ACUTE EFFECTS OF MUSCLE ENERGY TECHNIQUE AND JOINT MOBILIZATION ON SHOULDER TIGHTNESS IN YOUTH THROWING ATHLETES: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: Posterior shoulder tightness (PST), defined as limited glenohumeral (GH) horizontal adduction and internal rotation motion, is a common occurrence in overhead athletes, particularly baseball and softball players, as a result of the extreme forces on the GH joint and the high number of throwing repetitions. Despite clinical evidence suggesting the use of joint mobilizations and muscle energy techniques (MET) for treating PST, there currently are no data examining the overall effectiveness of joint mobilizations and MET to determine optimal treatment for posterior shoulder tightness.

Purpose: To compare the acute effectiveness of MET and joint mobilizations for reducing posterior shoulder tightness, as measured by passive GH horizontal adduction and internal rotation ROM, among high school baseball and softball players.

Study Design: Randomized controlled study

Methods: Forty-two asymptomatic high school baseball and softball players were randomly assigned to one of three groups (14 MET, 14 joint mobilization, 14 control). Glenohumeral passive adduction and internal rotation ROM were measured in all participants in a pre-test post-test fashion. Between testing, the joint mobilization group received one application of GH posterior joint mobilizations. The MET group received one cycle of MET applied to the GH horizontal abductors. The control group received no intervention. Posttests measures were completed immediately following intervention or a similar amount of time resting for the control group and then again 15 minutes later.

Results: One-way analyses of covariance showed that the MET group had significantly more horizontal adduction ROM post-treatment compared to the control group ($p=0.04$). No significant differences existed between groups in horizontal adduction ($p>0.16$) or internal rotation ($p>.28$) or at the 15-minute posttests ($p>0.70$).

Conclusion: The results of this study indicate the application of MET to the horizontal abductors provides acute improvements to GH horizontal adduction ROM in high school baseball and softball players, while joint mobilizations provide no improvements.

Level of Evidence: 1

Keywords: Baseball, glenohumeral joint, manual therapy, softball.

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INTRODUCTION

Due to the extreme ranges of motion (ROM) and high arm velocities that occur during the throwing motion, the glenohumeral (GH) joint is subjected to tremendous amounts of force.¹ As a result of the repetitive application of such large loads, specific adaptations commonly occur to the osseous and soft tissue components of the GH joint.^{2,3} A combination of these structural adaptations has been shown to modify the normative ROM of the throwing shoulder, resulting in increased external rotation and decreased internal rotation ROM. An increase in humeral retroversion typically leads to an equal shift in the total arc of motion, such that the gain in external rotation equals the loss in internal rotation. However, soft tissue tightness of the posterior shoulder can result in decreased GH internal rotation,^{2,4,5} without a concomitant increase in external rotation, as well as decreased horizontal adduction⁶⁻⁹ and an increased risk for injury.^{1,4,10,11}

Researchers have implicated posterior shoulder tightness (PST) as a potential cause of muscular dysfunction,^{12,13} superior labral anterior to posterior lesions,^{11,13-15} subacromial impingement,^{6,16} and pathological internal impingement.^{4,12,13} Many of the studies pertaining to shoulder ROM changes and PST focus on the loss of internal rotation, but decreased horizontal adduction has also been observed.¹⁰ PST may be managed effectively with different types of conservative treatment options.¹⁷⁻¹⁹ Muscle energy techniques (MET) applied to the GH joint have been shown to aid in improving shoulder ROM.¹⁷ Moore et al.¹⁷ explored the effects of a MET treatment applied to the GH external rotators compared to the horizontal abductors. These authors determined that treatment to the horizontal abductor muscle group yielded a greater improvement in both internal rotation and horizontal adduction motions when compared to a control group. Joint mobilizations are another form of manual therapy and have been clinically shown to improve joint motion and kinematics.²⁰⁻²²

Pathological implications of PST often only become prevalent once significant losses in ROM have occurred.^{1,4} However, it is difficult to determine if the loss of motion led to injury or if the injury was the cause of the lost ROM. Regardless, due to the potential negative effects of PST, determining optimal

treatment options for improving GH internal rotation and horizontal adduction ROM in asymptomatic throwing athletes could aid in decreasing the incidence and severity of shoulder injury. The purpose of this study was to compare the acute effectiveness of MET and joint mobilizations for reducing posterior shoulder tightness, as measured by passive GH horizontal adduction and internal rotation ROM, among high school baseball and softball players. The secondary purpose was to determine if any changes in ROM persisted over a 15-minute time period. It was hypothesized that the application of the joint mobilizations would yield the greatest acute restorative results in shoulder ROM.

