

COMPARISON OF INSTRUMENT-ASSISTED SOFT TISSUE MOBILIZATION
AND PASSIVE STRETCHING TO IMPROVE GLENOHUMERAL
RANGE OF MOTION AND FUNCTION

by

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TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF ABBREVIATIONS	viii
ABSTRACT	ix
CHAPTER	
1. INTRODUCTION	1
2. MANUSCRIPT	5
Abstract	6
Introduction	8
Methods	10
Results	24
Discussion	29
Conclusion	33
3. SUMMARY AND RECOMMENDATIONS FOR FUTURE STUDY	36
APPENDIX SECTION	38
REFERENCES	74

LIST OF TABLES

Table	Page
1 – Participant Inclusion and Exclusion Criteria.....	11
2 – Interday Test-Retest Reliability Results for Principal Investigator.....	23
3 – Participant Demographic Data at Entry into the Study.....	25

LIST OF FIGURES

Figure	Page
1 – Total Glenohumeral Range of Motion Arc.....	10
2 – The Edge™ Soft-Tissue Mobilization Tool.....	13
3 – Digital Inclinator.....	14
4 – Internal Rotation Passive Range of Motion Measurement Technique	16
5 – External Rotation Passive Range of Motion Measurement Technique	16
6 – Horizontal Adduction Passive Range of Motion Measurement Technique.....	17
7 – Parallel Stroke Technique for Instrument-Assisted Soft Tissue Mobilization of the Posterior Shoulder	18
8 – Perpendicular Stroke Technique for Instrument-Assisted Soft Tissue Mobilization of the Posterior Shoulder.....	18
9 – External Rotation Passive Stretching Technique	19
10 – Internal Rotation Passive Stretching Technique.....	19
11 – Cross Body Passive Stretching Technique.....	20
12 – Horizontal Adductor Passive Stretching Technique.....	20
13 – The Functional Arm Scale for Throwers	57
14 – The Kerlan-Jobe Clinic Shoulder and Elbow.....	60

LIST OF ABBREVIATIONS

GIRD	Glenohumeral Internal Rotation Deficit
TROM.....	Total Range of Motion
IASTM.....	Instrument Assisted Soft Tissue Mobilization
PROM.....	Passive Range of Motion
FAST	Functional Arm Scale for Throwers
KJOC	Kerlan-Jobe Orthopedic Clinic Scale for Shoulder and Elbow
MDC	Minimal Detectable Change

ABSTRACT

Context: The loss of shoulder internal rotation range of motion is common maladaptation that predisposes overhead sport athletes to injury. Instrument-assisted soft tissue mobilization (IASTM) has recently been suggested as an alternative to stretching exercises to reestablish normal range of motion. **Objective:** To determine the extent to which a 4-week program of traditional stretching plus IASTM improves glenohumeral range of motion compared to stretching alone. Our secondary purpose was to measure the effects of these interventions using two patient-rated outcome measures of shoulder function. **Design:** Prospective cohort study. **Setting:** Combined laboratory and field study. **Participants:** 20 intercollegiate baseball players; 10 in the Stretching + IASTM Group (age, 20.9 ± 0.9 yrs; height, 180.8 ± 8.1 cm; mass 85.7 ± 7.2 kg), and 10 in the Stretching group (age, 19.9 ± 1.4 yrs; height, 183.4 ± 7.4 cm; mass, 87.1 ± 8.5 kg). **Interventions:** Participants in the Stretching group received a clinician-administered shoulder stretching program 5 days/week for 4 weeks. Participants assigned to the Stretching + IASTM group received the same stretching program, plus IASTM treatments twice per week for 4 weeks. All participants completed the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow (KJOC) score and the Functional Arm Scale for Throwers (FAST) at the beginning and end of the study. **Main Outcome Measures:** Shoulder internal rotation, external rotation, and horizontal adduction passive range of motion (PROM); glenohumeral total range of

motion (TROM); and the KJOC and the FAST. **Statistical Analyses:** Five Group (2) x Time (2) between-within ANOVAs were performed ($\alpha = 0.05$). We also calculated Pearson correlations between the KJOC and FAST questionnaire scores. **Results:** Internal rotation PROM significantly improved from Week 0 to Week 4 in both treatment groups ($p = 0.005$). Stretching group mean internal rotation PROM increased 6.3%, from $52.8^\circ \pm 8.7^\circ$ to $56.1^\circ \pm 8.4^\circ$, while Stretching + IASTM group average internal rotation PROM improved 7.8%, from $52.6^\circ \pm 7.2^\circ$ to $56.7^\circ \pm 4.5^\circ$ over the course of this study. Total range of motion (TROM) improved 3.1% in the Stretching group, from $145.2^\circ \pm 17.0^\circ$ to $149.7^\circ \pm 18.4^\circ$, and 4.2% in the Stretching + IASTM group, from $143.0^\circ \pm 8.4^\circ$ to $149.0^\circ \pm 10.6^\circ$ between Week 0 and Week 4, respectively ($p = 0.005$). The KJOC and the FAST scores were inversely related at both the outset ($r = -0.874$, $p = 0.001$) and conclusion of our 4-week intervention ($r = -0.765$, $p = 0.001$). **Conclusions:** While both treatment protocols were effective in increasing glenohumeral internal rotation PROM and TROM, the IASTM protocol we employed did not have a significant effect on any of our disease-oriented outcome measures after 4 weeks. Future research studies should compare the effects of multiple IASTM treatment frequencies and durations to more fully evaluate the capacity of IASTM to create long-term improvements in glenohumeral joint range of motion and function.

Key Words: instrument-assisted soft tissue mobilization, total range of motion, patient-rated outcomes, overhead sport athletes

1: INTRODUCTION

Over the course of a competitive season, the overhead sport athlete exposes his or her shoulder joint complex to repetitive and often excessive rotational forces that can lead to soft tissue maladaptations in the posterior shoulder.¹⁻⁶ Continued stressors eventually cause soft tissue adaptations, bony adaptations, and/or capsular changes in the posterior glenohumeral joint which can present as loss of range of motion, more specifically, glenohumeral internal rotation deficit (GIRD), external rotation gain, and total range of motion (TROM) differences, as well as loss of horizontal adduction motion.^{16, 17} These changes put athletes at risk for developing microtrauma-related damage to the anatomical structures of the shoulder joint complex, including rotator cuff pathology, glenoid labral lesions, and subacromial impingement syndromes.¹⁻⁶ Upper extremity injuries in baseball are very common and account for 44% and 46% of all injuries that occur in games and practices, respectively.¹ Maintenance of the shoulder complex range of motion through interventions such as tissue mobilization is often the chief concern for the athletic trainer working with baseball athletes because of those reported figures, and the understanding of the path that leads to injury.¹⁻⁶

Instrument-assisted soft tissue mobilization (IASTM) can be a useful intervention for the athletic trainer for the efficient and proper treatment of soft tissue restrictions.¹¹ The use of IASTM can afford the athletic trainer the ability to more accurately and efficiently provide treatment for soft tissue dysfunction, while shortening treatment time and total sessions as well as strain on the athletic trainer's

hands.⁷ A recent critically appraised topic²⁰ investigated 5 studies that compared IASTM versus shoulder self-stretching exercises, and found moderate evidence that IASTM increased glenohumeral range of motion. When combined with the results of a recent systematic review⁷ that reported moderate evidence in favor of static stretching to decrease lost glenohumeral range of motion, clinicians should begin to look for methods other than traditional stretching to treat the shoulders of overhead sport participants.

Regarding IASTM applied to the shoulder, one goal is to induce plastic changes in the target tissue(s) in order to create additional length and/or mobility, and thereby regain normal range of motion and functioning of the affected tissue.^{7, 8} Research has shown that we can manipulate how the tissue heals by creating fibroblasts that are responsible for repairing soft tissue, with the goal of creating length.^{7, 9, 10} Our understanding of this process allows us to make informed decision in the clinic when choosing the appropriate intervention for our patients. If our goal is to regain range of motion, then we know the use of a manual therapy technique is indicated.⁸

To date, the clinical use of IASTM has been supported mainly by case studies, case series, anecdotal success stories, and success after one treatment exposure in the literature.⁹⁻¹³ Previous studies have shown success after one-time exposure to IASTM¹⁸ and with IASTM compared to a self-stretch group²¹ for increasing PROM. Only two studies have reported improvement in PROM after one treatment session, where ROM measurements were taken immediately post intervention;^{18, 21} therefore, the need remains to identify the effects of repeated IASTM treatments to determine

its effectiveness as a tool to gain or restore lost range of motion and reestablish normal function in the glenohumeral joint complex.

Gaining a better understanding of the effects of this therapeutic technique may encourage the athletic trainer to make it a part of the treatment protocol. The need to alleviate the overhead athlete from posterior shoulder tightness is a concern for the athletic trainer working with these populations due to the various pathologies that can arise from restricted motion in the shoulder complex.

The purpose of this study was to determine the extent to which a 4-week program of IASTM combined with traditional stretching exercises increased ROM in the shoulders of intercollegiate baseball participants when compared to stretching exercises alone. A secondary purpose was to determine the effect of the interventions on the function of the shoulder with the use of two patient-rated outcome measures, the Functional Arm Scale for Throwers (FAST) and the Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow Score (KJOC). We hypothesized that the use of IASTM would result in significantly greater gains in glenohumeral internal rotation and horizontal adduction passive range of motion (PROM) and total range of motion (TROM) than a traditional shoulder stretching protocol over the 4-week intervention period ($p \leq 0.05$). We also hypothesized that the IASTM + Stretching group would report greater increases in the FAST and KJOC scores compared to the Stretching group from Week 0 to Week 4.

Following the successful completion of this master's thesis, abstracts of the findings from this study will be submitted for presentation at both the 70th Annual Meeting of the National Athletic Trainers' Association, to be held in Las Vegas,

Nevada in June 2019, and the 65th Annual Meeting of the Southwest Athletic Trainers' Association to be held in Arlington, Texas in July 2019. The primary manuscript from this thesis will be submitted for publication in the *Journal of Athletic Training*.

2: MANUSCRIPT

COMPARISON OF INSTRUMENT-ASSISTED SOFT TISSUE MOBILIZATION AND PASSIVE STRETCHING TO IMPROVE GLENOHUMERAL JOINT RANGE OF MOTION AND FUNCTION

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ABSTRACT

Context: The loss of shoulder internal rotation range of motion is common maladaptation that predisposes overhead sport athletes to injury. Instrument-assisted soft tissue mobilization (IASTM) has recently been suggested as an alternative to stretching exercises to reestablish normal range of motion. **Objective:** To determine the extent to which a 4-week program of traditional stretching plus IASTM improves glenohumeral range of motion compared to stretching alone. Our secondary purpose was to measure the effects of these interventions using two patient-rated outcome measures of shoulder function. **Design:** Prospective cohort study. **Setting:** Combined laboratory and field study. **Participants:** 20 intercollegiate baseball players; 10 in the Stretching + IASTM Group (age, 20.9 ± 0.9 yrs; height, 180.8 ± 8.1 cm; mass 85.7 ± 7.2 kg), and 10 in the Stretching group (age, 19.9 ± 1.4 yrs; height, 183.4 ± 7.4 cm; mass, 87.1 ± 8.5 kg). **Interventions:** Participants in the Stretching group received a clinician-administered shoulder stretching program 5 days/week for 4 weeks. Participants assigned to the Stretching + IASTM group received the same stretching program, plus IASTM treatments twice per week for 4 weeks. All participants completed the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow (KJOC) score and the Functional Arm Scale for Throwers (FAST) at the beginning and end of the study. **Main Outcome Measures:** Shoulder internal rotation, external rotation, and horizontal adduction passive range of motion (PROM); glenohumeral total range of motion (TROM); and the KJOC and the FAST. **Statistical Analyses:** Five Group (2) x Time (2) between-within ANOVAs were performed ($\alpha = 0.05$). We also calculated Pearson correlations between the KJOC and FAST questionnaire scores. **Results:**

Internal rotation PROM significantly improved from Week 0 to Week 4 in both treatment groups ($p = 0.005$). Stretching group mean internal rotation PROM increased 6.3%, from $52.8^{\circ} \pm 8.7^{\circ}$ to $56.1^{\circ} \pm 8.4^{\circ}$, while Stretching + IASTM group average internal rotation PROM improved 7.8%, from $52.6^{\circ} \pm 7.2^{\circ}$ to $56.7^{\circ} \pm 4.5^{\circ}$ over the course of this study. Total range of motion (TROM) improved 3.1% in the Stretching group, from $145.2^{\circ} \pm 17.0^{\circ}$ to $149.7^{\circ} \pm 18.4^{\circ}$, and 4.2% in the Stretching + IASTM group, from $143.0^{\circ} \pm 8.4^{\circ}$ to $149.0^{\circ} \pm 10.6^{\circ}$ between Week 0 and Week 4, respectively ($p = 0.005$). The KJOC and the FAST scores were inversely related at both the outset ($r = -0.874$, $p = 0.001$) and conclusion of our 4-week intervention ($r = -0.765$, $p = 0.001$). **Conclusions:** While both treatment protocols were effective in increasing glenohumeral internal rotation PROM and TROM, the IASTM protocol we employed did not have a significant effect on any of our disease-oriented outcome measures after 4 weeks. Future research studies should compare the effects of multiple IASTM treatment frequencies and durations to more fully evaluate the capacity of IASTM to create long-term improvements in glenohumeral joint range of motion and function.

