[Physical Therapy]

Effectiveness of Manual Therapy and Stretching for Baseball Players With Shoulder Range of Motion Deficits

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Background: Baseball players displaying deficits in shoulder range of motion (ROM) are at increased risk of arm injury. Currently, there is a lack of consensus regarding the best available treatment options to restore shoulder ROM.

Hypothesis: Instrumented manual therapy with self-stretching will result in clinically significant deficit reductions when compared with self-stretching alone.

Study Design: Controlled laboratory study.

Methods: Shoulder ROM and humeral torsion were assessed in 60 active baseball players (mean age, 19 ± 2 years) with ROM deficits (nondominant − dominant, ≥15°). Athletes were randomly assigned to receive a single treatment of instrumented manual therapy plus self-stretching (n = 30) or self-stretching only (n = 30). Deficits in internal rotation, horizontal adduction, and total arc of motion were compared between groups immediately before and after a single treatment session. Treatment effectiveness was determined by mean comparison data, and a number-needed-to-treat (NNT) analysis was used for assessing the presence of ROM risk factors.

Results: Prior to intervention, players displayed significant ($P < 0.001$) dominant-sided deficits in internal rotation (−26°), total arc of motion (−18°), and horizontal adduction (−17°). After the intervention, both groups displayed significant improvements in ROM, with the instrumented manual therapy plus self-stretching group displaying greater increases in internal rotation (+5°, $P = 0.010$), total arc of motion (+6°, $P = 0.010$), and horizontal adduction (+7°, $P = 0.004$) compared with self-stretching alone. For horizontal adduction deficits, the added use of instrumented manual therapy with self-stretching decreased the NNT to 2.2 (95% CI, 2.1-2.4; $P = 0.010$).

Conclusion: Instrumented manual therapy with self-stretching significantly reduces ROM risk factors in baseball players with motion deficits when compared with stretching alone.

Clinical Relevance: The added benefits of manual therapy may help to reduce ROM deficits in clinical scenarios where stretching alone is ineffective.

Keywords: posterior shoulder tightness (PST); glenohumeral internal rotation deficit (GIRD); instrumented manual therapy; baseball

Throwing athletes displaying range of motion (ROM) deficits of the dominant throwing shoulder are at a greater risk of sustaining an arm injury.[20,22,28] Specifically, prospective studies have demonstrated that players with deficits as low as 5° in total arc of motion,[28] 20° in internal rotation,[22,28] and 15° in horizontal adduction[21] are up to 4 times more likely to be injured. Considering these relationships, clinical treatments that are effective in reducing ROM deficits may significantly influence injury rates among these athletes.

Because of the extreme forces on the shoulder with throwing, structural adaptations to the osseous and soft tissue structures are responsible for deficits in ROM.[2,3,12,14,16-18,24,26] In particular,

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Table 1. Subject characteristics

Variable	Instrumented Manual Therapy Plus Self-Stretching (n = 30)	Self-Stretching (n = 30)
Age, y, mean ± SD	18.8 ± 2.6	18.6 ± 2.1
Height, cm, mean ± SD	184.1 ± 6.0	182.1 ± 6.7
Weight, lbs, mean ± SD	187.2 ± 24.3	177.8 ± 20.9
Arm dominance (right/left)	27 right, 3 left	29 right, 1 left
PSS score, mean ± SD[a]	91.3 ± 6.4	92.1 ± 8.4
FAST score, mean ± SD[b]	15.4 ± 13.9	12.9 ± 13.6
Level of competition	9 high school, 21 collegiate/pro	12 high school, 18 collegiate/pro
Playing position	11 pitchers, 18 position players	13 pitchers, 17 position players

[a]PSS (Pennsylvania Shoulder Scale) scores are reported as raw totals of possible 100 points.
[b]FAST (Functional Arm Scale for Throwers) scores are reported as % of disability.

humeral torsion is strongly correlated with the degree of shoulder rotation ROM[17,23] and horizontal adduction.[14] When interpreting clinical ROM measurements, it may be useful to consider the influence of humeral torsion when screening for the presence of ROM deficits. The assessment of humeral torsion may help clinicians distinguish between bony and soft tissue involvement of ROM deficits.[3,14]

