. One of these studies was a Level I study and two were Level II studies. All studies provided evidence that the interventions were effective and potentially beneficial. As stated by

Turkmen et al. (2020), the study found improvement in active shoulder range of motion (ROM) values through a physiotherapist-supervised rehabilitation program. Video-based rehabilitation programs were found to be a beneficial treatment option as well.

Momenzadeh (2021) states that frozen shoulder is recognized as a capsular problem, the presence of myofascial trigger points (MTrPs) which are hyper-irritable points in the taut band of skeletal muscles that can cause local sensitivity and referred pain in the rotator cuff muscles, may induce or exacerbate low ROM, so it seems that releasing the muscles by using dry needling may have positive effects on improving muscle activity and increasing ROM.

Duymaz and Sindel (2019) found that shoulder ROM for patients in the radial extracorporeal shock wave therapy (rESWT) group had a statistically significant improvement ($p<0.001$). It is important to note that the evaluation parameters of pain intensity utilizing Visual Analog Scale, shoulder ROM, and QuickDASH scores improved greatly in both groups.

Limitations of the Studies on Increased Range of Motion

The study from Turkmen et al. (2020) did not reflect the long-term outcomes of the treatment therefore limited the study. Also, a larger sample size would be beneficial to confirm these results since there were only thirty-three patients and three of them dropped out. When considering limitations, Duymaz and Sindel (2019) shared that long term follow up assessing the overall success of the therapy was not performed. Furthermore, imaging techniques were not utilized to determine the success of the treatment and locating a certain amount of calcification. Functionality, range of motion, and shoulder pain were assessed in place of imaging techniques. Momenzadeh (2021) discussed that the limitations of this study were lack of follow-up and ignoring releasing possible MTrPs that could exist in other muscles in the shoulder region affecting the results of our study.

Discussion

The results of this systematic review suggest that pain reduction and increased range of motion is effective to improve symptoms and functional outcomes for rotator cuff injuries for adults. In the articles that reveal more of the pain management side of rotator cuff injuries, one can see that physical agent modalities and shoulder pain rehabilitation exercise regimens have been shown in all trials to be useful and perhaps helpful in relieving pain in patients with rotator cuff injuries. For ROM, there were improvement with these injuries from physiotherapist-supervised rehabilitation programs, dry needling, and radial extracorporeal shock wave therapy. With success in these areas, there were also limitations with each study. Limitations of these studies ranged from no follow-ups, diversity of participants, and small sampling size.

Strengths and Limitations

When considering strengths, this systematic review incorporated the PRISMA guidelines to identify the inclusion and exclusion criteria of the research articles and maintain organization throughout the research process. The team of researchers within this review met to determine a consensus for which articles to include, which led to overall rigor of the review process. Furthermore, an additional strength of the systematic review includes strong evidence (i.e., Level I and Level II studies) to support the findings from the research articles implying that multiple therapeutic modalities are deemed effective at improving range of motion and decreasing pain for individuals with a rotator cuff injury. Limitations in the results of the study conducted by Li et al. (2017) were the inclusion of a small sample size, the study only being conducted at a single center, and having their participants only being one ethnicity, which was Chinese Han. Duymaz and Sindel (2019) explained that they did not assess a long-term follow-up to see the success of the therapy. Another limitation is that the success of the treatment was only captured by functionality, ROM, and assessment of shoulder pain. Momenzadeh (2021) noted that post-needling soreness should be considered as a factor that may influence pain intensity and sensitivity, and they recommended that a sham group be included in any future dry needling studies. Pai et al. (2021) noted limitations including that participants were only assessed in three face-to-face visits and that the researchers stopped their assessment on the seventh day after needing therefore not assessing any long-term effects of treatment. The subject group in the study from Lee et al. (2024), was composed only of patients with shoulder joint diseases with shoulder pain, therefore it limits the study by not gathering data for other shoulder conditions.