Key Words: instrument-assisted soft tissue mobilization, total range of motion, patient-rated outcomes, overhead sport athletes

Word Count: 470

INTRODUCTION

When providing medical care for athletes who participate in overhead sports activities, maintaining full function of the shoulder joint complex is often a major concern for clinicians. Baseball pitchers, and to a lesser extent, baseball position players, often have reduced glenohumeral range of motion as a long-term result of the repetitive stresses that have been placed on their shoulders from the throwing motion, increasing the likelihood of injury.¹⁻⁶

Health care professionals who provide care for overhead athletes need to be aware of the potential dysfunctions including glenohumeral internal rotation deficit (GIRD) and differences in total range of motion (TROM). The combined arc of external rotation added with internal rotation creates the TROM measurement (internal rotation + external rotation = TROM). These altered movement patterns may be associated with injuries including rotator cuff tendinopathy and labral lesions.¹⁻⁸ Instrument assisted soft tissue mobilization (IASTM) can be a useful intervention for the athletic trainer for the treatment of soft tissue restrictions. IASTM has been shown as a valuable tool for the creation of length in soft tissue by manipulation of the way the tissues heal as a result of the treatment process. IASTM therapy is applied to the shoulder to induce plastic changes in the target tissue(s) to create additional length and/or mobility, and thereby regain normal functioning of the affected tissue.^{9, 10} Previous research has shown therapists can manipulate how the tissue heals with the goal of creating length.^{8, 10, 11} Our understanding of this process allows us to make informed decisions in the clinic when choosing the appropriate intervention for our

patients. If our goal is to regain range of motion, then we know the use of a manual therapy technique is indicated.⁹

Mine et al recently evaluated 10 studies in a systematic review of posterior glenohumeral capsular tightness and found only moderate evidence that static stretching was an effective treatment to reduce the effects of overhead sports on the shoulder complex.¹¹ The conclusions drawn by Mine et al demonstrated the need for a useful and effective therapeutic intervention other than stretching alone to increase shoulder range of motion, and avoid the potentially harmful effects of tissue shortening in the shoulder complex.¹¹

To date, the clinical use of IASTM has been supported mainly by case studies, case series, anecdotal success stories, and acute success in the literature, with special attention given to the lower extremity.^{9, 10, 12-16} Laudner et al. and Bailey et al. demonstrated the ability of IASTM to increase shoulder ROM immediately after 1 treatment session.^{17, 18} However, we could find no published studies evaluating the repeated use of IASTM treatments to determine its effectiveness as a tool to gain or restore lost range of motion, and reestablish normal function in the glenohumeral joint complex.

The use of IASTM can afford the athletic trainer the ability to more accurately and efficiently provide treatment for soft tissue dysfunction, while shortening treatment time and total sessions as well as strain on the athletic trainer's hands.¹¹ Gaining a better understanding of the effects of this therapeutic technique may encourage clinicians to make it a part of their treatment protocols. Reducing the effects of continued stress to the posterior shoulder capsule should be the main

concern for the athletic trainer working with this population of athletes. Regaining appropriate TROM reduces the likelihood of injury to the athletes, and if IASTM can do so, it can be a valuable tool for the athletic trainer.

The purpose of this study was to compare the effects of a 4 week IASTM + stretching program to a stretching only protocol to determine improvements in passive glenohumeral range of motion in a group of NCAA baseball players. We hypothesized that the use of IASTM would result in significantly greater gains in glenohumeral internal rotation, horizontal adduction (PROM) and TROM than a traditional shoulder stretching protocol. The secondary purpose was to determine the effect of the interventions on the function of the shoulder with the use of two patient-oriented outcome measures, the Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow Score (KJOC) and the Functional Arm Scale for Throwers (FAST).

METHODS

Design

This study was a single blind prospective cohort study that compared the capacity of IASTM and traditional stretching exercises to improve glenohumeral internal rotation, horizontal adduction PROM, and TROM. The independent variables in this study were Group and Time. There were two levels of the Group independent variable—one experimental group received shoulder stretching exercises and IASTM treatments (Stretching + IASTM), while an active control group received the same shoulder stretching exercises only (Stretching). The groups were assigned from intact populations at two NCAA intercollegiate baseball teams. There were also two levels

of the Time independent variable, with data collected pre-intervention (Week 0) and post-intervention (Week 4).

Our primary outcome measures were glenohumeral internal rotation and horizontal adduction PROM. We also obtained glenohumeral external rotation PROM measurements and combined these with our internal rotation PROM values to create a third outcome measure, total range of motion (TROM) deficit for both shoulders. TROM deficit is determined by summing glenohumeral internal rotation and glenohumeral external rotation for both shoulders and subtracting for the difference. The TROM is demonstrated in Figure 1.

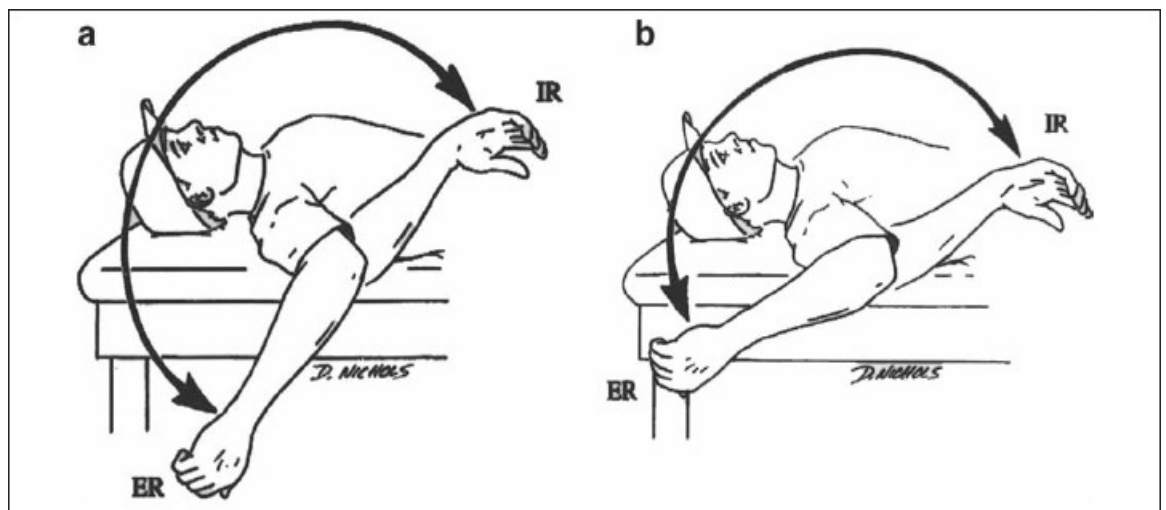


Figure 1. Total Glenohumeral Range of Motion Arc

Our secondary outcome measures were patient-reported outcomes, specifically, the 22-item Functional Arm Scale for Throwers (FAST), the FAST's 9-item pitcher's module if the participant was a pitcher, and the 10-item Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score (KJOC).

Participants

All volunteers were recruited by flyers and/or direct appeal from an existing pool of NCAA intercollegiate student-athletes, aged 18 and older, who were currently participating in varsity baseball at the university level.

The volunteers were screened for eligibility and satisfied all inclusion and exclusion criteria prior to enrollment in the study (Table 1). All volunteers were also screened to be sure that they were not currently receiving any additional physical medicine treatments that could affect the post-intervention measurements, e.g., muscle energy, active release therapy, massage.

Table 1. Participant Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Actively participating in baseball at the collegiate level	No history of shoulder surgery
Minimum age of 18 years old	No current shoulder injury
Minimum difference of 5 degrees difference of TROM compared to non-dominant side ¹⁶	Current prescription of soft tissue mobilization

All volunteers provided written informed consent prior to any involvement in this study, as mandated by the Texas State University (University A) and the St. Edward's University (University B) Institutional Review Boards.

Participant's treatment group allocation was determined by the university that they attended. The two participating universities were randomly dummy-coded either "University A" and University B". The baseball student-athletes from University A who volunteered and met the inclusion/exclusion criteria for this study were assigned to the Stretching treatment group. The baseball student-athletes who volunteered and

qualified for the study from University B were placed in the experimental group (Stretching + IASTM). The use of intact groups enabled the authors to blind the participants to the 2 treatments being compared in this study. Each participant's age, sex, height, body mass, and dominant/throwing arm were recorded to determine homogeneity between groups.

All experimental treatments and data collection sessions occurred at the university athletic training facility where the participants were enrolled as student-athletes. Participants in the stretching group received a total of 20 treatment sessions (5 per week for 4 weeks) over the intervention period and received the intervention immediately before practice. Participants in the Stretching + IASTM group received 20 identical stretching sessions over the 4-week period, plus 8 IASTM treatment sessions (2 sessions per week for 4 weeks). The IASTM treatments were completed at predetermined times that fit into the Participant's class/practice schedule. Both groups completed their treatment protocol during preseason activities before competition began. All IASTM treatments were administered by the principal investigator (TM).

We obtained pre-intervention measurements of glenohumeral internal rotation, external rotation, and horizontal adduction PROM just prior to administration of the first treatment during Week 0. Participants also completed the FAST, the FAST's pitcher's module (if they were a pitcher), and the KJOC as part of data collection. Within 48 hours of the final treatment session during Week 4 of this study, all participants returned to their respective athletic training clinics for post-intervention data collection. All ROM measurements were recorded by the principal investigator (TM).

Instrumentation

The study required the use of an instrument-assisted soft tissue mobilization device. A stainless-steel soft tissue mobilization tool known as The EDGE™ (Edge Mobility System, Buffalo, NY) was used for all treatments (Figure 2). This tool features 4 sides, a 45-degree beveled edge for accessing deeper tissues and a 90-degree scraping edge to work more superficial tissues.



Figure 2. The Edge™ Soft Tissue Mobilization Tool (Edge Mobility System, Buffalo, New York)

A digital inclinometer (Baseline™, White Plains, New York) (Figure 3) was used to obtain shoulder passive range of motion measurements. We used a method previously described by Laudner et al ^{17, 19} to assess glenohumeral internal rotation, external rotation, and horizontal adduction PROM. Their research on assessing posterior shoulder contracture found that their method had an intrarater reliability with ICC of 0.93, respectively, for the evaluator in their study.^{17, 19}



Figure 3. Digital Inclinometer (Baseline™, White Plains, New York)

Pilot Study

Prior to formal data collection, we conducted a pilot study with 7 physically-active, male volunteers (mean age = 20.6 ± 1.7 yrs), gathering data from a total of 14 shoulders, in effort to establish the intrarater reliability of the principal investigator (TM) for all clinical outcome measures. We calculated intraclass correlation coefficients from the 3-trial averages of all glenohumeral range of motion measurements obtained with a digital inclinometer.

According to Shrout and Fleiss intraclass correlation coefficient ($ICC_{3,1}$) values ≥ 0.75 indicate “excellent” intrarater reliability. Intraclass correlation

coefficient values between 0.40 and 0.74 are considered “good and fair” reliability, while values ≤ 0.39 reflect “poor” reliability.²⁰ We also used the pilot data to calculate the standard error of measurement and minimal detectable change values. All values are reported in Table 2.

Procedures for Data Collection

Each participant completed 2 patient-reported outcome measures to determine their upper extremity function and effects on sport specific activities. The self-reported questionnaires were completed at Week 0 prior to any treatments, and again at the completion of the study at Week 4. The FAST and the KJOC scores were used to gauge patient perceptions of the efficacy of the two treatment regimens being compared.