Therapeutic interventions have shown a promising ability to improve ROM deficits and pain.[7,13,16,18,25] However, there is little available evidence to guide clinicians in the selection of the best available treatment option(s) for improving these impairments. It is important to explore the best available means of restoring shoulder ROM. Therefore, the purpose of this study was to compare shoulder ROM deficits between baseball players receiving instrumented manual therapy plus self-stretching with those receiving stretching alone. We hypothesize that players receiving a combination of instrumented manual therapy and self-stretching will display fewer injury risk factors based on ROM deficits.

METHODS

Participants

Eligible participants provided both written and verbal consent approved by our institutional review board at the Greenville Health System in Greenville, South Carolina. Players were screened for shoulder ROM deficits on their dominant throwing shoulder (Table 1) to meet eligibility for participation. Deficits were defined as a decrease in motion relative to the nonthrowing arm. Inclusion criteria for this study included male baseball players (age ≥15 years) with current participation on an organized baseball team as a pitcher or position player. Additional inclusion criteria consisted of shoulder ROM deficits of 15° in total arc of motion (with at least 15° deficit in internal rotation) and/or a 15° deficit in horizontal adduction. These criteria were selected as previous research demonstrates deficits ≥20° as being predictive of arm injury.[22,28] Therefore, as a conservative screening criteria, we selected a threshold of ≥15° in an attempt to reduce injury risk factors while detecting potential changes in ROM. Participants were excluded if they reported a recent history of activity limiting shoulder pain (within 3 months), were not actively participating in all team activities, or had a previous surgical history on either shoulder.

Screening for participation included an initial assessment of shoulder ROM and completion of an activities questionnaire. Qualifying players were then asked to complete the Pennsylvania Shoulder Scale[8] and Functional Arm Scale for Throwers[19] and returned on a separate day to ensure that the presence of ROM deficits was stable over a minimum of 24 hours. The Pennsylvania Shoulder Scale is a 100-point scale that was used to determine the level of pain and disability for each participant (lower score = greater pain and disability). The Functional Arm Scale for Throwers is a 100-point functional scale developed for overhead throwers and was chosen to provide a sport-specific assessment of function (higher scores = greater sports-related pain and disability). Players scoring >30% disability on the Pennsylvania Shoulder Scale and/or the Functional Arm Scale for Throwers were excluded from participation.

Athletes were then randomly assigned (by random drawing) into 1 of 2 intervention groups (Figure 1). Those allocated to the instrumented manual therapy plus stretching group received 4 minutes of supervised posterior shoulder stretching followed by 4 minutes of instrumented manual therapy. Those in the self-stretching group received only 4 minutes of supervised posterior shoulder stretching. Assessments and treatments were administered on an individual basis and lasted approximately 10 minutes per athlete.

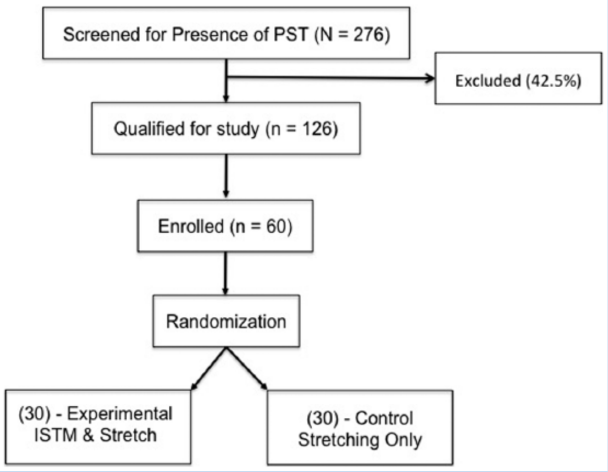

Figure 1. Study design. Two hundred seventy-six patients were screened for study eligibility, and shoulder range of motion was measured immediately pre- and postintervention. The "ISTM & Stretch" group received 4 minutes of instrumented manual therapy plus 4 minutes of supervised posterior shoulder stretching; the "Stretching Only" group performed 4 minutes of supervised posterior shoulder stretching. ISTM, instrument-assisted soft tissue mobilization; PST, posterior shoulder tightness.