Implications for Occupational Therapy Practice

An increase in range of motion and pain reduction shows positive effects when improving symptoms and functional outcomes for rotator cuff injuries. For pain reduction physical agent modalities and shoulder pain rehabilitation exercise programs may be beneficial and helpful when relieving pain for the effected side. For improvements with range of motion, it was found that physiotherapist-supervised rehabilitation programs, dry needling, and radial extracorporeal shock wave therapy are resourceful when trying to gain back functionality.

- Improvement of symptoms and functional outcomes for rotator cuff injuries through increased range of motion and pain reduction.
- Pain reduction has been shown to be effective through physical modalities and rehabilitation exercise regimens.
- Dry needling, extracorporeal shock wave therapy, and physiotherapist-supervised rehabilitation programs may improve functionality by increasing range of motion
- Positive effects were seen from the interventions, but limitations were present within each study

Conclusion

Studies included within this systematic review provide evidence of the effectiveness of rotator cuff interventions that improve range of motion and decrease pain. Additional research is necessary to identify the various treatments' long-term effectiveness. In the scope of occupational therapy, increasing ROM and reducing pain will lead to an increase in positive patient outcomes in ADL and IADL goals.

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Appendix A

Search Terms

Rotator cuff OR Rotator cuff injury AND Occupational Therapy AND Non invasive intervention AND Functional mobility

Appendix B

Evidence Table

Rotator Cuff OT Interventions					
Author/Year	Level of Evidence Study Design Risk of Bias	Participants Inclusion Criteria Study Setting	Intervention and Control Groups	Outcome Measures	Results
Duymaz and Sindel (2019)	Level 2B Comparative Study *Risk of Bias:* Moderate	80 participants with chronic Rotator Cuff Calcific Tendinitis (RCCT) (35 males, 45 females; mean age 53.3±9.6 years; range, 40 to 70 years) Inclusion Criteria: Minimum of 12 months of shoulder pain. In addition, diagnosis of calcification of the rotator cuff and age between 30 and 70 years Intervention setting: University	Intervention Group (n=40): treated with conventional physiotherapy and Radial Extracorporeal Shock Wave Therapy (rESWT). Physiotherapy program included transcutaneous electrical nerve stimulation, ultrasound, shoulder joint stretching and ROM exercises, and ice applications. Control group (n=40): Received conventional physiotherapy only All patients received treatment five days a week for four weeks, with a total of 20 treatments.	Outcome measure: Upper extremity functional assessment was performed with the QuickDASH to assess functional disability status Pain intensity with a Visual Analog Scale and shoulder ROM were evaluated before and after treatment	While it is important to note that all of the parameters of patients in both groups improved significantly, patients in the Radial Extracorporeal Shock Wave Therapy (rESWT) group had improvement that was statistically significant in ROM, pain, and Quick dash scores ($p<0.001$ across all 3 categories) No significant difference in age or BMI between the groups at $p>0.05$

Lee (2024)	Level 1B Risk of Bias: Moderate	Participants 58 patients (27 males, 31 females, age range 37-82) Inclusion Criteria Diagnosed with shoulder diseases (i.e adhesive capsulitis and rotator cuff disease) Intervention Setting Clinical setting	Intervention 1: 11 types of shoulder pain rehabilitation exercise programs were developed. Exercise was done 10x per session wearing an Inertial Measurement Unit (IMU sensor). The accelerometer and gyroscope of the IMU sensor were monitored in real-time. Intervention 2: The dataset was divided into training and testing sets. The training set was used to train the deep neural network model and the testing set was used for the final performance of the model.	Outcome measures: To assess pain and severity of shoulder pain and disability, The Shoulder Pain and Disability Index (SPADI) questionnaire was used.	Significant FIndings: 11 shoulder rehabilitation exercise programs done using one wearable IMU sensor can be distinguished with a 92.5% accuracy. The training accuracy was 0.975 and the test accuracy was 0.925. Nonsignificant Findings: None
Li et al. (2017)	Level 1B Randomized, double blind placebo control trial *Risk of bias:* Low	84 patients with chronic rotator cuff tendonitis (CRCT) Inclusion Criteria: diagnosis of CRCT without calcification, age between 18 and 65 years, history of clinical signs of	Intervention Group: Received extracorporeal shock-wave therapy (ESWT) for treating patients with chronic rotator cuff tendonitis (CRCT) Control group: Received placebo	Primary outcome: Measured by Numeric Rating Scale (NRS) Secondary outcome measurements: Constant–Murley score (CMS) and the simple shoulder test (SST) score were utilized.	Extracorporeal shock-wave therapy (ESWT) demonstrated greater efficacy in shoulder pain relief with regard to the Numeric Rating Scale (NRS) score and shoulder function as measured by the Constant–Murley