Passive Range of Motion Measurements

To measure glenohumeral internal rotation and external rotation, we positioned the participant supine on a standard examination table. The researcher positioned the participant’s arm in 90 degrees of abduction and 90 degrees of elbow flexion. The researcher then used one hand to apply a posterior force on the scapula to limit any accessory motion.¹⁸ With the other hand the researcher applied force to the dorsal area of the hand/wrist to internally rotate the humerus while also moving the digital inclinometer, once the researcher reached a point where no more glenohumeral rotation would be allowed without scapular movement the angle on the device was recorded (Figure 4). The same patient and clinician position and procedure was used to assess external rotation (Figure 5).¹⁷ To assess TROM, we measured both sides to compare and determine if the volunteer had a bilateral difference or loss of TROM.

According to Manske et al, a side-to-side TROM difference of 5 degrees or more has been defined as a TROM deficit.⁸



Figure 4. Internal Rotation Passive Range of Motion Measurement Technique



Figure 5. External Rotation Passive Range of Motion Measurement Technique

To obtain horizontal adduction PROM measurements, the participant was asked to lie supine on a standard examination table with their arm at 90 deg of

shoulder flexion and 90 deg of elbow flexion. The primary researcher then applied posterior force to the scapula with one hand to restrict any accessory movement, and with the other hand they grasp the elbow and horizontally adduct the arm until a firm end of range of motion is felt.¹⁸ The digital inclinometer was placed on the shaft of the humerus and the angle was recorded (Figure 6).¹⁸



Figure 6. Horizontal Adduction Passive Range of Motion Measurement Technique

Instrument-Assisted Soft Tissue Mobilization Techniques

In addition to performing stretching exercises 5 days per week, participants assigned to the Stretching + IASTM group received 2 IASTM treatments per week for 4 weeks with The Edge™ tool. These IASTM treatments consisted of 1 set of parallel strokes for 40 seconds (Figure 7), and 1 set of perpendicular IASTM strokes for 40 seconds to the posterior shoulder musculature (Figure 8) for a total treatment

time of 80 seconds. The target tissue for this intervention are those above the scapular ridge, from the medial border of the scapula to the lateral border of the scapula over the supraspinatus muscle.¹⁸ These techniques were chosen due to the success of acute (one-time) IASTM treatments reported by Laudner et al.¹⁸

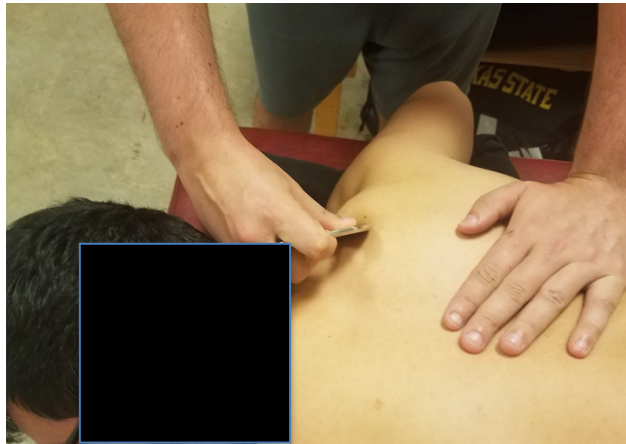


Figure 7. Parallel Stroke Technique for Instrument-Assisted Soft Tissue Mobilization of the Posterior Shoulder.



Figure 8. Perpendicular Stroke Technique for Instrument-Assisted Soft Tissue Mobilization of the Posterior Shoulder.

Shoulder Stretching Exercises

Both the Stretching and the Stretching + IASTM groups received the same stretching protocol for shoulder tightness including: external rotation passive static stretch (Figure 9), internal rotation passive static stretch (Figure 10), cross body passive static stretch (Figure 11), and horizontal adductor static stretch (Figure 12).¹¹ Each stretch was held for a total of 30 seconds and was repeated for 3 times each session.¹¹



Figure 9. External Rotation Passive Stretching Technique



Figure 10. Internal Rotation Passive Stretching Technique

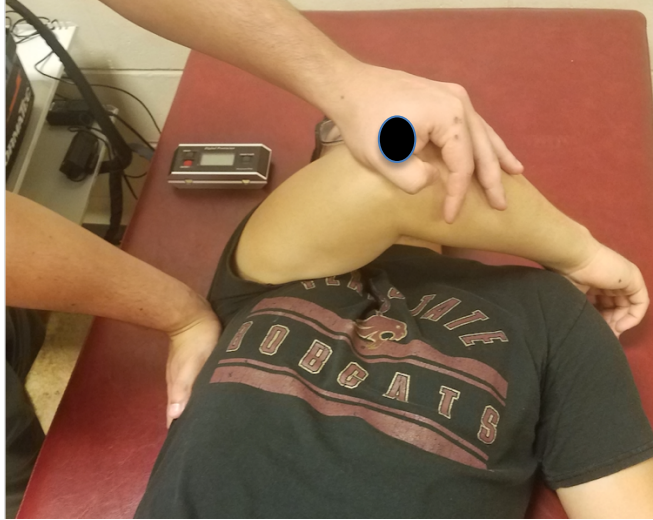


Figure 11. Cross Body Passive Stretching Technique



Figure 12. Horizontal Adductor Passive Stretching Technique

All stretching techniques were passive in nature and performed with the participant lying supine on a standard treatment table. A certified athletic trainer from each university performed the stretching protocol on their respective team players. The staff athletic trainer was informed of the participant's placement and was trained in what treatments they could not provide during the study period to protect the internal validity of the data collected.

We required that no additional or alternative therapeutic shoulder treatments could be applied to any participant during the 4-week intervention period, or else the participant would be dropped from the study. These banned treatments included soft tissue mobilizations, trigger point therapy, cupping techniques, and active release techniques.

Patient Reported Outcome Measures

Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow Score (KJOC). The KJOC is a 100-point scale that was created in 2011 by the orthopedic surgeons at the Kerlan-Jobe Orthopedic Clinic in Los Angeles, California, and has been used widely since that time.²¹ The purpose of the KJOC is to determine injury status, pain, and function of the shoulder or elbow of the patient.²¹ The KJOC questionnaire (see Appendix) begins a non-scored demographic information section, but then asked the respondent 10 questions about upper extremity function that each are scored on a 100 mm visual analog scale. The highest score on the KJOC is “100”, while the lowest score could be “0”.²¹ The KJOC was included due to its design for overhead athletes and use in the current literature.

The average KJOC scores recorded by Franz et al. assessing Major League and Minor League were 97.1 and 96.8, respectively, for uninjured participants.²² The authors also noted that those who had suffered previous upper extremity injuries/surgeries exhibited lower average score (86.7/75.4) and that pitchers reported the lowest average score by position group (90.9).²²

Functional Arm Scale for Throwers (FAST). The FAST is a 22-item questionnaire that was developed by researchers at the Arizona School of Health Sciences in 2017.²³ (see Appendix). There are 5 subscales on the FAST including: pain, impairment, functional limitation, disability, and societal limitation and these results can be used by the clinician to determine appropriate treatments and to determine if a treatment is positively impacting the patient.²³ The FAST was designed to be specific to the throwing athlete, including baseball players. Due to its recent inclusion in the literature there is limited data to compare our results to. There is also a 9-item Pitcher Module that can be completed along with the FAST to gain more specific data on those position players. The scoring system is based on a 5 point Likert-type scale, and range from “0” to “100”.²³ Higher scores on the survey indicate a lower health related quality of life.²³

Reference data for the FAST and baseball players has yet to be available in the literature due to its recent introduction into the sports medicine world.

Data Analysis

To determine whether the two intact groups of participants were statistically equivalent at the beginning of the study, we performed one-way ANOVAs on all 5 outcome measures, i.e., internal rotation and horizontal adduction PROM, TROM, KJOC score, FAST score, as well as on demographic data including age, height, mass, and years played.

Five Group (2) x Time (2) mixed (between/within) ANOVAs were performed to analyze the data. The assigned treatment Group (Stretching vs. Stretching +

IASTM) served as the between-subjects variable, while Time (Week 0 vs. Week 4) served as the within-subjects (repeated) measure.

Lastly, Pearson product moment correlations were calculated to quantify the relationships between the KJOC and FAST patient-reported outcome measures among our participants, both pre- and post-intervention. Alpha level was set *a priori* to $\alpha = 0.05$. All data were processed using version 24 of IBM SPSS software (IBM Corporation, Armonk, New York).

RESULTS

Pilot Study

Intraclass correlation coefficient (ICC_{3,1}) values were calculated from 3-trial average PROM values obtained by the principal researcher (TM) from 14 shoulders of 7 physically-active volunteers. The ICC values obtained for test-retest reliability were classified as “excellent” for glenohumeral external rotation and horizontal adduction PROM, and “good to fair” for glenohumeral internal rotation PROM (Table 2). In addition, standard error of the measurement (SEM) values were calculated from ICC values, and minimal detectable change values were calculated from SEM values.

Table 2. Interday Test-Retest Reliability Results for Principal Investigator

Glenohumeral Passive Range of Motion	Intra-Rater ICC Values (3-trial averages)	Standard Error of Measurement (deg)	Minimal Detectable Change (deg)
Internal Rotation	0.53	4.2	5.9
External Rotation	0.82	1.6	2.3
Horizontal Adduction	0.81	1.9	2.7

Analysis of Variance Results

Twenty of the 21 volunteers (95%) screened for participation completed all aspects of the study. A summary of the demographic information regarding our participants is presented in Table 3.

Tests for Homogeneity of Experimental Groups

In the absence of random assignment to the two experimental groups, we performed 5 one-way ANOVAs to determine if there were any statistically significant differences present between the groups at the outset of the study as well as one-way ANOVAs for demographic information including age, height, mass, and years played. There were no significant differences between ages, height, mass, or years played at baseline ($p > 0.05$). None of the 3 disease-oriented outcome measures were significantly different between the Stretching group and the Stretching + IASTM group at the beginning of the study ($p > 0.05$). There was also no statistically significant difference for the 2 patient-reported outcomes at baseline ($p > 0.05$).

The scores on the KJOC and FAST patient-reported outcome measures were also analyzed with one-way ANOVAs at the beginning of the study using to determine if there were any differences between groups. Like the disease-oriented outcome measures, none of the patient-oriented outcome measures were significantly different between the Stretching and the Stretching + IASTM groups at the beginning of the study ($p > 0.05$). However, the FAST scores reported in the Stretching and the Stretching + IASTM groups did approach a statistically significant difference, with $p = 0.06$.

Table 3. Participant Demographic Data at Entry into the Study

Parameter	Stretching + IASTM Group	Stretching Group	Total/Grand Mean
Number of Participants	10	10	20
Age (yrs)	20.9 \pm .9	19.9 \pm 1.4	20.4 \pm 1.3 yrs
Height (cm)	180.8 \pm 8.1	183.4 \pm 7.4	182.1 \pm 7.6 cm
Mass (kg)	85.7 \pm 7.2	87.1 \pm 8.5	86.4 \pm 7.7 kg
Years of Baseball Participation (yrs)	15.6 \pm 1.8	11.4 \pm 5.8	13.5 \pm 4.7 yrs
Arm Dominance	7 Right, 2 Left, 1 Ambidextrous	7 Right, 3 Left	14 Right, 5 Left, 1 Ambidextrous
Total Range of Motion Deficit > 5 degrees (deg)	5.23 \pm 10.1	13.45 \pm 11.9	9.3 \pm 11.5
Treatment Arm	6 Right, 4 Left	7 Right, 3 Left	13 Right, 7 Left
Position Played	5 Pitchers, 1 Catcher, 1 Infield, 3 Outfield	6 Pitchers, 2 Outfield, 2 Infield	11 Pitchers, 5 Outfield, 3 Infield, 1 Catcher

*Glenohumeral Joint Range of Motion*Internal Rotation PROM

Glenohumeral internal rotation PROM significantly improved in both groups between Week 0 and Week 4 ($p = 0.005$, $1 - \beta = 0.86$). Internal rotation PROM improved in the Stretching group from 52.8 ± 8.7 deg in Week 0 to 56.1 ± 8.4 deg (a 6.3% increase) in Week 4. Similarly, internal rotation PROM improved in the Stretching + IASTM group from 52.6 ± 7.2 deg in Week 0 to 56.7 ± 4.5 deg (a 7.8%

increase) in Week 4. There was no significant Group main effect or Group x Time interaction ($p > 0.05$) for this measure.

Total Range of Motion (TROM)

Total range of motion (TROM) significantly improved for both groups between Week 0 and Week 4 ($p = 0.005$, $1 - \beta = 0.87$). Total range of motion improved in the Stretching group from 145.2 ± 17.0 deg in Week 0 to 149.7 ± 18.4 deg (a 3.1% increase) in Week 4. Total range of motion also improved in the Stretching \pm IASTM group from 143.0 ± 8.4 deg in Week 0 to 149.0 ± 10.6 deg (a 4.2% increase) in Week 4. There was no significant Group main effect or Group x Time interaction ($p > 0.05$) for TROM.