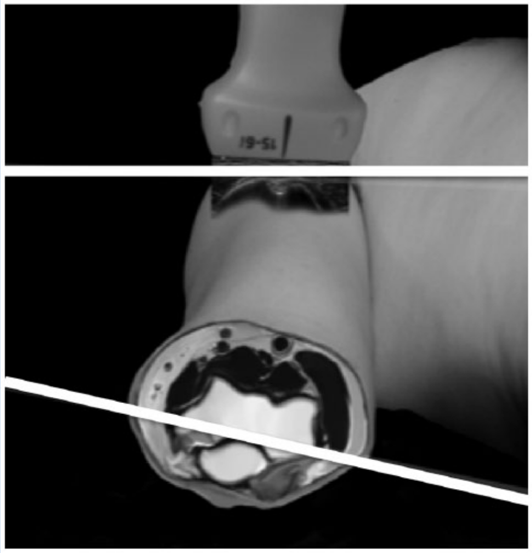

Figure 2. Humeral torsion. Humeral torsion was assessed by a sonographer who rotated the participant's humerus until the apices of the tuberosities were oriented parallel to the plinth under ultrasound imaging. Once aligned, a second examiner recorded the relative rotation angle via a digital inclinometer.

Shoulder Range of Motion Assessment

Internal and External Range of Motion

A baseline digital inclinometer (Fabrication Enterprises, Inc) was used for all ROM measures throughout the course of this study. For all shoulder ROM measures, participants were positioned in supine on a plinth in 90° of shoulder abduction and elbow flexion. The same clinician provided stabilization and performed all ROM measures. Internal rotation was assessed using a towel roll under the arm to maintain the position of the humerus, and the shoulder was passively rotated until the examiner felt movement at the coracoid process.[1,4,5,14,29] A second investigator then aligned the digital inclinometer along the ulnar border and recorded the corresponding angle in degrees. External rotation was measured in a similar manner with the shoulder passively rotated to the first resistance without overpressure (Figure 2). Two trials were recorded and used for measurement reliability and statistical analysis. Measurement reliability for this study was acceptable for internal rotation (intraclass correlation coefficient [$ICC_{(2,1)}$], 0.98; 95% CI, 0.98-0.99; standard error of measure [SEM], 1.3°; minimal detectable change [MDC_{95}], 3.7°) and external rotation ($ICC_{(2,1)}$, 0.98; 95% CI, 0.98-0.99; SEM, 1.5°; MDC_{95}, 4.0°). Passive total arc of motion was calculated for each arm (total arc of motion = external rotation + internal rotation).

Horizontal Adduction Range of Motion

Horizontal adduction was collected using methods described by both Laudner et al[7] and Myers et al[15] because of the previously established measurement reliability. The examiner stabilized the scapula in full retraction at the lateral scapular border and passively horizontally adducted the arm while maintaining neutral rotation and continued until resistance was felt. Once end range was reached, a second examiner measured the corresponding humeral horizontal adduction angle using the digital inclinometer at the humeral diaphysis relative the horizontal plane. Our test-retest reliability for horizontal adduction was $ICC_{(2,1)}$ = 0.99 (95% CI, 0.99-0.99; SEM, 1.3°; MDC_{95}, 3.7°). Reductions in ROM deficits were calculated for each ROM variable and used for statistical analysis (ROM deficit = mean nondominant value – mean dominant value).

Humeral Torsion Assessment

Humeral torsion was assessed using valid[13] measures of previously described techniques.[27,30] Participants were positioned supine on a plinth in 90° of shoulder abduction and elbow flexion. A SonoSite-Edge (SonoSite, Inc) ultrasound imaging unit with 4-cm linear array transducer (6-15 MHz) was used to collect all measurements. The probe was placed on the participant's shoulder at the level of the biceps groove and oriented perpendicular to the plane of the plinth and verified with a bubble level. The examiner then passively rotated the subject's humerus until the apices of the greater and lesser tuberosities were oriented parallel to the coronal plane. A second examiner then measured the corresponding angle using the digital inclinometer (Figure 2). The first 30 participants underwent both pre- and posttest examinations to demonstrate the measurement stability of an osseous structure. The last 30 subjects only received pretest assessments. The reliability for humeral torsion was $ICC_{(2,1)}$ = 0.99 (95% CI, 0.98-0.99; SEM, 1.3°; MDC_{95}, 3.5°).

