



The efficacy and fidelity of clinical interventions used to reduce posterior shoulder tightness: a systematic review with meta-analysis



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Background: Posterior shoulder tightness (PST) has been implicated in the etiology of numerous shoulder disorders and is a source of stiffness in both postoperative and nonsurgical cohorts. Identifying efficacious interventions to address PST has the potential to impact patient outcomes in both operative and nonoperative cohorts. Our purpose was to analyze the efficacy of nonoperative clinician-assisted interventions used to mitigate PST.

Methods: We performed a systematic review and meta-analysis. Relevant studies were assessed for inclusion, and selected studies were identified from the PubMed, Embase, Cochrane, and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases by a biomedical librarian. Data extracted from the selected studies underwent quality appraisal using Grading of Recommendations, Assessment, Development, and Evaluation analysis; fidelity assessment; and meta-analysis.

Results: The search identified 374 studies, with 13 ultimately retained. Grading of Recommendations, Assessment, Development, and Evaluation analysis revealed areas of concern regarding consistency and imprecision of reporting within the included studies overall. Treatment fidelity assessment showed that only 3 of the 13 studies received a rating of good to excellent, indicating a high risk of bias. When clinician-assisted interventions were compared with no treatment, meta-analysis showed a moderate effect size in favor of clinician-assisted interventions for improving range of motion. When a multimodal treatment approach for PST was compared with active comparator interventions, a small effect size was present for improving range of motion in favor of the multimodal approach.

Conclusion: The efficacy of clinician-assisted interventions for reducing PST was identified when using both a single treatment and multimodal treatments. Current evidence focuses mostly on populations with PST who were not seeking care and the immediate- to short-term effects of clinician-assisted interventions, which may limit generalization of findings.

This systematic review was exempt from Institutional Review Board approval.

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Shoulder pain affects up to 67% of the adult population at some point throughout the life span.^{18,19} The etiology of shoulder pain is multifactorial and inclusive of numerous impairments, including but not limited to the biomechanical consequences of restricted mobility.¹⁰ Posterior shoulder tightness (PST), in particular, has been associated with more common diagnoses such as labral tears, subacromial pain syndrome, and postoperative arthrofibrosis within both the general and athletic populations, with a predilection for the overhead athlete.^{6,13,21,25,26,28,29,32,33} PST has been defined as an extensibility limitation of the posterior soft tissue of the shoulder, including both contractile and noncontractile elements as well as osseous changes as seen in the form of humeral torsion within the overhead athlete through training adaptations.¹² Moreover, PST has been associated with restricted internal rotation (IR), horizontal adduction (HA), and flexion range of motion (ROM). From a biomechanical perspective, evidence suggests that PST may influence obligate translation and increased glenohumeral contact pressures, which are sources of subacromial and internal impingement, respectively.^{10,21,25,35} Owing to the well-documented association of PST and shoulder pain,²² sports medicine professionals and general orthopedic clinicians alike often seek to reduce PST as an element of their interventions.

Numerous techniques have been described and investigated within the literature that are intended to address PST. Interventions used to address PST can be grouped into either the category of self-stretching interventions or the category of clinician-assisted interventions. Both categories of interventions have been investigated extensively, with most participants in these studies being asymptomatic. Mine et al²² performed a systematic review of the literature surrounding the effectiveness of self-stretching interventions, which included mainly the cross-body and sleeper stretches, on glenohumeral joint IR and HA. Despite the large number of studies that have investigated clinician-assisted interventions to address PST, no synthesis of the literature has been performed to determine the efficacy of these interventions. Given the potential association between PST and various shoulder pathologies, it is necessary to determine the efficacy of clinician-assisted interventions as they are commonly administered in individuals with PST. Thus, the purpose of this study was to perform a systematic review and meta-analysis of the current literature that has investigated the efficacy of clinician-assisted interventions used to address PST.