Horizontal Adduction PROM

There were no significant Group or Time main effects, nor a Group x Time interaction observed for horizontal adduction PROM ($p > 0.05$, $1 - \beta = 0.10$). The Stretching + IASTM and the Stretching group means at Week 0 were $48^\circ \pm 4.7^\circ$ and $45.3^\circ \pm 3.9^\circ$, respectively. At Week 4, the means were $44.9^\circ \pm 4.8^\circ$ for the Stretching + IASTM group, and $46.1^\circ \pm 4.3^\circ$ for the Stretching group.

Patient-Reported Outcome Measures

KJOC

At Week 0, the IASTM + Stretching group and the Stretching group had similar mean scores of 75.9 ± 23.4 and 74.7 ± 23.6 , respectively ($p > 0.05$). By Week 4, both groups' average KJOC scores had improved (increased) significantly, with the IASTM + Stretching group reporting scores 85.3 ± 15.3 (+ 9.4 points) and for the Stretching group 89.7 ± 13.6 (+15.0 points) [$p = 0.556$]. There was no significant

Group effect ($p > 0.05$, $1 - \beta = 0.09$) or Group x Time interaction ($p > 0.05$, $1 - \beta = 0.18$) for the KJOC scores.

FAST

Average scores on the FAST at Week 0 for the IASTM + Stretching group and the Stretching group were 23.0 ± 20.0 and 17.6 ± 16.9 , respectively ($p > 0.05$). In comparison, Week 4 scores for the IASTM + Stretching group and the Stretching group were 8.7 ± 10.3 and 8.2 ± 11.4 , respectively. There was no significant Time main effect ($p > 0.05$, $1 - \beta = 0.41$) or Group x Time interaction for the FAST questionnaire scores ($p > 0.05$, $1 - \beta = 0.30$).

FAST Pitcher Module

No significant Group main effect nor Group x Time interaction ($p > 0.05$) was observed. The FAST 9-item Pitcher Module was completed by all 5 pitchers in the experimental group and all 6 pitchers in the traditional group. The scores on the FAST Pitcher Module significantly improved in both groups between Week 0 and Week 4 ($p = 0.049$, $1 - \beta = 0.53$). Specifically, the pitching module scores improved from 8.0 ± 16.8 at Week 0 to 3.33 ± 7.7 at Week 4 for the Stretching group, while these scores also improved for the Stretching + IASTM group from 31.3 ± 36.4 at Week 0 to 15.6 ± 21.9 by Week 4.

Pearson Correlation Results

The results of a Pearson product-moment correlations between the KJOC and the FAST indicated strong, inverse linear relationships between the two patient-rated outcome measures at Week 0 ($r = -0.874$, $p = 0.001$) and at Week 4 ($r = -0.765$, $p = 0.001$).

DISCUSSION

For all range of motion measures, our hypothesis that the Stretching + IASTM group would have statistically significant greater effect on glenohumeral internal rotation, horizontal adduction and TROM compared to the traditional Stretching group was rejected.

Glenohumeral Joint Passive Range of Motion

Internal Rotation PROM

The Stretching + IASTM group did not exhibit statistically greater improvements in internal rotation PROM when compared to the Stretching group, but both groups did improve their PROM over time. These results agree with the systematic review by Cheatham et al. who concluded IASTM was not better at increasing PROM than other interventions such as stretching or other soft tissue mobilization techniques after one-time exposures.¹⁰ One-time exposure studies that found significance had no follow up past the day of the treatment session, and therefore it would be problematic to compare the results of this study to the results of those.¹²⁻¹⁶ To the best of our knowledge, this is the first to investigate the effect of repeated IASTM treatments over an extended period of time, e.g., 4 weeks.

There are several possible explanations why the IASTM treatments did not increase PROM at the shoulder. As previously discussed, glenohumeral internal rotation in overhead sport athletes may be limited not only by soft tissue restrictions, but also by deep capsuloligamentous tightness and/or bony adaptations that IASTM is not capable of changing. Instrument-assisted soft tissue mobilization is most effective

for treating soft tissue restrictions or shortening.¹¹⁻¹⁵ If the cause TROM loss is due to capsular changes or bony adaptations, IASTM will not be an effective intervention.

Glenohumeral Total Range of Motion

The TROM measurement did not exhibit any statistically significant differences between groups; however, there were statistically significant TROM improvements for both groups across the 4 weeks of this study.

Reasons for the lack of difference between the groups are similar to the reasons listed above for glenohumeral internal rotation. Typically, TROM differences occur due to glenohumeral internal rotation deficit not meeting the external rotation gain that occurs in the throwing arm to maintain balance with the non-dominant shoulder. However, differences over Time that were found for both groups exceeded the minimal detectable change, indicating that the improvements were due to the stretching or the stretching + IASTM interventions.

Horizontal Adduction PROM

Our horizontal adduction PROM measurements did not change significantly in either group from the beginning of the study to the end. The cross-body stretch was chosen in lieu of the sleeper stretch due to its familiarity with the athletic trainers overseeing the stretching protocol and to ensure understanding and similar administration of the stretching protocol between the two groups. The lack of change in the horizontal adduction measurement may further enforce that some of participants included in the study were experiencing capsular or bony adaptations, and not soft tissue restrictions.

Patient-Reported Outcome Measures

KJOC

The results of the KJOC did not exhibit any statistically significant differences. This result may have been influenced by the exclusion criteria limiting the participants to volunteers without a current shoulder injury or a shoulder surgery within the past year. Although deficits were noted by the participants, meaning that the scores were not all 100s, the likelihood of increasing the score a significant amount was unlikely indicating that there was likely a ceiling effect.

The increases experienced by both groups indicate that they felt their shoulder was functioning better after conclusion of the study. Although there were not MDC values reported by Alberta et al., the values reported by Franz et al. in their study on professional baseball players reported average scores of 97.1 for uninjured major league athletes.²² This value does not correlate well with the results of this study, however the average value reported in the same study for previously injured/surgery athletes was 86.7, which is closer to the values for both groups after Week 4.

FAST

The FAST has not been widely used due to its recent introduction (2017) into the sports medicine realm.²³ Therefore, our results cannot be compared to the results of other studies. However, the results of the FAST did seem to be more responsive than the results of the KJOC, likely due to its focus on this population of throwing athletes.²³ There was also likely a ceiling effect, similarly to the KJOC, due to the use of uninjured participants.

The FAST has a self-reported MDC of 10.5 points, and the Stretching + IASTM group experiences a decrease (positive improvement) of 14.3 points, which was clinically important for the patient. The change (improvement) in the FAST scores in Stretching group approached clinical significance, with a difference of 9.4 points between Week 0 to Week 4.

Limitations

This study had several limitations that must be acknowledged. A relatively small number of participants were screened for inclusion in the study, and this led to small groups from both of the intact groups that we obtained permission to recruit to participate in this study. Recruitment of baseball players from more than the two universities sampled would have been too expensive, given the limited budget for this research project. Without question, recruitment of a larger number of intercollegiate baseball teams (and players) would have increased both the statistical power and external validity of this study.

The scope of this study was also constrained by the limited time available to collect data on active collegiate baseball players. We found that intercollegiate baseball pitching coaches are reluctant to allow their pitchers to alter their exercise and therapeutic regimens during an active NCAA season.

The addition of a soft tissue restriction screening measure such as diagnostic ultrasound or magnetic resonance imaging may have identified a specific subgroup of participants that would have been more appropriately treated with IASTM and stretching. As previously noted, shoulder capsule tightness and bony adaptations, i.e., humeral retroversion, may contribute to decreased PROM.

Expenses were also limiting in the scope of this study. The inability to add a more effective screening protocol such as diagnostic ultrasound or MRI, as mentioned above, as well as the number of trips that could be made between institutions were both limited by available thesis research funds.

The results of this study suggest that the reported successes of IASTM may be limited to short term effects on increasing PROM due to the success of other studies for increasing ROM after 1-time exposures.^{10, 11, 14, 15} This may be due to the design of IASTM treatment, with its intention for treating soft tissue adhesions.^{9, 10, 11, 14, 15} The effects of the treatment need to be reinforced with stretching and movement patterns that use the new available ROM. If the baseball participant continues to use his arm the same way, then a pattern of ROM loss will follow, with the same soft tissue adhesions or restrictions forming in a similar fashion.

CONCLUSION

The results of this study indicate that the IASTM treatment may not be effective when used at the current dosage to increase PROM in intercollegiate baseball players with GIRD or decreased TROM. The use of IASTM in combination with stretching was no better than stretching alone at improving glenohumeral PROM and TROM. If a patient presents with an acquired loss of glenohumeral PROM, other therapeutic interventions such as stretching should be considered along with IASTM.

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3: SUMMARY AND RECOMMENDATIONS FOR FUTURE STUDY

The purpose of this study was to determine if a 4-week therapeutic program of instrument-assisted soft-tissue mobilization (IASTM) and stretching would produce greater improvements in glenohumeral passive range of motion (PROM) than stretching alone. The results of our study suggest that both interventions generated glenohumeral range of motion improvements over time.

The key outcome measures for this study were glenohumeral internal rotation and horizontal adduction passive range of motion, total range of motion, as well as the patient reported outcomes (PROs), the Kerlan-Jobe Orthopedic Clinic scores (KJOC), Functional Arm Scale for Throwers (FAST), and 9-question FAST module for pitchers. In all three PROM measurements there were no statistically significant differences between the experimental group and the traditional group ($p > 0.05$). The participants in the traditional group received a stretching protocol that included a horizontal adductor static stretch, an internal rotator static stretch, an external rotator static stretch, and a horizontal cross body static stretch. The participants in the experimental group received a total of 8 IASTM treatments along with the stretching protocol. All participants received their intervention over a 4-week period with all PROM and PRO measurements taken before the first treatment session at Week 0, and 48 hours after the last treatment session of Week 4. Participants were assigned to groups based on the university they were attending. The decision to use 2 intact

groups allowed for blinding of the participants to the treatment received by the other group.

There were some limitations to the study including the recruitment of participants and the lack of an additional screening protocol. The number of participants that qualified for inclusion in the study from both institutions was limited to those who volunteered for screening. Since participation was open only to NCAA athletes, we could provide no financial incentive or compensation for involvement.

The addition of another screening protocol that would have lengthened the time commitment from the participants and potentially increased the cost may have also been beneficial to differentiate between participants who had a PROM limitation from soft tissue restrictions and not capsular or bony adaptations.

This study may be the first to have conducted IASTM treatments over a 4-week period of time. The results do indicate that both interventions were beneficial for improving PROM; however, future studies may be more specific with treatment parameters.

Recommendations for Future Research

- Increase the pool of research candidates to increase participation numbers and power of results.
- Prolong data collection time to out of season training to avoid conflict of daily practices or games that may diminish PROM.
- The addition of data collection points to determine if PROM gains from IASTM diminish after 24 hours, 48 hours and so on.

APPENDIX SECTION

Appendix A



IRB Application Texas State University Institutional Review Board

Section I: Filling Out and Saving the Form

Save this application on your desktop. Upon completion, upload it along with all supplemental documents to the applicable project listed on your on-line IRB Home Page.

Section II: General Information

1. Title of Study

Insert the project name below. It should be identical to the title of any related internal or external grant proposal.

Comparison of Instrument-Assisted Soft Tissue Mobilization and Passive Stretching to Improve Glenohumeral

2. Investigator (Primary Research)

First Name	Last Name	Title (i.e. grad student, student, etc.)
Troy	Mendenhall	Grad student
Degree Program/Department	Texas State Email Address	Phone Number
Athletic Training	t_m246@txstate.edu	240-434-2953

If you are a student, is this application for your thesis or dissertation research?

☒ Yes
☐ No

3. Co-Investigator or Texas State University Sponsoring Faculty (if applicable)

First Name	Last Name	Title (i.e. grad student, student, etc.)
Rod	Harter	Department Chair
Degree Program/Department	Texas State Email Address	Phone Number
Athletic Training	rh56@txstate.edu	

4. Project Dates

Anticipated Start Date: 12/1/2017
Anticipated End Date: 03/1/2018

5. Key Personnel

List the names of all other Key Personnel (including students) who are responsible for the design, conduct, recruitment of participants, data collection, or reporting of the study.

	Name	Email
1.	Natalie Myers	natalie.myers@txstate.edu
2.		
3.		

6. CITI IRB Training

Have you, any Co-Investigator, Student Investigator, and all other Key Personnel completed the CITI training course ("Social and Behavioral Research")?