Interventions

Passive shoulder ROM was assessed on both shoulders immediately before and after treatment intervention, which was only administered to the throwing shoulder. The primary investigator was blinded to group assignment and left the testing area for 10 minutes while treatment was provided by 1 of 2 orthopaedic physical therapists. Specific group interventions were as follows.

Self-Stretching Group

The self-stretching group (n = 30) was given standardized instruction and visual demonstration in the performance of the sleeper and cross-body adduction stretch, which are common treatment interventions for ROM deficits.[6,9,11,25] The sleeper stretch was performed with the subject positioned side-lying on the dominant throwing shoulder so that the scapula was retracted and stabilized using a towel roll (Figure 3a). The humerus was positioned in 90° of shoulder elevation with the elbow flexed to 90°; the shoulder was then rotated internally using the opposite hand until a stretch was felt along the posterior aspect of the shoulder. The stretch was held for 1 minute as the treating therapist timed and assessed for appropriate stretching technique. Participants performed the stretch twice and were asked to rest for 30 seconds between repetitions.

The cross-body adduction stretch was performed in the same starting position described above. Subjects were asked to grasp the dominant elbow with the opposite hand placed beneath the arm and pull across the front of the body until a stretch was felt in the posterior shoulder (Figure 3b). Players were asked to perform two 1-minute repetitions, while the investigator timed and evaluated the technique with 30 seconds of rest.

Instrumented Manual Therapy Plus Self-Stretching Group

Immediately after the stretching described above, the instrumented manual therapy plus self-stretching group (n = 30) also received instrumented manual therapy (SASTM; Carpal Therapy, Inc) targeting the infraspinatus and teres minor muscles. Subjects were prone with the dominant arm positioned in neutral rotation at 90° of shoulder abduction and elbow flexion. A towel was placed under the participant's shoulder to maintain alignment of the humerus within the scapular plane. Emollient was applied to the posterior axillary border to allow the tool to glide smoothly, and all participants were treated using the same instrument (SASTM No. 4). Treatment strokes were administered at approximately a 45° angle to the skin surface for 2 minutes in both parallel and perpendicular directions to the fiber alignment of the infraspinatus and teres minor muscles. To ensure standardized dosage between participants, a metronome was set at a rate of 45 Hz for each treatment to monitor frequency of strokes.