Materials and methods

Guidelines

This systematic review used the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines during the search and reporting phase of the research process. The PRISMA statement includes a 27-item checklist designed to improve reporting of systematic reviews and meta-analyses.²³

Literature search

An online literature search was conducted using the PubMed, Embase, Cochrane, and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases from the dates of their origin until July 2017. Another search was performed in July 2018 to determine whether any other articles had been published since the initial search prior to the final meta-analysis. The search strategy was created and performed by a biomedical librarian. An example of the search strategy used for the PubMed database is shown in [Supplement 1](#), and similar strategies were used for the remaining databases. This study was registered using the international prospective register of systematic reviews PROSPERO in March 2016 with the corresponding reference number CRD42016036286.

Study selection

All titles were independently appraised during the initial online literature search of studies by 2 authors (P.A.S. and M.J.K.) who are researchers with a clinical background in musculoskeletal orthopedics. The abstracts of these titles were read to determine whether the studies met the inclusion criteria. Studies with abstracts that met the inclusion criteria were then read in their full-text format to determine eligibility. Two authors undertook the study selection process for this review with discrepancies being decided by a third author if necessary (no discrepancies were present that needed to be brought to a third author). The inclusion criteria for studies included in this review consisted of the following: (1) studies including subjects identified as having PST; (2) human participants of any age; (3) any study design, including case studies; (4) clinician-assisted interventions (stretching, manipulation, and so on) clearly described in detail including frequency, intensity, and application directly to the glenohumeral joint; (5) clinician-assisted interventions performed in isolation or within a multimodal treatment approach; and (6) studies using within- or between-group outcome measures (pain, function, disability, recovery measure, or physical measure). There was no restriction on date published. Studies were excluded if they included a mixed patient population or were not published in the English language as we would be unable to interpret the findings. On initial screening, the inclusion criterion regarding the clinical

interventions being described in detail including frequency, intensity, and application directly to the glenohumeral joint was modified given that very few studies provided this level of detail.

Data extraction

Data and results from the studies selected for this review were extracted using a standardized Population, Intervention (Treatment), Comparison, Outcome, and Setting (PICOS) format. PICOS includes the characteristics of the population studied, treatments performed, comparative treatments, primary and secondary outcomes, and setting in which the data were collected. Data were extracted, reviewed, and analyzed by 2 authors (P.A.S. and M.J.K.). A single author (P.A.S.) extracted the data, and this was verified by a second author (M.J.K.). Discrepancies in data collection were resolved through discussion.

Grading of Recommendations, Assessment, Development, and Evaluation analysis

The approach for systematic reviews is based on recommendations of the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) Working Group. This approach uses a systematic method and offers judgments of the total body of evidence that investigates a specific health care question through the determination of the confidence the reviewers have in the effect estimates.⁵ The GRADE approach allows for judgments made by the reviewers, with the understanding that the quality of evidence cannot always be determined objectively. The method calls for transparency from the reviewers to explain why decisions were made. This explicit approach allows for a better understanding of the authors' viewpoints, ensures transparency, and promotes further scholarly dialogue regarding the health care question.^{1,5,9} The strength of this approach is that the results of a review will not eliminate disagreements surrounding a health care question but will allow them to be transparent. As such, this approach is the recommended method for high-quality reviews, such as those found in the Cochrane Library.

Each health care question may be answered by identifying a variety of outcomes used in the literature. The importance of these outcomes is rated initially by the investigative team performing the review or by a panel of experts identified by the authors when formulating the health care question. The outcomes identified are rated according to their importance. The GRADE approach uses a specific framework to evaluate the entire body of evidence for each individual outcome by looking critically at the risk of bias, inconsistency, indirectness, and imprecision. This is in contrast with other review methods that examine the quality of individual articles investigating a topic.¹