METHODS

The participants who volunteered for this study consisted of youth throwing athletes recruited from two high schools. A university institutional review board approved this study prior to all data collection. All participants 18 years or older provided informed consent. All participants under the age of 18 years provided written assent, and their parents or guardians provided written permission for their daughter or son to participate. Inclusion criteria required participants to be a current member of a competitive high school baseball or softball team (pitchers and position players). Participants were excluded from the study if they had any recent history (prior three months) of upper extremity injury that prevented participation in their respective sport or any history of upper extremity surgery. The total number of participants for this study was 42 (24 baseball, 18 softball) based on a sample of convenience. Thirty-six participants were right-hand dominant throwing athletes, while six were left hand dominant throwing athletes. Participant demographics are presented in Table 1.

Participant demographic information was recorded and included age, height (cm), body mass (kg), injury history, and throwing arm preference. Group allocation (control, MET, joint mobilizations) was determined, by the principal investigator, prior to subject participation, such that an equal number of participants were randomly assigned to each group. Multiple high schools participated in this study, so testing of each team was conducted in their respective

Table 1. *Participant Demographics.*

Group	Age (years)	Height (cm)	Mass (kg)
MET (n=14)	17.07±1.0	176.17±14.7	69.81±12.9
Joint mobs (n=14)	16.43±0.8	172.72±11.4	71.88±17.4
Controls (n=14)	16.50±1.2	174.46±11.4	72.23±26.6
There were no significant differences between groups for any characteristics ($p > 0.07$). MET = muscle energy technique; joint mobs = joint mobilizations			

sports medicine facility. All participants completed three testing sessions (pre-test, immediate post-test, 15 minutes posttest). The immediate posttest measurements were recorded directly following the treatment application for the experimental groups and after following a one minute waiting period for the control group. All participants then waited an additional 15 minutes for a second round of posttests. All pre- and posttest measurements were performed in an identical manner. The order of the passive ROM measurements was not randomized and the investigators were not blinded to the group of each participant. All measurements and interventions were performed by the principal investigator.

Data collection occurred during the midpoint of the competitive season for all participants. Prior to data collection, participants completed their team's specific standard warm-up. This warm up consisted of mild jogging, static and dynamic total body stretches, and low velocity overhead/throwing motions. The warm up for this study was not standardized in order to mimic the normal playing conditions and regular training regimen for each specific participant. After completing the warm up, each participant was assessed for a baseline measurement of horizontal adduction and internal rotation ROM of their throwing shoulder.

A Pro 3600 digital inclinometer (SPI-Tronic, Garden Grove, CA, USA) was used to record ROM measurements for GH horizontal adduction and internal rotation. To assess GH horizontal adduction ROM, each participant was positioned supine with both shoulders flush against a standard examination table. An examiner stood at the top of the examination table towards the participant's head and stabilized the lateral border of the scapula by providing a posterior force. The participant's arm was placed in a position of 90 degrees of GH abduction with 90 degrees of

Figure 1. *Horizontal adduction range of motion measurement.*

elbow flexion. The opposite hand of the clinician held just distal to the participant's elbow and passively horizontally adducted the arm (Figure 1). At the first point of resistance a second examiner recorded the amount of motion present by aligning the digital inclinometer with the shaft of the humerus.

Passive GH internal rotation ROM was measured with the participant lying supine on an examination table, with the shoulder abducted to 90 degrees (frontal plane) and the elbow in 90 degrees of flexion. The examiner applied a posterior stabilizing

force to the acromion processes of the scapula, and internally rotated the arm until the first point of resistance. The second examiner then recorded the amount of motion by aligning the digital inclinometer with the shaft of the ulna.