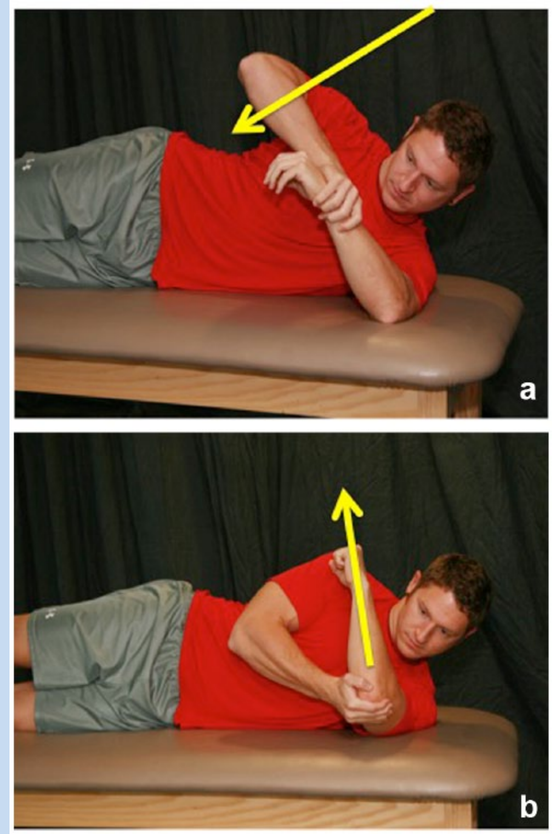

Figure 3. Supervised self-stretching. Athletes were supervised during the standardized performance of 2 stretches, which were both held for 1 minute each. Both stretches were performed with the athlete in a side-lying position and the shoulder elevated to 90° of flexion. (a) The sleeper stretch was performed by internally rotating the shoulder until a gentle stretch was felt in the posterior shoulder. (b) The cross-body adduction stretch was performed by pulling the throwing arm toward the ceiling until a gentle stretch was felt in the posterior shoulder.

Statistical Analysis

A 1-way analysis of variance (ANOVA) was performed to compare age, height, weight, subjective outcomes (Pennsylvania Shoulder Scale and Functional Arm Scale for Throwers), and level of competition between the 2 treatment groups. Separate 3-way mixed-model ANOVAs (group × arm × time) were used to determine the underlying treatment effects for each dependent variable. Post hoc planned comparisons were made between sides and groups for the dependent variables of interest (external rotation, internal rotation, total arc of motion, and horizontal adduction) using simple main effects differences. Pearson correlation coefficients (r) were calculated to assess the association between humeral torsion and the ROM deficits.

To further examine the clinical utility of our results, a number-needed-to-treat (NNT) statistic was calculated to examine the change in ROM risk factors between intervention groups. The NNT statistic is useful for examining the comparative effectiveness between 2 interventions when the

Table 2. Glenohumeral range of motion comparison (mean ± SD)

Variable	Instrumented Manual Therapy Plus Self-Stretching (n = 30)			Self-Stretching (n = 30)		
	Pretest	Posttest	Pre/Post Δ[a] (*P* Value)	Pretest	Posttest	Pre/Post Δ[a] (*P* Value)
External rotation (deg)						
Dominant	110.5 ± 9.6	112.3 ± 9.1	+1.8 (0.070)	114.7 ± 10.3	115.8 ± 10.8	+1.2 (0.181)
Nondominant	105.6 ± 8.6	105.1 ± 8.2	–0.5 (0.444)	104.4 ± 8.7	104.4 ± 8.5	0.0 (0.996)
Internal rotation (deg)						
Dominant	20.7 ± 10.9	32.8 ± 10.5	+12.1 (<0.001)[b]	20.7 ± 9.5	27.9 ± 9.7	+7.2 (<0.001)[b]
Nondominant	44.5 ± 11.3	45.6 ± 10.2	+1.1 (0.110)	48.7 ± 6.8	48.9 ± 7.7	+0.2 (0.792)
Total arc of rotation (deg)						
Dominant	131.2 ± 13.7	145.2 ± 13.3	+14.0 (<0.001)[b]	135.3 ± 13.0	143.7 ± 11.7	+8.4 (<0.001)[b]
Nondominant	150.2 ± 10.4	150.8 ± 10.6	+0.6 (0.535)	153.0 ± 10.4	153.2 ± 9.8	+0.2 (0.835)
Horizontal adduction (deg)						
Dominant	–2.2 ± 9.3	11.3 ± 8.0	+13.5 (<0.001)[b]	1.8 ± 11.0	8.7 ± 9.2	+6.9 (<0.001)[b]
Nondominant	14.6 ± 7.8	13.7 ± 6.6	–1.0 (0.282)	19.6 ± 12.5	18.6 ± 11.2	–1.0 (0.178)
Humeral torsion (deg)						
Dominant	13.9 ± 8.6	13.3 ± 8.1	–0.6 (0.453)	13.0 ± 11.2	13.0 ± 11.2	0.0 (0.992)
Nondominant	33.0 ± 7.4	33.5 ± 6.6	+0.6 (0.552)[b]	38.8 ± 13.0	37.7 ± 13.3	–1.1 (0.780)[b]

[a]Δ = Posttest – pretest range of motion in degrees.
[b]Statistically significant differences between treatment groups, $F_{(1,59)}$ ($P < 0.050$).