Treatment fidelity assessment

Treatment fidelity assessments were performed to determine whether the retained studies followed appropriate measures to ensure that valid comparisons of replicable interventions were being carried out. Treatment fidelity was assessed through a modified version of a tool developed by Borrelli et al.⁴ They originally created a scale that was applicable to psychological interventions, using domains that are outside the scope of clinical interventions. The tool was modified to identify the 11 items that

best represented the core items germane to a study investigating clinical interventions. This modified scale has not been previously validated but has been used in similar reviews to examine treatment fidelity.^{8,27} Items were scored as 0 (not present), 1 (minimally described), or 2 (more than minimally described). In addition, owing to the study designs of included articles, some elements were scored as not applicable (Table 1). Scores were recorded as both the count (number present; maximum possible, 11) and total score (maximum possible, 22) and were determined by 2 authors, 1 of whom was not included in the abstract screening (P.A.S. and W.H.), who are researchers with a clinical background in musculoskeletal orthopedics and are experienced in fidelity scoring. Discrepancies between the 2 authors for which agreement could not be reached through discussion were mediated by a third author (no discrepancies required a third author's intervention). We identified item scores greater than 6 and total scores greater than 12 as indicating studies that exhibited good or excellent treatment fidelity and as threshold values that were similar to clinical practice and less likely to falsely represent the actual effect of the treatment provided.

Data synthesis and analysis

Studies were grouped based on the following treatment categories: (1) a single clinician-assisted intervention vs. no treatment and (2) multimodal clinician-assisted interventions vs. active comparators. When reported, the mean and standard deviation in the ROM outcome measure before the intervention and after the intervention, as well as the sample size for each group, were recorded. Effect sizes based on standardized mean differences (SMDs) were calculated for each comparison. The standard deviation of the difference scores was computed from the standard deviation of the pre-post scores, when not provided, using a correlation of 0.50.³ Random-effects meta-analyses were performed for each subset of studies to examine an outcome variable when reported by 2 or more studies. A pooled random-effects estimate of the overall effect size was determined for all studies with acceptable clinical homogeneity. For an increase in ROM, a positive effect size favors the clinician-assisted intervention treatment group (ie, a single clinician-assisted intervention or multimodal clinician-assisted interventions) over the comparison group (ie, no treatment or active comparators). The magnitude of effect size was interpreted as follows: 0.8 or greater, large effect; 0.50-0.79, moderate effect; and 0.49 or lower, weak effect. Heterogeneity was assessed using the Q statistic after the meta-analysis.^{3,11} The Q statistic follows a χ^2 distribution with $n - 1$ *df*. A small P value ($P < .05$) for the Q statistic indicates that heterogeneity is present and the meta-analysis model has some unaccounted-for bias. All meta-analyses were conducted using Stata statistical software (version 12.1; StataCorp, College Station, TX, USA) and the "metan" command. All data analysis was performed by 1 author (X.L.), an academician with a specialty in biostatistics and health informatics.

Results

Search results

The search of the databases yielded 374 independent study titles, resulting in 358 studies once duplicates were

Table I Fidelity scoring

Authors	Item 1*	Item 2†	Item 3‡	Item 4§	Item 5	Item 6¶	Item 7#	Item 8**	Item 9††	Item 10‡‡	Item 13§§	Summary	Total score
Bailey et al, ² 2017	1	1	1	1	1	2	2	0	0	0	0	7	9
John and Chachra, ¹⁵ 2010	1	1	2	1	1	1	2	0	0	0	0	7	9
Laudner et al, ¹⁷ 2008	1	1	NA	NA	1	1	2	0	0	0	0	5	6
Laudner et al, ¹⁶ 2014	1	1	NA	NA	1	2	2	1	0	0	0	6	8
Manske et al, ²⁰ 2010	1	1	2	1	1	2	2	1	0	0	0	8	11
Moore et al, ²⁴ 2011	2	2	2	2	2	1	2	0	0	0	1	8	14
Salamh et al, ²⁸ 2015	2	2	2	1	1	2	2	1	0	0	0	8	13
Sauers et al, ³⁰ 2007	2	NA	2	NA	2	1	2	0	0	0	0	5	9
Sharma et al, ³¹ 2010	1	1	2	1	1	1	2	0	0	0	0	7	9
Tyler et al, ³² 2010	1	NA	1	NA	1	1	2	0	0	0	0	5	6
Umehara et al, ³⁴ 2017	2	2	1	2	2	2	2	1	0	0	0	8	14
Yang et al, ³⁷ 2012	2	2	NA	1	1	2	2	0	0	0	0	6	10
Yu et al, ³⁸ 2015	1	NA	NA	NA	1	1	2	0	0	0	0	4	5

NA, not applicable.