		chronic tendinitis for more than 6 months, no alternative therapy. Intervention Setting: Hospital setting			score (CMS) and simple shoulder test (SST) score at 4 weeks (P < .05) and 8 weeks (P < .01) after treatment. It is important to note that there were no adverse events that occurred in both groups.
Momenzadeh et al. (2021)	1B Randomized, single-blinded trial. Moderate p=40	Aged between 35 and 65 years VAS* at least 3 at subscapularis MTrPs* while they compressed (25). Conducted in a physiotherapy clinic related to the Tabriz University of Medical Sciences.	Control Group: participants in this group will receive conventional physiotherapy during 10 sessions on alternate days by an expert PT. Conventional physiotherapy consists of using continuous ultrasound, high frequency transcutaneous electrical nerve stimulation (TENS), and the use of hot packs simultaneously with the application of the electrical current. Intervention group Participants in this group will receive the exact treatment	The primary outcomes for this study are pain intensity and ROM, which would be felt in the shoulder region.	This study is the first study to determine if subscapularis DN* has positive effects and will help to determine its effects on clinical symptom improvement for people with a frozen shoulder. If deactivation of MTrPs in the subscapularis muscle via DN would have positive effects, it could be introduced as an adjunct treatment for these people.

			protocol of the control group, added 3 sessions of DN in the 3rd, 6th, and 9th sessions of the treatment		
Pai et al. (2021)	1B randomized, sham-controlled study Moderate N=20, sham=21	Participants n=20, sham= 21 Inclusion Criteria: Inclusion criteria included individuals aged 18 to 70 years, the presence of chronic unilateral shoulder pain or asymmetrical bilateral shoulder pain, with the most painful side presenting a score of at least 40/100 mm higher in the visual analog scale. Intervention Setting: Pain Center of the Hospital das Clinicas of the University of São Paulo, Brazil	Intervention: The active needling group (A) was composed of participants who underwent one session of standardized trigger point dry needling Control Group: the sham group (S) receiving a standardized sham session of dry needling,	Outcome Measures: (1) The VAS is a self-report pain scale, (2)The numerical rating scale that measures pain from 0 (no pain) to 10 (worst pain) (3) The *Douleur Neuropathique*-4 (DN4) questionnaire (4) The BPI (5) The short-form McGill Pain Questionnaire. (6) The Hospital Anxiety and Depression Scale.	Results: The group treated with active needling had significantly lower pain scores than the sham group at follow-up with an average pain intensity change from 6.30 ± 2.05 before the therapy to 2.40 ± 2.46 at the end of treatment (D14) in the active group and 6.04 ± 1.32 before the treatment to 5.14 ± 1.49 at the end of therapy (D14) in the sham group ($F(1,39) = 5.908$; $P = 0.02$; 95% CI, 1.25 to 3.55, Cohen's d effect size = 1.34.