A pilot test consisting of 16 subjects (separate from those used in the current study) was completed a priori to determine intraclass correlation coefficients (ICC), standard error of measurements (SEM), and minimum detectable change (MDC) for all ROM tests. Each subject had their throwing shoulder ROM measured resulting in 32 total limbs tested. Subjects were initially tested and then follow-up tests were collected at least 24 hours later. All measurements showed excellent intra-rater reliability and SEM (horizontal adduction: ICC = .85, SEM = 2.3°, MDC = 6.4°; internal rotation: ICC = .87, SEM = 4.2°, MDC = 11.6°).

The principal investigator, who performed all ROM testing and performed all treatments is a certified athletic trainer with extensive training in manual therapy. The participants that received the joint mobilization intervention were positioned supine along the edge of an examination table, so that the humeral head did not have any support in a posterior direction, but so that the table provided scapular stabilization. The participant's shoulder was abducted to 90 degrees and internally rotated to the first barrier of resistance, with the elbow flexed and relaxed (Figure 2). The participant's distal forearm was braced on the examiner's hip as a support, with

the clinician's hand applying overpressure to the GH joint in the posterior direction. The examiner then applied fifteen, one second, grade III posterior oscillations to the humeral head parallel to the glenoid treatment plane. There was also a one second rest period between oscillations, resulting in a 30 second total treatment period. Grade III posterior GH mobilizations were chosen based on the clinical experiences of the investigators and from the findings of previous research.²⁴

The participants in the muscle energy technique (MET) treatment group were positioned supine on the examination table with the examiner stabilizing the lateral border of the scapula. The examiner passively horizontally adducted the arm until the first barrier to motion by applying pressure to the distal humerus. This passive stretch was applied for three seconds. The examiner then instructed the participant to attempt to horizontally abduct the test arm at 25% of their maximal effort while the examiner applied manual resistance at the distal humerus to create an isometric contraction lasting five seconds. The examiner then brought the participant's arm back into horizontal adduction, for a three second active assistive stretch. Four of these application cycles were completed in totaling approximately 60 seconds. The control group rested in a supine position for one minute in between pre and post-tests.

STATISTICAL METHODS

SPSS Statistical software (IBM SPSS Statistics for Windows, version 22.0; IBM Corp, Armonk, NY) was used to analyze all data. Statistical analyses were conducted via separate one-way analyses of covariance (ANCOVA) for horizontal adduction and internal rotation ROM. The dependent variables consisted of posttest ROM and the covariates were pretest ROM. Fisher's least significant difference post hoc analysis was used when appropriate. All analyses were considered significant at the 0.05 alpha level. Effect sizes were used to provide impression of clinical significance and were calculated as: experimental group mean – control group mean / largest standard deviation.

RESULTS

There were no significant differences between groups for age ($p > 0.07$), height ($p > 0.49$), or mass

Figure 2. Posterior joint mobilizations.

($p > 0.72$). There was a significant between group difference for post-intervention horizontal adduction ROM ($F(2,38) = 8.7$; $p = 0.001$). Post hoc analysis showed that the shoulders treated with MET had significantly more passive horizontal adduction ROM post-treatment compared with the control group ($p = 0.04$) (Table 2). There were no significant differences between joint mobilizations and MET ($p = 0.16$) or joint mobilizations and control ($p = 0.48$) for post-intervention horizontal adduction passive ROM (Table 2). There was no significant between group difference in internal rotation PROM post-intervention ($F(2,38) = 1.3$; $p = 0.28$) (Table 3). When analyzing the results of measurements collected 15 minutes post intervention, there was no significance between groups differences for either horizontal adduction ($F(2,38) = 0.4$; $p = 0.70$) or internal rotation ($F(2,38) = 0.1$; $p = 0.91$) (Tables 2 & 3).