Items were scored as follows: 0, not present; 1, minimally described; or 2, more than minimally described.

* Item 1: Was information about the treatment dose in the intervention condition provided?

† Item 2: Was information about the treatment dose in the control or comparison condition provided?

‡ Item 3: If more than 1 intervention was described, were they all described equally well?

§ Item 4: Were methods used to ensure the dose was equivalent between conditions?

|| Item 5: Were methods used to ensure the dose was equivalent within a condition?

¶ Item 6: Were characteristics to be sought and avoided by the treatment provider addressed a priori, and was some mention made of credentials?

Item 7: Was there a mention of a theoretical model or clinical guidelines on which the intervention was based?

** Item 8: Did the authors indicate how providers were trained? Did the authors indicate that provider training was standardized?

†† Item 9: Was there a method to ensure that the content of the intervention was being delivered as specified?

‡‡ Item 10: Was there a method to ensure that the dose of the intervention was being delivered as specified?

§§ Item 13: Were nonspecific treatment effects evaluated?

removed. After title and abstract screening, 345 studies were removed for the following reasons: objective measures other than those related to PST, patient-performed interventions only, and not published in the English language. After review of the full-text studies, 13 were ultimately included in the analysis (Supplement 2).^{2,15-17,20,24,28,30-32,34,37,38} Study characteristics for each of the 13 included studies are included in the PICOS table (Supplement 3).

GRADE analysis

Selection of outcomes was based on a survey of clinicians and researchers who are orthopedically trained clinicians

and have published research related to rehabilitation management of orthopedic conditions. The outcomes rated as most critical included improvements in glenohumeral joint IR and improvements in glenohumeral joint HA. The group members surveyed expressed their reasons for these ratings as being based on the understanding that the intent of clinician-assisted techniques is to produce a mechanical change in tissues resulting in improved mobility of the joint. PST is associated with reduced glenohumeral joint IR, total ROM, and HA ROM. Thus, it was intuitive to select these outcomes as measures of effectiveness when evaluating the evidence of techniques designed to reduce PST. This process is aligned with recommendations for the GRADE analysis.⁵

Listed as important—but not critical for making a clinical decision—is the outcome of improved functional status. The choice to rate this outcome in this manner was based on the understanding that changes in functional status are based on many factors external to joint mobility improvements such as strength, cognitive-behavioral constructs, medical comorbidities, function of neighboring body regions, and pain. Only 1 study included a functional outcome measure, the Simple Shoulder Score.³² This is due to the fact that all of the studies, except that of Tyler et al,³² consented subjects without shoulder injury for study participation. Therefore, functional outcome measures were not included in the review but are identified as an area that requires further exploration, particularly as participants in all studies had documented PST.

The rating of evidence is based on the GRADE criteria for systematic reviews, which rates evidence associated with each individual outcome rather than the individual studies included in the review. As such, evidence examining the use of clinician-assisted interventions to address PST using the outcomes of IR and HA is discussed herein.

Of the 13 studies included in the systematic review, 12 used IR as an outcome measure.^{2,15-17,20,24,28,30-32,37,38} Of these 12 studies, 9 also included HA as a measurement of PST after the intervention.^{2,15-17,24,28,30-32} Limitations in study design were noted across these studies. Ten studies were randomized controlled trials (RCTs),^{2,15-17,20,24,28,30,31,37} and two did not reveal subject group allocation processes and blinding.^{15,17} One study revealed allocation methods but did not reveal blinding.³¹ In another study, the clinician who provided the intervention and assisted in performing the measurements was blinded to the measurement values but not to the experimental groups.²⁸ It is unclear how these processes may have affected the results. No issues were identified with incomplete accounting of patients or outcomes or with selective outcome reporting (Table II).