outcome is dichotomous (ie, success vs failure). In the current study, players no longer displaying ROM risk factors (<15° deficit) after the intervention were considered to have a successful outcome. Conversely, those that still displayed 15° of deficits or more were considered an unsuccessful outcome. Fifteen degrees was selected as a successful outcome threshold based on previous research indicating that baseball players have up to 4 times the relative risk of sustaining a prospective arm injury when values meet or exceed this limit.[28] NNT statistics were calculated for the following categories of injury risk factors: (1) internal rotation + total arc of motion (≥15°), (2) horizontal adduction (≥15°), and (3) those who qualified for both categories (internal rotation + total arc of motion and horizontal adduction). The success and failure rates were calculated as the relative change from pretest to posttest and compared between intervention groups using a chi-square test. NNT statistics were then calculated with an associated 95% CI. G-Power software (version 3.1.6) was used to estimate the required effect size and power based on a moderate a priori estimation of 0.30 and 0.80, respectively. PASW Statistic 18 software (SPSS Inc) was used with a significance level of α = 0.05 for all comparisons.

RESULTS

Two hundred seventy-six athletes were screened for eligibility, with the first 60 enrolled and included within the statistical analysis (Figure 1 and Table 1). A significant interaction (group × side × time) was observed after treatment for dominant internal rotation, total arc of rotation, and horizontal adduction between groups (Table 2). Secondary regression analysis indicates that a majority of the total arc of rotation gained on the dominant shoulder was in internal rotation ($R^2 = 0.71$). While both groups displayed ROM deficit reductions, players receiving instrumented manual therapy gained greater internal rotation, total arc of motion, and horizontal adduction than the control group ($P < 0.01$) (Figure 4). No changes were observed in external rotation for either group ($P > 0.05$).

Table 3. Number-needed-to-treat (NNT) analysis[a]

	Instrumented Manual Therapy Plus Self-Stretching (n = 30)	Self-Stretching (n = 30)
Risk of injury based on all criteria		
Treatment failure rate	9/30 (30%)	15/30 (50%)
Absolute risk reduction (95% CI)	0.20 (0.19-0.21)	
NNT (95% CI)	NNT with instrumented manual therapy plus stretching (vs stretching only) to prevent another unsuccessful outcome: 5.0 (4.7-5.4)	
Risk of injury based on total arc of rotation criteria		
Treatment failure rate	8/22 (36%)	9/21 (43%)
Absolute risk reduction (95% CI)	0.07 (−0.22 to 0.36)	
NNT (95% CI)	NNT with instrumented manual therapy plus stretching (vs stretching only) to prevent another unsuccessful outcome: 14.3 (10.7-17.9)	
Risk of injury based on horizontal adduction criteria		
Treatment failure rate	2/19 (11%)[b]	10/18 (56%)[b]
Absolute risk reduction (95% CI)	0.45 (0.41-0.49)	
NNT (95% CI)	NNT with instrumented manual therapy plus stretching (vs stretching only) to prevent another unsuccessful outcome: 2.2 (2.1-2.4)	

[a]The absolute risk reduction (ARR) was calculated as |rate instrumented manual therapy plus self-stretching − rate stretching only|. The NNT was calculated as 1/(ARR).
[b]Significant difference in treatment failure rates (chi-square test).

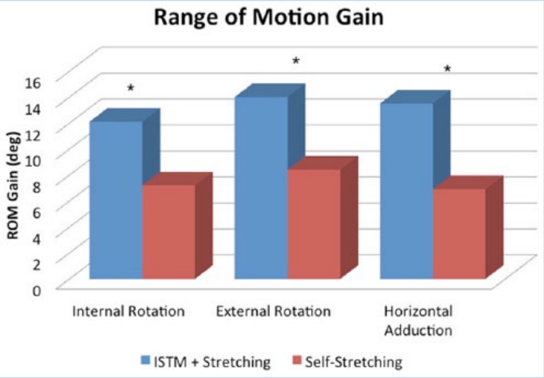

Figure 4. Posttest range of motion deficits. ISTM, instrument-assisted soft tissue mobilization; ROM, range of motion.*Indicates significant differences between treatment groups.