☒ Yes

☐ No

If you answered "No," this training is required for all Key Personnel before your study can be approved. The CITI course may be accessed by visiting: <https://www.citiprogram.org/>. Training is valid for 3 years and will require a refresher course when it expires. Your application will not be approved until all required training is completed and current.

7. Funding Information (if applicable)

Has *external or internal funding* been proposed or awarded for this project?

☐ Yes

☒ No

If yes, please include the OSP Proposal/Project Number (external) or Texas State account number (internal) for this project.

OSP Proposal/Project Number:

Texas State Account Number:

8. Financial Conflict of Interest Disclosure (if applicable)

Do you or any other person responsible for the design, conduct, or reporting of this research have an economic interest in, or act as an officer or a director of, any outside entity whose financial interests would reasonably appear to be affected by the research?

☐ Yes

☒ No

For externally funded research, Texas State University requires the Principal Investigator, Co-Investigator, project director, and all other personnel with responsibility for designing, conducting, or reporting of externally funded research to complete an online Financial Conflict of Interest disclosure each fiscal year.

Section III: Risk Review

Please click the box indicating your answer to each of the following questions:

1. Will your research study involve any vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, cognitively impaired elderly, or minority ethnic groups?
☐ Yes
☒ No
2. Could public disclosure of any identifiable data you collect place the participants at risk of criminal or civil liability or be damaging to the participants' financial standing, employability or reputation?
☐ Yes
☒ No
3. Will your study involve data collection procedures other than surveys, educational tests, interviews, or observation of public behavior?
☒ Yes
☐ No
4. Will your study involve the collection of sensitive data such as: illegal drug use, alcohol abuse, victims of violence, health history, prior diagnosis of mental disorders, sexual activity, criminal activity, or personal academic history?
☐ Yes
☒ No
5. Will your study involve audio or video-recording research participants?
☐ Yes
☒ No
6. Will your study involve obtaining individually identifiable information from health care providers, clearinghouses, or plans?
☐ Yes
☒ No
7. Will you be collecting anonymous data (results cannot be linked to individual participants)?
☐ Yes
☒ No
8. Will you be using data that was previously approved by the Texas State IRB?
☐ Yes
☒ No

If yes, please provide the Texas State IRB approval number:

9. Will you be using data that was previously approved by a non-Texas State IRB at an another institution, organization, center?

☐ Yes
☒ No

If yes, please provide the name of the institution/organization and upload the applicable original IRB approval that authorized the data collection:

Were you provided and instructed to sign and complete a Data Use Agreement (DUA)?

☐ Yes
☐ No

If yes, please provide a copy of the agreement. Please note that the AVPR is the only University official authorized to sign this legally binding document.

10. Does this project SOLELY involve analysis of publicly available existing database?

☐ Yes
☒ No

If yes, please provide the complete URLs for all databases that are relevant to this application:

**If you answered yes to questions 8, 9, or 10, please submit the appropriate documents and only complete the Purpose of Study (1), Previous Research (2), and Publication of Results (11) in Section IV of this application.*

Section IV: Research Protocol Information

1. Purpose of Study

Provide a brief summary of the proposed research. Include the hypothesis and research design.

The purpose of this study will be to determine the extent to which a four-week program of static stretching (SS) plus instrument-assisted soft tissue mobilization (IASTM) will increase shoulder range of motion and improve function in comparison to a program of static stretching (SS) alone in a group of intercollegiate overhead sport participants.

We hypothesize that the use of IASTM will create significantly greater gains in shoulder passive range of motion (glenohumeral horizontal adduction and internal rotation) than a traditional shoulder stretching protocol over the four-week intervention period ($p < 0.05$).

We will employ a prospective cohort experimental design to compare a static stretching plus instrument-assisted soft tissue mobilization (SS + IASTM) group to a static stretching (SS) group for differences in range of motion, pain level and function. We chose to conduct a study on this topic due to the paucity of prospective, well-controlled studies utilizing this newer IASTM clinical technique, as well as the desire to identify a more efficient approach to increasing shoulder range of motion in those who already have a restricted or limited range.

We will analyze the seven dependent variables associated with this study with a two-way Treatment Group (SS, SS +

2. Previous Research

Briefly summarize previous research leading to the formulation of this study, including any past or current research conducted by the Investigator that leads directly to the formulation of this study.

Currently, there are no long-term clinical studies that have used instrument-assisted soft tissue mobilization as a treatment for restricted shoulder range of motion or improved shoulder function. Past research in this area has been limited to the single treatment use of instrument-assisted soft tissue mobilization for improving range of motion in the upper extremity, or has not focused on the upper extremity exclusively.

Previous studies by Laudner et al (2014) and Bailey et al (2015) both reported immediate range of motion improvements following the one-time application of instrument-assisted soft tissue mobilization, with Bailey et al reporting better results in their IASTM group compared to a static stretching group. However, there remains a need to identify the effects of repeated IASTM treatments to determine its effectiveness as a tool to gain or restore lost range of motion, and reestablish normal function in the glenohumeral joint complex. IASTM has been shown in the literature to be a safe and effective way to regain range of motion in one-time applications. There have been no reported adverse effects of IASTM in the current evidence.

3. Recruitment of Participants

Describe the source(s) of subjects and the selection criteria. Include the gender, racial/ethnic composition, age range, occupation, etc. Specifically describe how will you recruit and contact potential subjects. Also, include the anticipated number of research participants. All recruitment materials such as flyers, e-mails, verbal scripts, advertisement, etc. are required to be submitted and approved by the IRB.

Volunteers for this study will be recruited from Texas State University and St. Edward's University intercollegiate baseball teams, as baseball players are the primary clinical population in sports medicine with shoulder range of motion restrictions. These institutions were selected due to the lead researchers' relationships with both institutions, and also to blind the participants to their assigned treatment group. Each participant will be 18 years or older, will have not had shoulder surgery in the past six months, and will be actively participating on the baseball team. We will recruit volunteers from each university via the staff athletic trainers at each university through the use of direct appeal who will describe the study specific to the group in which they will be participating: the static stretching program at Texas State University and a static stretching program plus instrument-assisted soft tissue mobilization at St. Edward's University.

All volunteers for the study will have their shoulder range of motion measured bilaterally for glenohumeral internal rotation, glenohumeral external rotation, and glenohumeral horizontal adduction. Each range of motion measurement will be recorded using a protocol developed by Laudner et al (2006). The Laudner protocol was chosen for its reported excellent intrarater reliability ICC at 0.93 and SEM of 0.9 degree.

To qualify for this study, the volunteer must exhibit a 10 degree difference for internal rotation between the non-throwing shoulder and the throwing shoulder, as well as at least a 5 degree difference between total range of motion difference between the non-dominant shoulder and the throwing shoulder. Total range of motion of the shoulder is calculated by summing the internal rotation range of motion value and the external rotation range of motion value.

4. Vulnerable Populations

Please identify any vulnerable populations that will be recruited to participate in this study:

☐ Children

☐ Pregnant Women

☐ Prisoners

☐ Mentally Impaired

☐ Cognitively Impaired Elderly

☐ Ethnic Minorities, Non-English Speaking Individuals

☐ Other: Please list:

☒ N/A, this study will not use vulnerable populations as research participants.

If applicable, describe any special precautions that will be taken for the inclusion for identified vulnerable populations. I.e., use of informed assent and parental consent for minors or consent documents in an alternative language for individuals who do not speak English.

5. Informed Consent

Describe the consent process and upload all consent documents. If you are requesting a waiver of signed informed consent, please state the rationale and how consent will be alternatively obtained (verbal, "clicking" an on-line button or link, participation will imply consent, etc.)

Written consent will be obtained from each participant via an approved Informed Consent document. By reading and signing the informed consent document, the participant will acknowledge why we are conducting the study, their particular role in the study, and the potential risks and benefits associated with the study.

6. Procedures

Provide a step-by-step description of each procedure, including the frequency, duration, and location of each procedure. Also, for data collection sites other than Texas State that involves the authorization and coordination with an outside agency, please upload a signed and dated letter on the cooperating institution's letterhead granting approval for the data collection.

The initial screening of each volunteer will be conducted by the principal investigator (TMM) and include shoulder passive range of motion measurements of internal rotation, external rotation, and horizontal adduction to determine their eligibility for the study. Those participants who qualify for the study will be provided an Informed Consent document, and those who sign the informed consent document will be assigned a numerical subject identifier to ensure confidentiality is maintained. The passive range of motion data gathered at the initial screening will be used as the pretest (Week 0) data for all baseball players who qualify for participation in the study. At the conclusion of the study (Week 4), the same three passive range of motion measurements will be obtained.

In order not to confound the results of our study by having members of the same baseball team receive two different experimental treatments for a similar medical condition, we decided to assign one treatment protocol at one university, and our other treatment protocol to an intact group at a different university. This way, the participants at one institution will be blinded to the results of a comparison treatment protocol that may produce better clinical outcomes over the c

7. Confidentiality

Describe the procedures that will be used to maintain the confidentiality of all personally identifiable data. (Please note: All data must be securely kept for a minimum of three years on campus. The location of the secured data should be listed below.)

To maintain confidentiality, each participant who qualifies for inclusion in this study will be assigned a coded numerical identifier that indicates the treatment protocol they will receive ("01" for the SS group or "02" for the SS + IASTM group) and a subject number, e.g., S0215. After data collection, the numerical assignment will be the only identifier for each subject to protect their information from those not involved in the study. The master list of the participant codes, as well as the raw data generated from this study will be maintained in a locked file cabinet in the faculty office of Dr. Rod Harter, chair of this thesis committee (Jowers Center A132).

8. Risks

Describe any foreseeable or anticipated risks that may be presented to the participants as a result of taking part in the study. Please describe all of the precautions that will be implemented to minimize such risks.

While there are minimal risks associated with participation in this study, risk of further injury, albeit small, does exist. All participants in this study will be members of intercollegiate baseball teams, and as such, have daily access to unlimited, free sports medicine care provided by the athletic trainers and team physicians at their respective institutions.

For the participants who will be assigned to the static stretching (SS) treatment group, the risks associated with the stretching protocol are minimal and include only mild discomfort during the stretching, and possibly some residual muscle soreness common to any muscle stretching program.

For the participants in the static stretching plus instrument-assisted soft tissue mobilization (SS + IASTM) treatment group, the risks associated with the protocol include the potential redness and bruising in the area treated by the IASTM tool, as well as the same risks for mild discomfort and muscle soreness from the stretching protocol. To address these potential side effects for the SS + IASTM group, we will require a minimum of 48 hours between their two treatment

9. Benefits

Describe the anticipated benefits to subjects, and the importance of the knowledge to your field that may reasonably be expected to result.

Those participants in the static stretching (SS) group will be receiving the current established standard treatment for improving shoulder range of motion and may experience relief from general posterior shoulder tightness. Those participants in the static stretching plus instrument-assisted soft tissue mobilization (SS + IASTM) group will be receiving the current standard treatment and a potentially superior treatment for improved shoulder range of motion and may experience relief from general posterior shoulder tightness. We expect both treatment groups to have increased shoulder range of motion, less pain, and improved after the four-week intervention.

Additionally, the results of this study will advance the body of knowledge in this area of research. Currently there is very scarce evidence supporting the use of instrument-assisted soft tissue mobilization, or any well-controlled research studies that investigate the effects of IASTM treatment method past one exposure. This study will provide new evidence regarding the repeated and/or extended use of IASTM, which is important to physical medicine practitioners who often currently employ this technique.

10. Compensation

Describe any compensation subjects will receive for participating in the study. Include a description of the compensation, timing for payment, and conditions for receipt of such compensation. Please note: If extra course credit is offered as an incentive for participation, the instructor must provide an alternative form of extra credit to students who do not want to participate in the research.

Since this study is only open to student-athletes involved in NCAA-sponsored sports that involve scholarship support, per NCAA rules, participants are not eligible to receive compensation or incentives for their participation.

11. Publication of Results

Please identify all methods in which you may publicly disseminate the results of your study.

- | | |
|--|--|
| <input checked="" type="checkbox"/> Academic Journal | <input checked="" type="checkbox"/> Thesis or Dissertation |
| <input checked="" type="checkbox"/> Academic Conference Presentation | <input type="checkbox"/> Texas State University Scholarly Works Repository |
| <input type="checkbox"/> Academic Conference Poster | <input type="checkbox"/> Other: Please list <input type="text"/> |
| <input type="checkbox"/> Book or Textbook Chapter | |

Section V: Investigator Certification

- ☒ By checking this box, I am certifying that the information in this application is complete and accurate. I agree that this study will be conducted in accordance with Texas State IRB Guidelines. I will request IRB approval before making any modification to the research procedures or forms. I understand that neither recruitment nor data collection will be initiated until final IRB approval is received. I will notify the IRB any unexpected or otherwise significant adverse events and general problems within one week of the incident. I understand that if these conditions are not met, this research could be suspended and/or not recognized by Texas State University.