Two studies were non-RCTs and included 1 case series and 1 observational study.^{32,38} The risk-of-bias assessment for these studies were judged using different criteria from the RCTs, which included evaluating control populations, measurement methods, controlling for confounding and discrepancies in follow-up measures between groups, and follow-up procedures. The multimodal nature of the interventions performed in the study of Tyler et al³² makes it difficult to define whether the clinician-applied interventions resulted in the changes observed in IR ROM improvements or whether those improvements were a result of the multimodal intervention approach incorporating both clinician-applied interventions and therapeutic exercise interventions performed by the subjects. Tyler et al did not control for this in their study, as it was their intent to describe outcomes associated with a multimodal treatment approach. The study performed by Yu et al³⁸ did not offer a

control group, possessed a small sample size, and measured IR only immediately after the intervention, with no longer-term follow-up.

For these reasons, we rated the risk of bias across studies for both the IR and HA outcomes as unclear (Supplement 4). Some plausible bias exists that raises doubt about the results; however, potential limitations are unlikely to lower the confidence in the estimate of the effect.

The large Q value calculated from the meta-analysis data suggests heterogeneity within the studies causing appreciable differences in outcomes and leading us to downgrade the evidence for issues with inconsistency. These differences may be found in the varying intervention methods between studies. Although only studies using clinician-assisted techniques as interventions were included in this review, the methods used within those techniques varied greatly and included massage, joint capsule mobilization, and passive stretching performed by the clinician. There were also differences in outcome measurement times across studies. Of the 12 studies that evaluated IR,^{2,15-17,20,24,28,30-32,37,38} 8 used an immediate measurement method after a single intervention.^{2,16,17,24,28,30,37,38} Two studies used interventions lasting for 4 weeks^{20,31} and one for 3 weeks.¹⁵ The case series applied the interventions over a 7-week period and included a 2-week follow-up after the last intervention was provided.³² For these reasons, inconsistency was rated down 1 level. The choice to not rate down further for inconsistency was based on the understanding that various types of clinician-applied techniques used to improve joint mobility do so through a similar mechanism despite a variance in method. In addition, the studies with longer treatment application times provided substantially larger improvements in the degrees of motion gained over the studies that used an immediate post-intervention measure. This difference can be explained in the intervention dosing, where more of the applied techniques resulted in greater gains of mobility, which likely contributed to some variation in the point estimates of the studies vs. chance. Owing to the same factors contributing to the evaluation of indirectness, we chose not to rate down in this area to avoid a duplication of the factors involved in downgrading inconsistency.

For imprecision, when each individual outcome measure within the studies included in the meta-analysis is evaluated, imprecision should be downgraded as the optimal information size criteria are not met. When we consider all of the subjects together in the interventions used in the meta-analysis, a single clinician-applied intervention vs. no treatment and multimodal interventions vs. active comparator(s), the sample sizes are both great enough where imprecision is not an issue. Thus, in the summary of findings in Table II, imprecision for each individual variable is downgraded. Moreover, when we consider just the outcomes of IR and HA alone, independent of the presence of

Table II GRADE scoring

Certainty assessment							No. of patients		Effect		Certainty	Importance
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Clinician assisted	No intervention	Relative (95% CI)	Absolute (95% CI)		
Increased glenohumeral joint internal rotation with clinician-assisted technique vs. no intervention (assessed with goniometer or inclinometer; scale from 0 to 26)												
5*	Randomized trials	Not serious	Serious†	Not serious	Serious‡	None	150	124	—	SMD 0.63 higher (0.22 higher to 1.04 higher)	□□○○: low	Critical
Increased glenohumeral joint horizontal adduction with clinician-assisted technique vs. no intervention (assessed with inclinometer)												
3*	Randomized trials	Not serious	Serious†	Not serious	Serious‡	None	91	71	—	SMD 0.97 higher (0.27 higher to 1.67 higher)	□□○○: low	Critical
Increased glenohumeral joint internal rotation with clinician-assisted technique vs. active comparator (assessed with goniometer or inclinometer)												
3*	Randomized trials	Not serious	Serious†	Not serious	Serious‡	None	79	80	—	SMD 0.39 SD higher (0.01 lower to 0.79 higher)	□□○○: low	Critical
Increased glenohumeral joint horizontal adduction with clinician-assisted technique vs. active comparator (assessed with inclinometer)												
2*	Randomized trials	Not serious	Serious†	Not serious	Serious‡	None	60	60	—	SMD 1.02 SD higher (0.37 higher to 1.67 higher)	□□○○: low	Critical
Increased glenohumeral joint rotation												
12	Randomized trials	Not serious	Serious†	Not serious	Not serious	None					□□□○: moderate	
Increased horizontal adduction												
9	Randomized trials	Not serious	Serious†	Not serious	Not serious	None					□□□○: moderate	

GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; CI, confidence interval; SMD, standardized mean difference; SD, standard deviation.