For those qualifying for both categories of injury risk, the NNT was 5.0, indicating that approximately 5 players would need to be treated to observe the benefits of instrumented manual therapy to significantly reduce their injury risk factors (Table 3).

For total arc of motion + internal rotation, the NNT was 14.3, indicating that the added use of instrumented manual therapy offers little benefit to total arc of motion + internal rotation. The horizontal adduction category resulted in an NNT of 2.2 (P = 0.010), suggesting that approximately 2 players would need to be treated with instrumented manual therapy plus stretching (vs stretching alone) to see the comparative benefits of instrumented manual therapy for reducing injury risk factors.

DISCUSSION

The primary results of this study indicate that baseball players treated with instrumented manual therapy plus self-stretching display greater improvements in ROM deficits when compared with self-stretching alone. Additionally, an NNT analysis suggests that ROM risk factors are more effectively managed with the added use of instrumented manual therapy. Considering these results, a single treatment session may effectively reduce the presence of ROM risk factors in at-risk baseball players.

These results are in agreement with previous research showing that ROM deficits are responsive to conservative treatment.[9-11,25] More specifically, the internal rotation gains observed within this sample are comparable to those observed in 4- to 6-week stretching programs (range, 12°-15°).[9-11] In contrast, however, only marginal gains were reported in internal rotation (+3°, $P < 0.05$) immediately following a similar stretching routine.[6] Large treatment effects, however, would not necessarily be anticipated within their study, as players did not display significant baseline ROM deficits. Players in the current study also performed cross-body adduction stretches and sleeper stretching for an overall greater total end range time (4 vs 1.5 minutes[6]), potentially contributing to these differences.

The increase in horizontal adduction was also comparable to previous studies performed over the course of multiple weeks (4-6 weeks).[9,25] Similar horizontal adduction gains of +11° (±1°) were seen in players performing a 6-week regimen of sleeper stretching.[8] Increases in horizontal adduction of +17° were also seen after a standardized therapy program in individuals diagnosed with symptomatic internal shoulder impingement.[24] In contrast, smaller increases of +3° horizontal adduction have been accomplished with the acute application of sleeper stretching.[6] Collectively, these results indicate that horizontal adduction and total arc of motion are key to understanding the specific impairments associated with throwing athletes.

The NNT statistic highlights the impact ROM deficit grouping can have on clinical decision-making. The difference in NNT indicates that players with only horizontal adduction deficits should receive instrumented manual therapy plus self-stretching to avoid injury risk factor qualification while players with only total arc of motion + internal rotation deficits would likely respond well to stretching alone. The NNT results used in this study were based on previously reported ROM risk factors.[22,28] However, injury rates were not tracked to validate these data for injury prevention; therefore, caution should be taken when interpreting these data.

This is not the first study to examine the combined use of manual therapy techniques and stretching in this population. In contrast to our results, previous work found no additive treatment benefit for the use of posterior joint mobilization, as both groups displayed similar gains in internal rotation.[9] Manual therapy techniques directed at the musculotendinous tissue may provide more acute benefits for improving ROM deficits than posterior joint mobilization focused on altering capsuloligamentous restraint.

Limitations

The thresholds for risk factors used in this study were based on previous research. Athletes were not followed longitudinally to determine the influence that our interventions may have on decreasing long-term injury risk. However, the data suggest that these treatments may be beneficial in immediately reducing ROM risk factors that have been associated with upper extremity injury. Second, the isolated and long-term benefits of instrumented manual therapy are unknown. Last, it is unknown which specific tissue(s) were responsible for the ROM changes observed within this study. A better understanding of these mechanisms may help to focus therapeutic interventions on the tissue(s) likely to respond.

CONCLUSION

Baseball players exhibiting ROM deficits can acutely acquire clinically meaningful gains in ROM with the application of instrumented manual therapy and posterior shoulder stretching. The addition of instrumented manual therapy with stretching appears to significantly augment treatment effectiveness when compared with stretching alone, particularly for horizontal adduction deficits. This suggests that the combination of these interventions may be more beneficial to restore ROM in baseball players with ROM deficits than stretching alone.

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