This application and all supplementary documents must be submitted together to be processed for review. The IRB will contact you if additional information or revisions are needed for approval. All revisions must be submitted within 30 days of the request. After that time all the application will be discontinued. If your application is discontinued you will be required to resubmit another application.

Contact The Office of Research Integrity and Compliance at (512) 245-2334 or avpr-irb@txstate.edu for any questions concerning the approval status of your application.

Meeting verbal script

"Hello, and thank you for your time. My name is Troy Mendenhall and I am a graduate assistant athletic trainer at Texas State University. I requested this meeting with your team to recruit you to participate in my master's thesis study. My study will compare two treatment protocols for baseball players who have shoulder tightness and decreased range of motion. My study will be 4 weeks long, and is designed to occur in parallel with your baseball practices.

If you decide to volunteer to be screened for inclusion in this research study, I will measure your shoulder range of motion measurements to determine your eligibility. This study has been approved by the Texas State University Institutional Review Board. If you are eligible to participate in this study, you will be given an Informed Consent document that describe the protocol in greater detail and what your participation will mean."



In future correspondence please refer to 2018214

November 30, 2017

Troy Mendenhall
Texas State University
601 University Dr.
San Marcos, TX 78666

Dear Mr. Mendenhall:

Your application 2018214 titled, "Comparison of Instrument Assisted Soft Tissue Mobilization and Passive Stretching to Improve Glenohumeral Range of Motion and Function," was reviewed by the Texas State University IRB and approved. It has been determined there are: (1) research procedures consistent with a sound research design and they do not expose the subjects to unnecessary risk. (2) benefits to subjects are considered along with the importance of the topic and that outcomes are reasonable; (3) selection of subjects is equitable; and (4) the purposes of the research and the research setting is amenable to subjects' welfare and producing desired outcomes; that indications of coercion or prejudice are absent, and that participation is clearly voluntary.

1. In addition, the IRB found that you need to orient participants as follows: (1) informed consent is required; (2) Provision is made for collecting, using and storing data in a manner that protects the safety and privacy of the subjects and the confidentiality of the data; (3) Appropriate safeguards are included to protect the rights and welfare of the subjects.

This project is therefore approved at the Expedited Review Level until October 31, 2018

2. Please note that the institution is not responsible for any actions regarding this protocol before approval. If you expand the project at a later date to use other instruments, please re-apply. Copies of your request for human subjects review, your application, and this approval, are maintained in the Office of Research Integrity and Compliance.

Report any changes to this approved protocol to this office. A Continuing Review protocol will be sent to you in the future to determine the status of the project. Notify the IRB of any unanticipated events, serious adverse events, and breach of confidentiality within 3 days.

Sincerely,

Monica Gonzales
IRB Regulatory Manager
Office of Research Integrity and Compliance
Texas State University

CC: Dr. Rod Harter

OFFICE OF THE ASSOCIATE VICE PRESIDENT FOR RESEARCH

601 University Drive | JCK #489 | San Marcos, Texas 78666-4616

Phone: 512.245.2314 | fax: 512.245.3847 | WWW.TXSTATE.EDU

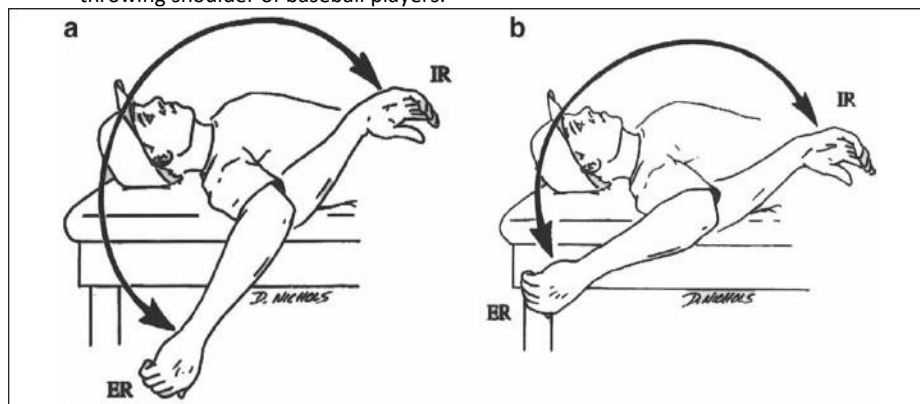
This letter is an electronic communication from Texas State University-San Marcos, a member of The Texas State University System.

1. All individuals included in the study will be collegiate baseball players who have been determined to have an orthopedic condition known as pathological-glenohumeral (shoulder) internal rotation deficit (GIRD). The clinical definition of GIRD is a difference of greater than 5 degrees of total shoulder range of motion (ROM) between the dominant and non-dominant shoulders of an overhead sport athlete. In this context, "total range of motion" is calculated as the shoulder internal rotation ROM + external rotation ROM.

Previous research has shown that a side-to-side difference of greater than 5 degrees puts the athlete at a greater risk for injury. The difference presents as a loss of range of motion in the dominant arm, not an increase in range of motion. Any participant who is screened and has increased range of motion will not meet the inclusion criteria for the study. A volunteer may be screened and be found to have pathological GIRD though they currently do not exhibit pain as a symptom, they will be given the choice to participate in the study via the Informed Consent document.

The diagram below (**Figure a**) demonstrates the shoulder external rotation gain and internal rotation deficit that often presents in the throwing shoulder of baseball players.

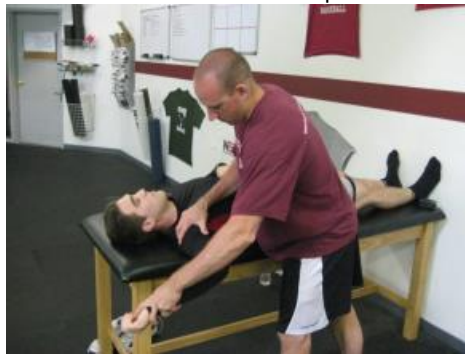
Figure b demonstrates the normal (typical) total range of motion arc in the non-throwing shoulder of baseball players.



2. The stretching program includes 4 passive, static stretches that target the surrounding shoulder musculature. They address different shoulder muscle groups that contribute to the throwing motion. All 4 stretches are completed in a similar position that was used for the range of motion measurements, supine on a standard assessment

table. The participant will be instructed to verbalize to the athletic trainer when they feel tension at the end range of motion that may feel unpleasant but not painful.

For the **shoulder external rotator stretch** the arm is moved into 90 degrees of abduction and 90 degrees of elbow flexion. The athletic trainer then passively moves the participant's arm into external rotation until they feel an end point or the athlete verbalizes that they feel a stretch, this position is held for 60 seconds. An example of the stretch is demonstrated in the photo below.



The **shoulder internal rotator stretch** uses the same starting position and protocol. The athletic trainer then passively moves the participant's arm into internal rotation until they feel an end point or the athlete verbalizes that they feel a stretch, this position is held for 60 seconds. The photo below demonstrates this stretch.



The **cross body stretch** has the participant in the same supine position. The athletic trainer will passively move the arm across the body so the hand reaches towards the opposite side of the table until they feel an end point or the participant verbalizes that they feel a stretch; this end position is held for 60 seconds. The photo below demonstrates this stretch.



The **anterior chest muscle** stretch keeps the participant in the supine position but requires their arm to be off of the table, the athletic trainer brings the participant into 90 degrees of abduction, then pushes the arm towards the floor until they feel an endpoint or the participant verbalizes that they feel a stretch, this position is held for 60 seconds. An example of the stretch is demonstrated in the photo below.



3. The SS + IASTM group will perform the static stretch protocol 5 days a week.
4. IRB concern addressed in **Risks** section of the revised consent form.
5. IRB concern addressed in the **Benefits** section of the revised consent form.
6. The athletic trainers at each university will invite their respective teams attend a meeting with the lead researcher (Troy Mendenhall), to discuss their potential participation in this research study. I will then read the following script to them at the meeting:

“Hello, and thank you for your time. My name is Troy Mendenhall and I am a graduate assistant athletic trainer at Texas State University. I requested this meeting with your team to recruit you to participate in my master’s thesis study. My study will compare two treatment protocols for baseball players who have shoulder tightness and decreased range of motion. My study will be 4 weeks long, and is designed to occur in parallel with your baseball practices.

If you decide to volunteer to be screened for inclusion in this research study, I will measure your shoulder range of motion measurements to determine your eligibility. This study has been approved by the Texas State University Institutional Review Board. If you are eligible to participate in this study, you will be given an Informed Consent document that describe the protocol in greater detail and what your participation will mean.”

7. IRB concern addressed in the **Procedures** section of the revised consent form.



INFORMED CONSENT

Study Title: Comparison of Two Rehabilitation Programs Designed to Improve Shoulder Joint Range of Motion and Function in Overhead Sport Athletes

Principal Investigator: Troy Mendenhall

Co-Investigator/Faculty Advisor: Dr. Rod Harter

This consent form will give you the information you will need to understand why this research study is being done, and why you are being invited to participate. This document will also describe what you will need to do to participate as well as any known risks, inconveniences or discomforts that you may have while participating. We encourage you to ask questions at any time. If you decide to participate, you will be asked to sign this form and it will be a record of your agreement to participate. You will be given a copy of this form to keep.

PURPOSE AND BACKGROUND

You are invited to participate in a research study that will compare two different rehabilitation protocols designed to reduce the posterior shoulder tightness in your throwing arm. The purpose of this study is to determine the extent to which a 4-week program of static stretching (SS) vs. static stretching (SS) plus instrument-assisted soft tissue mobilization (IASTM) will increase shoulder range of motion and improve function in a group of intercollegiate overhead sport participants.

PROCEDURES

We have arranged a date and time for you to meet the principal investigator (TM) of this study at your school's athletic training room to be screened for eligibility to participate in this study. The researcher will ask you several questions about your throwing shoulder, your history of injuries to that shoulder, and measure your passive range of motion in both shoulders to determine whether you are eligible to participate in our study.

If you meet the inclusion criteria and agree to be in this study, you will be asked to do the following:

- At the beginning (Week 0) and at the end (Week 4) of this study, permit the measurement of the passive range of motion of both of your shoulders.
- At the beginning (Week 0) and at the end (Week 4) of this study, complete two brief sports injury questionnaires, the 22-item Functional Arm Scale for Throwers (FAST) and the 10-item Kerlan-Jobe Orthopaedic Clinic (KJOC) Shoulder and Elbow Score to assess the functional ability of your throwing shoulder.
- Be assigned to one of two treatment groups, and receive the assigned treatment protocol for 4 weeks as directed by the principal investigator (TM) or your school's athletic trainer responsible for the baseball team.

PROCEDURES—continued:

If you agree to be in the study, you will be asked to participate in 2 to 5 treatment sessions per week (a total of 8 to 20 sessions, depending on the treatment group you are assigned) for a period of 4 weeks. Each treatment session will last between 5 to 15 minutes. Completion of the questionnaires will take approximately 15 minutes. The total time will take no longer than 30 minutes.

RISKS/DISCOMFORTS

For the participants who perform the static shoulder muscle stretches, the risks associated are minimal, and include mild discomfort during the stretching itself, and possibly some residual muscle soreness that is associated with any muscle stretching program.

For the participants who receive instrument-assisted soft tissue mobilization treatments, the risks include the potential redness and bruising in the area treated by the IASTM tool. You may also experience the risks associated with static stretching including mild discomfort during the stretch itself, and possibly some residual soreness that is associated with any muscle stretching program.

As a member of an intercollegiate baseball team, you have daily access to unlimited, free sports medicine care provided by the athletic trainers and team physicians at your school. Please be sure to let the principal researcher and an athletic trainer at your school know if you experience discomfort after any treatment.

In the unlikely event that the sports injury questions on the FAST or KJOC questionnaires make you uncomfortable or upset, you are always free to decline to answer, or to stop your participation at any time.

BENEFITS/ALTERNATIVES

The goals of this study are to improve shoulder range of motion and function, and reduce pain in the throwing shoulders of intercollegiate baseball players. You may experience decreased shoulder pain and tightness from participation in this study. Also, the information gained from your participation will help us identify a better treatment protocol for posterior shoulder tightness for future athletic trainers and other sports medicine practitioners.

EXTENT OF CONFIDENTIALITY

Reasonable efforts will be made to keep the personal information in your research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. The members of the research team and the Texas State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants.