* Number of studies in this category included in meta-analysis.

† The *Q* value with *P* < .05 suggests heterogeneity within the meta-analysis with some unaccounted-for bias. The heterogeneity may be a result of different measurement methods used (use of horizontal adduction, internal rotation, or both) to identify posterior shoulder tightness as it relates to range of motion. Both current clinically accepted and applied methods were used. Thus, the choice to downgrade only 1 level in this category was made. A large variance in intervention methods was found across studies; some variance in time to outcome measurement was found across studies. Although there exists a large variance in interventions across studies, we only graded indirectness as serious because different manual therapy interventions show similar outcomes and physiological responses despite a variation of mechanical parameters between interventions.^{7,14,36} Despite this evidence, a downgrade was made because these studies used different clinician-assisted interventions and applications on the spine.

‡ Optimal information size (OIS) not met.

a comparator, the optimal information size criteria are met. The results of the 95% confidence intervals (CIs) for HA and IR exclude no effect.

Treatment fidelity assessment

Assessment of treatment fidelity produced a wide range of values (Table I). With a maximum of 11 items and 22 total points, the average number of items identified was 6.5 ± 1.4 (median, 7; range, 4-8) and the average total score was 9.5 ± 2.9 (median, 9; range, 5-14). No single study had all items represented; items 1 (Was information about the treatment dose in the treatment condition provided?), 5 (Were methods used to ensure the dose was equivalent within a condition?), 6 (Were characteristics to be sought and avoided by the treatment provider addressed a priori, and was some mention made of credentials?), and 7 (Was a description of the theory underlying treatment provided?) were each identified in all studies. Although no validated cutoff exists for this tool, by use of our criteria, 3 studies had item scores of 6 or greater and total scores of 12 or greater^{24,28,34}; these studies were independently identified as good or excellent and therefore as having a low risk of bias related to treatment fidelity.

Meta-analysis

Of the 13 studies included in the systematic review, 8 provided sufficient data to be included and pooled in the meta-analysis.^{2,16,17,20,24,28,30,37} Five studies were included to compare a single clinician-assisted intervention vs. no treatment in the assessment of ROM,^{16,17,24,30,37} with 2 studies for glenohumeral joint external rotation,^{17,30} 5 studies for IR,^{16,17,24,30,37} and 3 studies for HA.^{16,17,24} The meta-analysis for comparing a single clinician-assisted intervention with no treatment resulted in a moderate effect size (SMD, 0.67; 95% CI, 0.37-0.96) in favor of the clinician-assisted intervention. The homogeneity statistic (Q) was 34.71 ($df = 11$, $P < .001$), indicating that significant heterogeneity was present among the included studies and the variability in the SMD values was greater than that expected by a sampling error alone (Fig. 1, A).

Three studies were included in the comparison of multimodal clinician-assisted interventions and a comparator treatment,^{2,20,28} with 2 studies for glenohumeral joint external rotation,^{2,20} 3 studies for IR,^{2,20,28} 2 studies for total ROM,^{2,20} and 2 studies for HA.^{2,28} The summary SMD indicated a small effect size (SMD, 0.44; 95% CI, 0.16-0.72) in the assessment of ROM in favor of multimodal clinician-assisted interventions. The homogeneity statistic (Q) was 18.63 ($df = 8$, $P = .017$), indicating that significant heterogeneity was present among the included studies and the variability in the SMD values was greater than that expected by a sampling error alone (Fig. 1, B).