DISCUSSION

Due to the extreme velocities and high repetitions sustained by the throwing shoulders of baseball and softball players, these athletes often present with PST.^{1,3,25} This tightness has been repeatedly shown to alter shoulder ROM,^{2,3,10} kinematics^{26,27} and kinetics.^{26,27} Alterations to GH ROM in the overhead athlete have been linked to various pathologies including muscular dysfunction,^{12,13} labral lesions,^{11,13-15} and impingement syndromes.^{4,6,12,13,16} In order to prevent

and treat various pathologies related to this tightness, it is essential to implement techniques that lengthen both the contractile and non-contractile tissues of the posterior shoulder. The results of this study demonstrate that the application of MET to the horizontal abductors provides acute improvements in GH horizontal adduction ROM in high school baseball and softball players. The MET application to the horizontal abductor group yielded significant improvements in horizontal adduction when compared to the control group. This result revealed a moderate-to-large effect size as evaluated by Cohen's d (0.73). The difference between the pre and posttest values (8.3 degrees) was also larger than the SEM (2.3 degrees), which may indicate clinical significance. These findings did not support the author's hypothesis that joint mobilizations would produce greater improvements in ROM compared to the use of MET. These results demonstrate that MET applied to the horizontal abductors may be beneficial in treating athletes with PST due to muscular limitations amenable to MET versus joint mobilizations which targets the joint capsule. MET should be considered in the prevention and treatment of injuries associated with PST tightness.

Despite the importance of maintaining normal ROM in the overhead athlete to prevent the development of altered kinetics during the throwing motion,²⁷ there is no definitive consensus on which manual

Table 2. Means and Standard Deviations for Horizontal Adduction Range of Motion.

Group	Pre test (°)	Acute post test (°)	Difference (°)	Effect size	15 Minutes post test (°)	Difference (°)	Effect size
MET*	15.6±7.7	24.0±7.4	8.3±7.6	.73	17.8±5.7	2.2±5.7	.02
Joint mobs	18.5±5.8	19.9±6.9	1.4±4.0	.24	19.1±7.4	0.6±5.4	.13
Control	18.6±9.7	17.9±8.4	-0.7±5.0	.07	18.0±8.2	-0.6±7.1	.06
MET=muscle energy technique; Joint mobs=joint mobilizations * = significant post-intervention acute difference between MET and control groups ($p = 0.04$)							

Table 3. Means and Standard Deviations for Internal Rotation Range of Motion.

Group	Pre test (°)	Acute post test (°)	Difference (°)	Effect size	15 Minutes post test (°)	Difference (°)	Effect size
MET	53.2±8.9	58.2 ±9.4	5.0±5.5	.04	54.6±10.0	1.4±6.8	.28
Joint mobs	55.4±11.5	57.9±11.8	2.5±4.1	.02	57.3±10.6	1.9±4.6	.06
Control	55.2±9.8	57.7±10.5	2.5±3.6	.24	58.0±12.1	2.9±6.2	.23
There was no significant between group acute differences post-intervention ($p=0.28$). MET=muscle energy technique; Joint Mobs=joint mobilizations							

therapy provides the most significant reductions in PST. Previous literature has determined that a variety of stretching techniques targeting the musculature of the posterior shoulder are effective methods for reducing the ROM discrepancies associated with PST.^{4,10,18,19,28,29} Most commonly, studies have demonstrated that the sleeper stretch^{4,18,29} and the cross body stretch¹⁹ are beneficial. Both stretches have been shown to be effective for increasing horizontal adduction and internal rotation, with the largest increases in both motions occurring when the scapula is stabilized.^{19,28} This research focused on stretching techniques targeting the soft tissue components of the GH joint. Because the application of MET targeted several muscles of the GH joint these results would support these previous findings. However, not everyone can tolerate the cross-body stretch or the sleeper stretch, especially throwing athletes because these stretches place the shoulder in an impingement prone position, which can be uncomfortable or painful and result in muscle guarding.