Your name will not be used in any written reports or publications which result from this research. Data will be kept for three years (per federal regulations) after the study is completed and then destroyed.

PAYMENT/COMPENSATION

Since this study is only open to student-athletes involved in NCAA-sponsored sports that involve scholarship support, per NCAA rules, participants are not eligible to receive compensation or incentives for their participation.

PARTICIPATION IS VOLUNTARY

You do not have to be in this study if you do not want to. You may also refuse to answer any questions you do not want to answer. If you volunteer to be in this study, you may withdraw from it at any time without consequences of any kind or loss of benefits to which you are otherwise entitled.

QUESTIONS

If you have any questions or concerns about your participation in this study, you may contact the Principal Investigator, Graduate Assistant Troy Mendenhall: 240-434-2953, or t_m246@txstate.edu.

This project was approved by the Texas State IRB on November 30, 2017. Pertinent questions or concerns about the research, research participants' rights, and/or research-related injuries to participants should be directed to the IRB Chair, Dr. Denise Gobert 512-245-8351 (dg46@txstate.edu) or to Monica Gonzales, IRB Regulatory Manager 512-245-2314 – (meg201@txstate.edu).

DOCUMENTATION OF CONSENT

I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement and possible risks have been explained to my satisfaction. I understand I can withdraw at any time.

Printed Name of Study Participant

Signature of Study Participant

Date

Signature of Person Obtaining Consent

Date

IRB approved application # 2018214
Version # 1



Page 4 of 4

Appendix B

Figure 11. The Functional Arm Scale for Throwers

Functional Arm Scale for Throwers[®] (FAST[®])

ID: _____

Today's date: _____

This questionnaire asks about how your arm (shoulder, upper arm, elbow, forearm, wrist, hand, fingers) feels. It asks about how your arm condition affects your ability to throw and to function in sport and daily activities.

Instructions: Please answer every question based on your arm condition **during the last week** by circling the number for the appropriate response. If you did not engage in an activity in the past week, please answer questions based on your estimate of how your arm condition would affect your ability to engage in the activity.

Pitchers, please be sure to complete the pitcher-specific section at the end.

	Complete y	Extremel y	Moderatel y	Slightly	Not satisfied at all
1. How satisfied are you with the way your arm is now functioning?	1	2	3	4	5
	None	Mild	Moderate	Severe	Extreme
2. How much pain do you have in your injured arm prior to your start, following your warm-up?	1	2	3	4	5
3. How much pain or discomfort do you have in your arm at night?	1	2	3	4	5
4. How much strength have you lost in your arm as a result of your arm injury?	1	2	3	4	5
	Not at all	Slightly	Moderatel y	Severel y	Extremel y
5. How much has your arm injury limited your ability to advance in baseball or softball?	1	2	3	4	5
6. How much have you modified your behavior to avoid making your arm injury worse?	1	2	3	4	5
7. Since your arm injury, do you have a more negative outlook on life?	1	2	3	4	5
8. How much does your arm injury interfere with things that are important, other than sports?	1	2	3	4	5
9. How stiff is your arm at night?	1	2	3	4	5
10. How much has your playing time gone down since the injury to your arm?	1	2	3	4	5
11. How much are you limited when lifting your arm overhead to get dressed?	1	2	3	4	5
	No, not at all	Yes, slightly	Yes, moderatel y	Yes, severel y	Yes, extremel y
12. Has your enjoyment of life decreased since your arm injury?	1	2	3	4	5

13. Has your arm injury decreased how long you can continue throwing during a single practice or game?	1	2	3	4	5
14. Have your sports accomplishments decreased since your arm injury?	1	2	3	4	5
	No, not at all	Yes, slightly	Yes, moderately	Yes, severely	Yes, extremely
15. Has your life been more stressful because of your arm injury?	1	2	3	4	5
16. How much pain or discomfort do you have in your arm with daily activities involving reaching?	1	2	3	4	5
17. How much pain or discomfort do you have in your arm if you use it for activities that last longer than 30 minutes?	1	2	3	4	5
	Not at all	Slightly	Moderately	Severely	Unable to throw
18. How much has your arm injury limited your ability to throw 'long toss'?	1	2	3	4	5
19. How much has your throwing accuracy decreased since your arm injury?	1	2	3	4	5
20. How weak does your arm feel during throwing?	1	2	3	4	5
21. How painful is your arm during "game speed" throwing?	1	2	3	4	5
22. How painful is your arm during 50-75% effort throwing?	1	2	3	4	5

Pitcher Module (All Pitchers MUST Complete this Section)

The following questions are to determine the impact of a baseball/softball pitcher's arm injury on pitching-specific functional performance.

	Not at all	Slightly	Moderately	Severely	Unable to perform
1. How much has your arm injury limited the speed of your pitches?	1	2	3	4	5
2. How much has your arm injury limited your ability to throw 'bullpen' sessions?	1	2	3	4	5
3. How much has your arm injury limited your ability to 'hit' your spots?	1	2	3	4	5
4. How limited is your ability to pitch your turn in the rotation?	1	2	3	4	5
5. How much have your overall pitching statistics been hurt since your arm injury?	1	2	3	4	5
6. How much has your pitch count decreased since your arm injury?	1	2	3	4	5
7. How much has your arm injury limited your ability to throw different types of pitches?	1	2	3	4	5
8. Has your 'feel' for pitching decreased since your arm injury?	1	2	3	4	5

9. Do you need more time to recover between outings since your arm injury?	1	2	3	4	5
---	---	---	---	---	---

Pain subscale questions

2, 3, 16, 17, 21, 22

Throwing subscale questions

1, 2, 4, 6, 13, 18, 19, 20, 21, 22

ADLs subscale questions

3, 9, 11, 16, 17

Psychological health subscale questions

7, 8, 12, 15

Advancement subscale questions

14, 10, 5

Appendix C

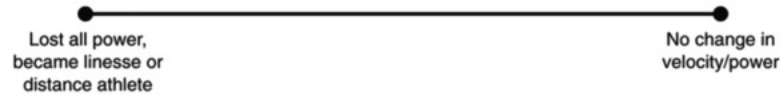
Figure 12. The Kerlan-Jobe Clinic Shoulder and Elbow Score

Kerlan-Jobe Orthopedic Clinic Shoulder & Elbow Score			
Age _____	Sex _____	Dominant Hand (R) _____ (L) _____ (Ambidextrous)	
Position _____		Sport _____	Years Played _____
Please answer the following questions related to your history of injuries to YOUR ARM ONLY :			
		YES	NO
1. Is your arm currently injured?		<input type="checkbox"/>	<input type="checkbox"/>
2. Are you currently active in your sport?		<input type="checkbox"/>	<input type="checkbox"/>
3. Have you missed game or practice time in the last year due to an injury to your shoulder or elbow?		<input type="checkbox"/>	<input type="checkbox"/>
4. Have you been diagnosed with an injury to your shoulder or elbow other than a strain or sprain?		<input type="checkbox"/>	<input type="checkbox"/>
If yes, what was the diagnosis? _____			
5. Have you received treatment for an injury to your shoulder or elbow?		<input type="checkbox"/>	<input type="checkbox"/>
If yes, what was the treatment? (Check all that apply)			
<input type="checkbox"/> Rest <input type="checkbox"/> Therapy <input type="checkbox"/> Surgery (please describe): _____			
Please describe your level of competition in your current sport:			
(Use Professional Major League, Professional Minor League, Intercollegiate, High School as the choices)			
6. What is the highest level of competition you've participated at? _____			
7. What is your current level of competition? _____			
8. If your current level of competition is not the same as your highest level, do you feel it is due to an injury to your arm?		<input type="checkbox"/>	<input type="checkbox"/>
Please check the ONE category only that best describes your current status:			
<input type="checkbox"/> Playing without any arm trouble <input type="checkbox"/> Playing, but with arm trouble			
<input type="checkbox"/> Not playing due to arm trouble			
Instructions to athletes:			
The following questions concern your physical functioning during game and practice conditions. Unless otherwise specified, all questions relate to your shoulder or elbow . Please answer with an X along the horizontal line that corresponds to your current level.			
1. How difficult is it for you to get loose or warm prior to competition or practice?			
<div style="display: flex; justify-content: space-between;"> <div>Never feel loose during games or practice</div> <div>Normal warm-up time</div> </div>			
2. How much pain do you experience in your shoulder or elbow?			
<div style="display: flex; justify-content: space-between;"> <div>Pain at rest</div> <div>No pain with competition</div> </div>			
3. How much weakness and/or fatigue (i.e., loss of strength) do you experience in your shoulder or elbow?			
<div style="display: flex; justify-content: space-between;"> <div>Weakness or fatigue preventing any competition</div> <div>No weakness, normal competition fatigue</div> </div>			
4. How unstable does your shoulder or elbow feel during competition?			
<div style="display: flex; justify-content: space-between;"> <div>"Popping out" routinely</div> <div>No instability</div> </div>			
5. How much have arm problems affected your relationship with your coaches, management, and agents?			
<div style="display: flex; justify-content: space-between;"> <div>Left team, traded or waived, lost contract or scholarship</div> <div>Not at all</div> </div>			
The following questions refer to your level of competition in your sport. Please answer with an X along the horizontal line that corresponds to your current level.			

6. How much have you had to change your throwing motion, serve, stroke, etc., due to your arm?



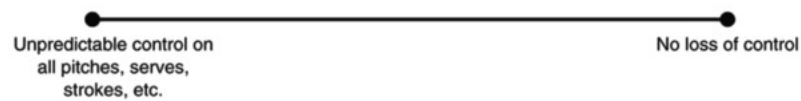
7. How much has your velocity and/or power suffered due to your arm?



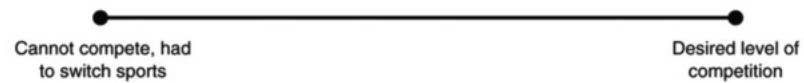
8. What limitation do you have in endurance in copetition due to your arm?



9. How much has your control (of pitches, serves, strokes, etc.) suffered due to your arm?



10. How much do you feel your arm affects your current level of competition in your sport (i.e., is your arm holding you back from being at your full potential)?



Appendix D

REVIEW OF LITERATURE

During the last decade, the shoulder complex has been extensively researched with regard to the etiology and diagnosis of the various injuries that it can incur. Much less research attention has focused on the use of manual therapy, namely instrument-assisted soft tissue mobilization (IATSM), and the effects it can have on the shoulder complex. This study aims to test the effectiveness of IATSM on improving shoulder range of motion by focusing on posterior soft tissue structures in overhead athletes. But to understand the clinical effects of instrument assisted soft tissue mobilizations, we need to have an understanding of the shoulder complex anatomy, and then more specifically how the role of the scapula as a stabilizer and the injuries that can occur as a result of dysfunction.²⁻⁶ Then we can discuss the efficacy and clinical application of an intervention like instrument assisted soft tissue mobilization, from a physiological and usefulness standpoint.

Shoulder Complex

The shoulder complex is an intricate structure because it offers such a high degree of mobility with limited stability. Stability does not come from bony support but rather a shallow glenoid labrum and the surrounding musculature as well as the shoulder capsule and ligamentous support.² The shoulder complex is composed of the glenohumeral joint, scapulothoracic articulation, acromioclavicular joint, and sternoclavicular joint.¹ The acromioclavicular joint is the only bony attachment that the scapula has with the axial skeleton, affording it a great deal of mobility.² The scapula is supported by a network of muscle and ligamentous attachments that it uses

to stabilize itself on the thoracic wall.³ The proper synergy of these surrounding muscles is key for the proper function of not only the scapula but the entire shoulder complex.