Discussion

The purpose of this study was to investigate the efficacy of clinician-assisted techniques used to reduce PST. We sought to evaluate the current literature by investigating the quality and fidelity of each study as well as available components through meta-analysis. A combined-assessment approach allowed for a more critical and comprehensive appraisal of each study selected.

The results of the GRADE analysis revealed a few areas of concern regarding the studies included in this investigation. The 2 most notable areas of concern are inconsistency and imprecision. Regarding inconsistency, a wide range of clinician-assisted techniques were described among studies including massage, mobilization, instrument-assisted soft-tissue techniques, and various stretches performed by the clinician. Although some of these inconsistencies may have been avoided by narrowing the overall inclusion criteria within our search strategy, we believed that synthesizing all clinician-assisted interventions would be a more comprehensive approach and in line with current clinical practice. Beyond the variation in techniques used, there were also inconsistencies regarding when the outcome measures were performed and how long the interventions were performed. The timing of outcome measures for the included studies ranged from immediately after the intervention to a 2-week period after the last intervention. Finally, regarding inconsistency, there was great variability in the duration the treatment was applied, leading to greater changes in overall outcome measures among those studies with a greater overall treatment duration. Regarding imprecision, the concerns are most notably seen when considering each individual outcome measure within the included studies as they do not meet the optimal information size criteria. This becomes less of a concern when considering all studies investigating IR and all studies investigating HA as the collective sample sizes are larger and meet the optimal information size criteria for each outcome measure.

The assessment of treatment fidelity revealed further evidence to support the presence of inconsistencies among the included studies regarding the application of clinician-assisted interventions. Despite the arbitrary nature of the developed threshold for both the number of items identified and the overall scoring, we were surprised that only 3 of the studies were identified as good or excellent, which is associated with a low risk of bias.^{24,28,34} Of further concern is the lack of methodology among all studies to ensure that the intervention was both being performed as specified and being delivered at the appropriate dose. In addition, we found that no studies appropriately evaluated nonspecific treatment effects in their investigations.

The results of the meta-analysis were as expected. When a single clinician-assisted intervention was compared with no treatment, there was a moderate effect size of improving