In addition to the use of stretching techniques to improve range of motion, MET has also been explored as a treatment targeting the soft tissue extensibility issues behind motion restrictions. A series of studies have validated the use of MET for increasing ROM by observing the effects on different segments and directions of trunk motion³⁰⁻³² and hamstring extensibility.³³ Relatively few studies have applied this technique to the upper extremity,^{17,34} however these past studies have shown evidence that support MET for improving GH ROM. Moore et al.¹⁷ examined the effects of a MET application to the shoulder external rotators and horizontal abductors with a similar technique as used in this study. This previous research demonstrated that the horizontal abductors responded well to an acute MET treatment, creating significant improvements in horizontal adduction and internal rotation ROM. The results of this study support those of Moore¹⁷ as the current MET technique was also able to induce a significant increase in horizontal adduction. However, Moore also reported a significant improvement in internal rotation. This could be due to several factors, such as Moore's use of a larger sample size and a longer stretch phase (30 seconds) during the MET intervention. Moore et al.¹⁷ discussed that at the time of

their publication that it was unknown if muscular or capsular tightness was a larger contributor to PST and the associated ROM changes. Further research is necessary to determine the anatomical contribution to PST.

Conversely, previous research has postulated that capsular tightness contributes significantly to PST.^{4,12} Several studies have shown that joint mobilizations are an effective method for treating conditions such as adhesive capsulitis, by targeting the motion restrictions created secondary to capsular tightening and effectively increasing motion.^{21,22} However, the literature surrounding the use of joint mobilizations to decrease PST has not yet examined the isolated effects of joint mobilizations, but rather paired the mobilizations with a series of different stretching and therapeutic exercise protocols.^{24,35,36} The findings of this study support previous studies that have focused on treatments directed at improving muscular extensibility.^{4,10,17,18,28,29,34} The findings of this study may suggest that the contributions of the GH capsule in the development of PST is limited, especially in high school baseball and softball players. As such, youth athletes may have not experienced the same degree of posterior capsular tightening as an adult overhead athlete. However, further research is needed to confirm this topic.

The effects of the MET treatment were transient, lasting less than 15 minutes. The principles of soft tissue extensibility emphasize the clinical importance of preventative treatments that may reduce the prevalence of shoulder pathologies over time. The results of this study indicate the effectiveness of MET for short term changes in improving GH ROM and decreasing PST. Similarly, previous research has shown that repeated static and MET treatments applied to the soft tissue components of the GH joint are effective in creating improvements to GH ROM among non-athletes and swimmers.^{19,34} Unfortunately, there is little research determining the length of time this improvement in GH ROM lasts. Furthermore, athletes who perform MET prior to sport participation may see longer lasting results when immediately followed by their sport activity, as opposed to being static, as during our study. However, future research is needed to validate this hypothesis.

Several limitations of this work are worth noting. First, there was a relatively small sample size for each group ($n=14$). The authors conducted a power analysis based on an alpha level of 0.05 and a power of 0.80 and found that the joint mobilization group would have required 191 participants to see a statistically significant improvement in horizontal adduction ROM, which is not feasible. The population of this study consisted of youth athletes, limiting the application of these results to older athletic populations. The subjects were also limited to participation in baseball and softball, limiting the generalizability of these results to other overhead sports such as volleyball and tennis that also often present with PST. This study evaluated the effects of these treatments in asymptomatic subjects who were not previously identified with PST. Unfortunately, the methodology used in this study cannot confirm that the subjects who received joint mobilizations had significant capsular stiffness. Therefore, these participants may not have had significant PST prior to the intervention. Similarly, those with injury may respond to MET and joint mobilizations in a different manner. The results of this study indicate that a single application of MET is an effective method of acutely decreasing passive horizontal adduction ROM. Future research should be directed toward observing any potential lasting changes in GH ROM following a course of multiple MET applications.

CONCLUSIONS

The findings of this study indicate that a single application of MET to the GH horizontal abductors significantly increases horizontal adduction ROM among asymptomatic high school baseball and softball players. However, the effects of the treatment were transient, lasting less than 15 minutes. The application of MET did not have any significant effect on internal rotation motion. These findings also indicate that the results created by the application of joint mobilizations were negligible at both the immediate posttest and 15 minutes posttest for both horizontal adduction and internal rotation measures. Therefore, the application of MET to the horizontal abductors may assist in treating PST in youth baseball and softball players.

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