Overhead athletes put an excessive strain on these structures during throwing, swinging, and striking motions that create osseous and soft tissue adaptations.⁴ Throwing athletes typically present with increased glenohumeral external rotation or external rotation gain and a decrease in internal rotation, or glenohumeral internal rotation deficiency (GIRD). Both external rotation gain and GIRD occur on the dominant arm as an adaptation, the athlete presents with greater external rotation and diminished internal rotation when compared to the non-dominant arm.⁴ Borsa et al presented radiographic evidence that throwers shoulders also present with humeral retroversion, that is the shaft of the humerus is externally rotated compared to the humeral head. This adaptation is only seen on the dominant/throwing arm.³ This has been described as a possible explanation for the excessive external rotation that throwing athletes present with.^{4, 5, 6} The force generated by the throwing motion also creates soft tissue adaptations, specifically in the posterior shoulder. The reliance on the structures of the posterior shoulder to absorb energy and slow down the arm during follow through motions creates tightness across the posterior shoulder region.⁴ This posterior tightness creates a “wind-up” effect that pulls the scapula anteriorly, lessening the space under the acromion.³ However, the evidence still does not agree if it is mainly the rotator cuff musculature, the posterior shoulder capsule, or bony adaptations that create the loss of motion.⁴ This phenomenon is attributed to the microtrauma that this region receives from the repetitive force from the follow

through phase.^{4, 6} These adaptations can have clinical implications, athletes who present with the various adaptations listed above may be more prone to soft tissue damage.^{4, 5, 24}

Scapular Function

The configuration of the scapula on the thoracic wall allows it a great deal of freedom in all planes. The scapula's main responsibility in the movement of the arm is to aid in the stability for glenohumeral motion, the movement of the scapula along with the humerus keeps the humeral head squarely in the glenoid fossa.³ The "safe zone", as Kibler described, is a 30-degree arc of both flexion and extension from the scapular plane. This zone is where the humeral head has maximum contact with the glenoid fossa, and therefore has maximum stability in upper extremity motions.³ The scapula also retracts and protracts along the thoracic wall to allow for functional movements such as the overhead throw, tennis serve, and in various swimming strokes.^{3, 24} This loading motion creates stretch in the anterior soft tissue structures that allows for explosive energy in the previously mentioned actions.^{3, 24} The elevation of the acromion is also a crucial movement, the space the scapula creates by elevating the acromion allows for the proper function of the cuff musculature.^{3, 24} Decreased scapular upward rotation may be an effect of musculature dysfunction. If the scapula cannot properly attain upward rotation the acromion will not be able to lift off of the humerus, thus decreasing the amount of space underneath the acromion.^{4, 24} This combination can lead to tissue damage and injury, mainly of the rotator cuff musculature.^{4, 24} This is termed impingement and is a common shoulder pathology. The rotator cuff musculature tendons rely on the acromion clearing out as the

humerus moves superiorly as the arm abducts, if it fails to clear the rotator cuff tendons become impinged between the humeral head and acromion and sustain damage.^{4, 24} Borsa et al described a study that found 54% percent of patients suffering from subacromial impingement presented with increased upward rotation and scapular dyskinesis.⁴

The movement of energy from the ground through the trunk must also flow through the scapula as it continues into the hand, for that reason proper alignment and function of the shoulder complex must be maintained to avoid injury.^{3, 6, 24} Too much tightness in the shoulder complex, or any restrictions in the scapulohumeral rhythm does not allow for the proper transfer of energy, which over time may lead to chronic and potentially traumatic injuries to the shoulder complex.^{3, 4, 24} One study has shown a predisposition for this kind of malfunction in male overhead athletes.²⁵ In their comparison of overhead athletes (volleyball and handball) versus non athletes they observed a significant difference in the resting and active angles of the athletes scapulae compared to matched controls, the athletes presented with more downward rotation of the scapula in rest and more scapular upward rotation in motion measured at 90 degrees and 135 degrees of abduction.²⁵ This resting position and difference in scapular rotation may result in inadequate transfer of energy through the shoulder complex.

Scapular function must be able to remain stable for the dynamic motion at the glenohumeral joint, for both proper action of the muscles that contribute to scapular motion and stability and to maintain as much contact as possible for the humeral head in the glenoid fossa. Because of the lack of bony support around the scapula it relies

heavily on the surrounding musculature to maintain its various positions. Any dysfunction between the scapula and its associated musculature can create an unstable environment for glenohumeral motion.^{3, 4, 6, 24, 25}

Scapular Dyskinesis

Because of the force generated through the kinetic chain in athletic overhead motions, maintenance of the scapula and scapulohumeral rhythm is key to a healthy shoulder.²⁻⁶ Fatigue, improper mechanics, and other factors can contribute to chronic and acute injuries to the shoulder complex.^{2-6, 24} Common injuries include labral tears/lesions, impingement syndrome, and tendinopathies to the cuff musculature.^{3, 4, 6, 24}

A condition referred to as scapular dyskinesis may be a cause of shoulder pathology, or an athlete who suffers a shoulder pathology may compensate with dysfunctional scapular motion to avoid painful movements and protect the damaged soft tissue.^{3-5, 24} This condition is any number of dysfunctions in the movement of the scapula on the thoracic wall.⁴ Kibler and Sciascia described scapular dyskinesis as “abnormal static scapular position and/or dynamic scapular motion characterized by medial border prominence; inferior angle prominence and/or early scapular elevation or shrugging on arm elevation; rapid downward rotation during arm lowering”.²⁴ There can be multiple causes for this condition including muscle imbalance or weakness, acromioclavicular joint injuries, clavicle fracture, rotator cuff injury, and superior labral tears.²⁴ This condition also effects the scapulohumeral relationship, restricting proper alignment of the humeral head in the glenoid fossa.^{3, 4, 24} Muscle imbalance and muscle weakness in the periscapular musculature can arise either as a

result of a hypermobile or hypomobile scapula.²⁴ The upper back musculature, including the trapezius, rhomboid major and minor, levator scapulae, and serratus anterior are responsible for the stabilization and rotation of the scapula.^{2,3} The scapula relies on these muscles to stabilize it, so it can create proper alignment of the glenohumeral joint and rotator cuff musculature during glenohumeral movement.^{3,24}

If one of these muscles is weaker than the others, overly tight, not firing properly, or fatigues, the muscle synergy is out of rhythm.³ This altered relationship can over or under rotate the scapula. The over rotation of the scapula puts greater strain on the rotator cuff musculature by over stretching the tendons as they attempt to hold the humeral head in the glenoid fossa.^{4,24} Because of the aggressive nature of athletic overhead motions, e.g., throwing, spiking, serving, every repetition with the scapula over rotated increases the likelihood of developing various rotator cuff muscular/tendinous pathologies such as strain and/or tendinopathy or potentially tendon rupture.^{4,24} The over rotation also indicates the scapula at rest is already in a protracted/upward rotated position.⁴ The increased distance between the medial border of the scapula and the spine create an unfavorable position for retraction, and the cocking phase of the throwing motion.²⁴ This is important because it can lead to the glenohumeral joint “opening up” anteriorly, creating stress/strain on the anterior shoulder capsule, this is termed glenoid antetilting.^{4,24} This leads to the humeral head translating off of the glenoid fossa, increasing the risk of anterior shoulder pathology.⁴ The increase in protraction may also a result of posterior shoulder tightness, as the arm moves through overhead motions the scapula likely has to

protract further in order to reach the necessary horizontal adduction in follow through.⁴

Because the clavicle is the only bony attachment to the axial skeleton, the healthy function of the acromioclavicular must be considered for proper scapular rotation.²⁴ Acromioclavicular joint sprains create an unstable connection between the scapula and clavicle, and as a result the scapula loses stability and can fall into a position of increased downward rotation and protraction.²⁴ With this loss as the scapula rotate up we may see an increase in glenoid antetilting and the potential pathologies that we described above.⁴

Maintaining a functional scapula is key to keeping a shoulder healthy. Scapular dyskinesis can be present in an athlete with no symptoms for a period until finally an injury occurs. Losses of motion or excessive tightness around the scapula are both dysfunctions that can easily be treated by the clinician with the appropriate interventions.^{2-5, 24}

Instrument-Assisted Soft Tissue Mobilization: Physiology and Efficacy

Before we understand the use of instruments as manual therapy aids, we must understand our clinical goals for using various tools on our patients. Typically, we are interested in increasing range of motion, reducing pain and inflammation over an area, and realigning connective tissues after injury.^{9, 10, 11} We also must understand what is happening physiologically, specifically with proliferation, microtrauma and fibroblast production.^{9, 11}

Connective tissue is a collection of tendons, ligaments, fascia, and any combination of those soft tissues.⁹ These structures have a specific alignment of their

cells based on their location in the body, and the physical stresses they are subjected to.^{2,9} These tissues sustain injury therefore they go through the healing phases of inflammation, proliferation, and remodeling.² We understand that as new tissue is being laid down and remodeled the body lays an abundance of collagen to try and regain strength and mobility in the tissue.^{2,9} But the body lays the collagen in random directions and this can create shortness across the tissue.⁹ This shortness is what we are interested in with regards to manual therapy. We are interested in creating a plastic change in the tissue to create length and/or mobility and regain normal function of the tissue.^{9,10} Through research we have learned that by purposely reinjuring the tissue with mechanical loads, we can manipulate how the tissue heals with the goal of creating length.^{9,11,12} Our understanding of this process allows us to make informed decision in the clinic when choosing the appropriate intervention for our patients. If our goal is to regain range of motion, then we know the use of a manual therapy technique is indicated.⁹

Ghelsen et al studied how fibroblast proliferation was affected after instrument assisted soft tissue mobilization (IASTM).¹³ Thirty rats were used as the subjects of this study, they were randomly allocated to one of 5 groups. The rats were injected with collagenase to induce tendon injury.¹³ 4 of the groups received soft tissue mobilization with a modified soft tissue mobilization instrument designed for use on rats Achilles.¹³ The researchers used differing pressures for each of the 4 intervention groups.¹³ The rats Achilles were harvested and studied under light microscopy for physiological differences.¹³ They found that the group that received the IASTM intervention presented an increase the number of fibroblasts present, and

an increase in new collagen fibers.¹³ The group that received the heaviest pressure presented with the most fibroblasts.¹³ Their results lead us to understand that the microtrauma caused instrument assisted soft tissue mobilization does incite the tissue healing cycle as well increases the amount of fibroblasts recruited to the damaged tissues.¹³ This is important because it provides evidence showing the usefulness of this manual therapy technique, if we can overload tissue to create plastic changes, then we can regain length and normal function when our patients present with these symptoms.

Instrument-Assisted Soft Tissue Mobilization: Current Literature

Studies using Graston technique, foam rolling and stretching techniques were found by this researcher that all pertain to instrument assisted soft tissue mobilization.^{10, 12, 14, 15} Typically the researchers compared their various interventions to a control group that received no intervention and compared the outcomes by measuring range of motion and in some cases pain and/or inflammation.^{12, 14, 15} The most promising results came from a case series conducted by Hammer, he researched the Graston technique and its effects on supraspinatus tendinitis, Achilles tendinosis, and plantar fasciosis.¹² He found in all three cases patient reported pain reduction, range of motion gains, return of normal function.¹² A study conducted by Laudner et al found similar results. Their random Controlled trial focused on the acute effects of the Graston technique on asymptomatic college baseball players.¹⁴ They found acute gains is range of motion (horizontal adduction at the shoulder) at 24 hours post intervention. Markovich conducted a study on the effects of foam rolling versus an instrument assisted soft tissue mobilization technique called fascial abrasion.¹⁵ A

similar method to Launder et al was used, but they had no control group.¹⁵ Their results indicated a statistically significant increase in range of motion at the hip and knee 24 hours post intervention when compared to the foam rolling group, and that both groups showed immediate range of motion gains immediately post intervention.¹⁵

A systematic review of IASTM by Cheatham et al, published in 2016 is the most current and only systematic review to the researcher's knowledge.¹⁰ Their database search identified more than 200 articles on the subject, and their methods resulted in 7 eligible studies.¹⁰ Each study they reviewed was a randomized controlled trial and their results were both conflicting and inconclusive. The results indicated no support to strong support of the use of some IASTM technique, and did not always compare to a control group. There are few published studies that have investigated the therapeutic effects of instrument-assisted soft tissue mobilization beyond 24 hours post intervention.¹⁰

There remains a large gap in our knowledge regarding instrument-assisted soft tissue mobilization, with only anecdotal success stories and case studies or small case series in the literature. As reported by Cheatham et al, the results of IASTM studies are conflicting, only study acute effects or effects after one day, and have varying interventions and methods.¹⁰ Instrument-assisted soft tissue mobilization is gaining popularity in the athletic training profession, and it is prudent that we understand where it fits into clinical practice.

Summary

The shoulder complex at its core is an intricate balancing act of muscular synergy and high degrees of mobility.^{2, 3, 6, 24} The scapula is the key player in maintaining a healthy shoulder; its function relies heavily on the musculature that supports the scapula as well as the supporting soft tissue acting properly to glenohumeral joint moves above the head.^{2-5, 24} Any dysfunction around the scapula, termed scapular dyskinesis, creates an environment in the shoulder that is prone to injury.^{3, 4, 5, 24} Muscular dysfunction and posterior shoulder tightness are common in the overhead athlete and therefore as clinicians we must have the proper tools to combat these various inhibitions. The use instrument assisted soft tissue mobilization has been shown to have acute benefits in different areas of the body.¹⁰⁻¹⁴ However, the long-term effects of these tools to prove their indication for our patients in the clinic are unknown

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