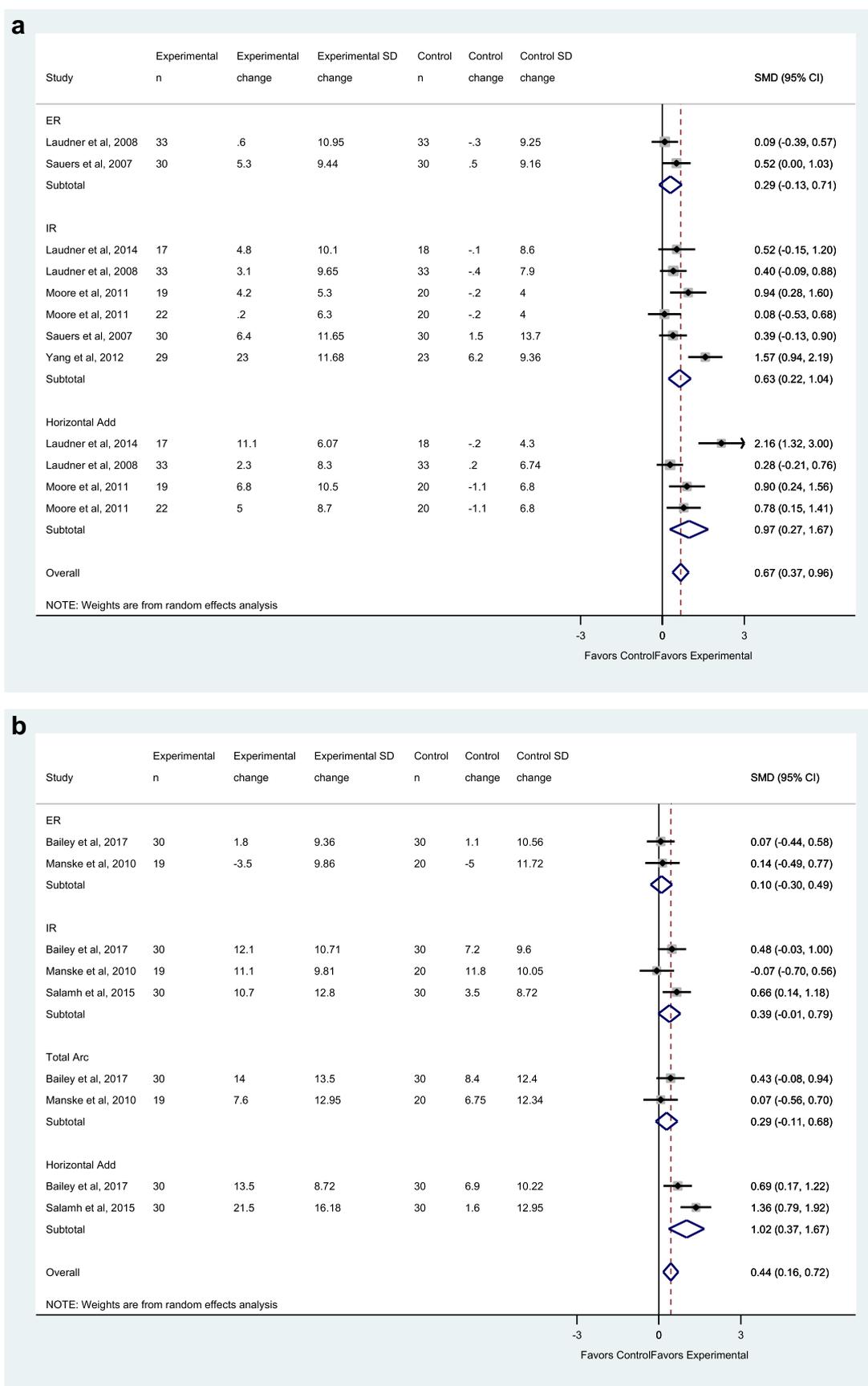


Figure 1 Meta-analysis for patients experiencing posterior shoulder tightness. **(a)** Results of single manual therapy (MT) intervention vs. no treatment. **(b)** Results of multimodal MT interventions vs. active comparator(s). *SD*, standard deviation; *SMD*, standardized mean difference; *CI*, confidence interval; *ER*, external rotation; *IR*, internal rotation; *Add*, adduction.

ROM in favor of the clinician-assisted interventions. However, most of these studies investigated the immediate- and short-term effects of clinician-assisted interventions on various ROMs within an asymptomatic population. It is difficult to determine from these investigations whether the short-term effects of increased ROM will have a long-term effect beyond a few weeks after treatment or whether they will in any way have a comparable effect on a symptomatic shoulder. In addition, a small effect size was seen when we compared multimodal treatment approaches, including clinician-assisted interventions, with comparator treatments, which included mostly self-stretching. These results may help to emphasize the importance of a combined-treatment approach when considering a plan of care for individuals with PST regarding improving mobility.

Directions for future research

Future investigations should focus on the long-term effects of clinician-assisted interventions to reduce PST within the symptomatic populations seeking care. Although short-term evidence was identified in this analysis regarding those populations in whom PST is known to develop, such as overhead athletes, carefully designed studies that investigate the long-term effects of a multimodal treatment approach on ROM, pain, and overall shoulder function are warranted.

Limitations

There are several limitations to this study including the inclusion of only those studies published in the English language. We also did not include a search of the gray literature as we believed that, within the area being investigated, this type of search would not lend any further results beyond our current search. Further limitations among the included studies can be found in the asymptomatic nature of all but one of the sample populations.³² Although many of the asymptomatic populations investigated among the included studies involved overhead athletes, a population known to have PST, the results can provide only theoretical evidence to support the efficacy of these interventions within the symptomatic population. Variables among the asymptomatic population such as greater ROM deficits, pain, inflammation, and apprehension, as well as other factors, may contribute to differing responses to treatment compared with the symptomatic population.

Conclusion

Individuals presenting with PST may benefit from clinician-assisted interventions both in isolation and as part of a multimodal treatment approach to improve overall shoulder ROM. It is not clear from the current

literature whether the improvements in ROM gained during treatment have more than a short-term effect.

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Supplementary data

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