Turkmen (2020)	Level 1B Risk of Bias: Moderate Prospective randomized controlled clinical trial	Participants N=33 (<40 yr older) Inclusion Criteria Diagnosed with partial rotator cuff tear in the supraspinatus muscle by an orthopedic surgeon specializing in shoulder pathologies Intervention Setting	2 Intervention Groups - Video based rehabilitation (VBR) group and physiotherapist-supervised rehabilitation (PSR) group for a common 6-week rehabilitation program	Active shoulder range of motion, functional status, and health-related quality of life of the patients assessed before/after treatment. Treatment satisfaction level was assessed at the end of treatment.	Significant Findings: Improvement in active shoulder ROM values Level of satisfaction from treatment in the PSR group was higher than in the VBR group Nonsignificant Findings: No statistically significant differences in terms of outcome measures between groups.

Note. DN: Dry Needling, VAS: Visual Analogue Scale, MTrPs: Myofascial Trigger Points, IMU: Inertial Measurement Unit, SPADI: The Shoulder Pain and Disability Index, VBR: Video Based Rehabilitation, PSR: Physiotherapist-Supervised Rehabilitation.

Appendix C

Risk-of-Bias Table

Risk-of-Bias Table: Randomized Controlled Trial (RCT) and Non-RCT										
	Selection Bias (Risk of bias arising from randomization process)			Performance Bias (effect of assignment to intervention)		Detection Bias		Attrition Bias	Reporting Bias	Overall risk-of-bias (low, moderate, high
Citation	Random Sequence Generation	Allocation Concealment (until participants enrolled and assigned)	Baseline difference between intervention groups (suggest problem with randomization?)	Blinding of Participants During the Trial	Blinding of Study Personnel During the Trial	Blinding of Outcome Assessment: Self-reported outcomes	Blinding of Outcome Assessment: Objective Outcomes	Incomplete Outcome Data (data for all or nearly all participants	Selective Reporting	
Li et al. (2017)	+	+	+	+	+	+	+	+	+	Low
Duymaz and Sindel (2019)	+	+	+	-	-	-	-	+	+	Moderate
Momenzadeh 2021	+	+	+	-	+	+	+	-	+	Moderate p=40
Turkmen (2020)	+	+	+	+	+	+	+	+	+	Low
Pai et al. 2021	+	-	+	+	-	+	+	+	-	low N=20 SHAM=21

Note. Categories for risk of bias are as follows: Low risk of bias (+), unclear risk of bias (?), high risk of bias (–). Scoring for overall risk of bias assessment is as follows: 0–3 minuses, low risk of bias (L); 4–6 minuses, moderate risk of bias (M); 7–9 minuses, high risk of bias (H).
Citation. Table format adapted from Higgins, J. P. T., Sterne, J. A. C., Savović, J., Page, M. J., Hróbjartsson, A., Boutron, I., . . . Eldridge, S. (2016). A revised tool for assessing risk of bias in randomized trials. Cochrane Database of Systematic Reviews 2016, Issue 10 (Suppl. 1), 29–31. https://doi.org//10.1002/14651858.CD201601

Risk-of-Bias Table 2

Risk of Bias for Before-After (Pre-Post) Studies with No Control Group												
Citation	Study question or objective clear	Eligibility or selection criteria clearly described	Participants representative of real-world patients	All eligible participants enrolled	Sample size appropriate for confidence in findings	Intervention clearly described and delivered consistently	Outcome measures pre-specified, defined, valid/reliable, and assessed consistently	Assessors blinded to participant exposure to intervention	Loss to follow-up after baseline 20% or less	Statistical methods examine changes in outcome measures from before to after intervention	Outcome measures were collected multiple times before and after intervention	Overall risk of bias assessment (low, moderate, high risk)
Lee (2024)	Y	Y	Y	Y	Y	Y	Y	Y	NR	Y	Y	Low

Note. Y = yes; N = no; NR = not reported. Scoring for overall risk of bias assessment is as follows: 0–3 N, Low risk of bias (L); 4–8 N, Moderate risk of bias (M); 9–11 N, High risk of bias (H).

Citation. Table format adapted from National Heart Lung and Blood Institute. (2014). Quality assessment tool for before–after (pre–post) studies with no control group. Retrieved from https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools