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A COMPARISON OF THE EFFECTS OF JOINT MOBILIZATIONS VERSUS MUSCLE ENERGY ON INCREASING SHOULDER RANGE OF MOTION IN HEALTHY INDIVIDUALS

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By

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ABSTRACT

A COMPARISON OF THE EFFECTS OF JOINT MOBILIZATION VERSUS MUSCLE ENERGY ON INCREASING SHOULDER RANGE OF MOTION IN HEALTHY INDIVIDUALS

By

Anna Lynn Leyland

The purpose of this study was to compare joint mobilizations versus muscle energy on increasing shoulder range of motion in healthy individuals. The study included 35 healthy individuals, which were placed in one of three groups (22 years ± 2.296, 67.03 inches ± 3.709, 164.95 pounds ± 34.323). Group A received a grade 4 anterior joint mobilization intervention, group B received a muscle energy intervention, and group C did not receive an intervention. The participants each received both a pre-test and post-test range of motion measurements on both shoulders, and the appropriate intervention to only one shoulder. Range of motion was measured with a universal goniometer and Dartfish software. Demographical data was also collected on all participants.

A paired t-test, one-way ANOVA, and multivariate tests were all run at a significant level of $p \leq 0.05$ to analyze the data. The results showed there were no significant increases in internal and external rotation with either intervention. There was also no significant difference between groups and sexes. There were a few limitations to this study which included the sample population, and the instrumentation. This study suggests that future research look at the effect of multiple treatments, measuring all ranges of motion, and studying a population with decreased shoulder range of motion.

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CHAPTER 1

Introduction

Overview of the Problem

Manual therapy encompasses a broad range of techniques that are used to treat neuromusculoskeletal dysfunction (Threlkeid, 1992), which includes muscle energy and joint mobilizations. Muscle energy and joint mobilization techniques are used to affect muscles and connective tissue, which may restrict joint mobility (Threlkeid, 1992). Joint mobilizations can be defined as a manual therapy technique that involves passive low-velocity oscillatory movements within or at the limit of joint range of motion (Houglum, 2005; Threlkeid 1992). Additionally, muscle energy can be defined as a manual therapy technique that involves directed patient movement from a precisely controlled position against a defined resistance by the operator (Licciardone, Stoll, Cardaelli, Gamber, Swift, & Win, 2004). The use of manual therapy techniques has increased in clinical settings and among athletic trainers, yet there is little documentation on the efficacy of these techniques (Fabio, 1992). In previous studies there are many references to the use of joint mobilizations in rehabilitation of sports injuries (Michener, Walsworth, & Burnet, 2004; Rundquist & Ludwig, 2005; Vermeulen, Obermann, Burger, Kok, & Ende, 2000; Yang, Chang, Chen, Wang, & Lin, 2007).

When used in the clinical setting, manual therapy techniques are used in conjunction with other rehabilitation techniques. In a study by Michener et al., (2004) a meta-analysis was performed to determine which rehabilitation techniques are most effective in treating shoulder injuries. The analysis included 635 articles, where exercise, joint mobilization, ultrasound, acupuncture, and laser therapy were all used as treatment methods (Michener et al., 2004). The article concluded that joint mobilizations combined with exercise were the most effective techniques (Michener et al., 2004).

Despite the lack of research on muscle energy, athletic trainers and physicians continue to use this manual therapy technique. In a survey of osteopathic physicians the most commonly used manual therapy techniques were soft tissue treatment, joint mobilizations, and muscle energy treatment (Ray, Cohen, & Buser, 2004). In another survey of osteopathic physicians done by Johnson and Kurtz (2003), approximately 30% of the physicians surveyed used muscle energy on a daily basis. With muscle energy increasing in use among athletic trainers and physicians there needs to be more research done on the subject.

Significance of the Problem

In previous studies there are many references to the use of manual therapy techniques, such as joint mobilizations, in the rehabilitation of sports injuries; yet it cannot be completely concluded from those studies that the manual therapy techniques decrease the patient's recovery time (Michener et al., 2004). A study done in the Netherlands looked at traditional medical care versus joint mobilizations on subjects with shoulder dysfunction (Bergman, Winters, Heijden, Postema, & Jong, 2002). The study concluded that joint mobilizations of the shoulder girdle are effective when combined with traditional medical care. This study demonstrates that joint mobilizations are effective in increasing a patient's recovery; but as to how effective the technique is alone has not been shown.

Documented research is needed to show the effects of manual therapy techniques and to support the clinical use of those techniques (Johnson & Kuntz, 2003; Rundquist &

Ludwig, 2005). Not only is this important to help our patients recover quicker, but it is also important in obtaining insurance reimbursement for manual therapy techniques. Slezynski and Glonek (2005) state that in order for appropriate reimbursements from third party payers there must be complete documentation and evidence on the effectiveness of these unique treatment techniques.

Normal shoulder range of motion is needed to perform activities of daily living (ADL's). Joint mobilizations and muscle energy techniques have been shown to increase joint range of motion (Yang et al., 2001; Vermeulen, Rozing, Obermann, Cessie, & Vlieland, 2006; Burns, & Wells, 2006). Up to three percent of the general population is affected by idiopathic loss of shoulder range of motion (Rundquist, & Ludwig, 2005). Individuals experiencing a loss in shoulder motion have difficulty performing ADL's (Rundquist, & Ludwig, 2005). Reduced shoulder range of motion is also an important factor in the development of persistent shoulder complaints (Bergman et al., 2002). A study done by Winters, Sobel, Groeiner, Arendzen, and Mayboom-de Jong (1999) looked at the relationship between shoulder complaints and decreased shoulder mobility. The majority of the subjects suffered from decreased mobility of the shoulder and the shoulder girdle, so the authors suggested that a reduction in range of motion of the shoulder girdle might be an explanation for the high recurrence of shoulder complaints (Winters et al., 1999).

Research Plan

The purpose of this study was to compare joint mobilizations and muscle energy techniques on increasing shoulder range of motion in normal, healthy subjects. The change in range of motion was determined by measuring the participants' shoulder internal and external rotation before and after an intervention of either joint mobilizations or muscle energy. The participants were placed in one of three groups, experimental group A, experimental group B, or group C, the control group. Experimental group A received a joint mobilization intervention, and experimental group B received an intervention of muscle energy. Group C was considered the control group and the participants did not receive an intervention. The effectiveness of joint mobilizations and muscle energy on increasing shoulder range of motion was determined by comparing the shoulder external rotation and internal rotation, of the participants in group A, group B and group C.

Need for the Study

Due to the need for documented research on various manual therapy techniques, this research will provide data on the efficacy of joint mobilizations and muscle energy on increasing shoulder rotation in healthy individuals. Documented research on manual therapy is needed to increase the quality of care for our patients. This research study will attempt to document the change in internal rotation and external rotation of the shoulder after an intervention of either joint mobilizations or muscle energy. The study will provide objective measurements on the effects of joint mobilizations and muscle energy on increasing shoulder rotation. This will be accomplished by measuring shoulder internal and external rotation before and after an intervention of joint mobilizations or muscle energy, and will be compared against a control group.

Hypotheses

Documented research is needed to show the effects of joint mobilizations and muscle energy on increasing shoulder motion. Previous research shows that these techniques can be used to increase range of motion (Maitland, 1991; Yang et al., 2001; Vermeulen et al., 2006; Wells, Giantinoto, D'Agate, Areman, Fazzini, Dowling, & Bosak, 1999). This study looked at shoulder internal and external rotation. It was hypothesized that males and females with no current shoulder injury, no previous history of shoulder injury or shoulder surgery, and no glenohumeral multidirectional instability would not see an increase in shoulder range of motion after receiving an intervention of joint mobilizations. A second hypothesis was that males and females with no current shoulder injury, no previous history of shoulder injury or shoulder surgery, and no glenohumeral multidirectional instability would not see an increase in shoulder range of motion after receiving an intervention of muscle energy. Finally, a third hypothesis was that there would be no difference in the pre and post measurements of shoulder internal rotation and external rotation between the joint mobilization experimental groups, the muscle energy experimental group and the control group.

Definition of Terms

- Manual Therapy- a broad range of hands-on techniques that are used to treat and evaluate neuromuscluoskeletal dysfunctions (Houglum, 2005; Threlkeid, 1992)
- Joint Mobilizations- a manual therapy technique that involves passive low-velocity oscillatory movements within or at the limit of joint range of motion, that create movement at a joint by other means than which the muscles of that joint are able to create (Fabio 1992; Green, Refshauge, Crosbie, Adams, 2001)
- Muscle Energy- a manual therapy technique that involves directed patient movement from a precisely controlled position against a defined resistance by the operator (Licciardone et al., 2004)

- Joint Play- movement within a synovial joint that is independent of, and cannot be introduced by, voluntary muscle; the movements are small with a precise range that depends on the contour of the opposing joint surface (Greenman, 2003)

CHAPTER 2

Review of Related Literature

Review of Content Literature

Shoulder Anatomy. The shoulder joint has the greatest range of motion of any joint in the body. Due the large amount of motion at the joint the body relies on bony and soft tissue restraints to provide stability. The bony anatomy of the shoulder includes the humerus, clavicle and the scapula (Terry, & Chopp, 2000). The humerus articulates with the scapula at the glenoid fossa. The humeral head is larger than the glenoid fossa, adding to the instability of the shoulder. The clavicle attaches the shoulder girdle to the trunk at the sternum (Terry, & Chopp, 2000). The glenoid labrum is a dense fibrous structure that is located on the glenoid fossa increasing the articular surface for the humerus and adding stability (Terry, & Chopp, 2000). The scapula attaches to the posterior shoulder through muscular attachments and the coricoid process of the scapula attaches to the acromioclavicular joint (Terry, & Chopp, 2000). As the glenohumeral joint moves, the scapula moves along with it, which is known as scapulohumeral rhythm.

The joint capsule and glenohumeral ligaments tighten and loosen during shoulder motion to prevent translation of the humeral head (Terry, & Chopp, 2000). The anterior joint capsule is comprised of thee ligaments, the superior glenohumeral ligament (SGHL), the middle glenohumeral ligament (MGHL) and the inferior glenohumeral ligament complex (IGHLC). The SGHL limits inferior humeral translation and external rotation (McCluskey, & Getz, 2000). The MGHL is absent in approximately 30% of patients and limits anterior translation with the arm at 45 degrees of abduction (McCluskey, & Getz, 2000). The IGHLC is the primary stabilizer of the humerus when the arm is at 45 degrees of abduction and 90 degrees of external rotation (McCluskey, & Getz, 2000). When the arm is abducted and externally rotated the IGHLC prevents anterior translation; and when the arm is abducted and internally rotated the IGHLC prevents posterior translation (McCluskey, & Getz, 2000). The posterior joint capsule has no defined glenohumeral ligaments (McCluskey, & Getz, 2000).

The rotator cuff muscles and surrounding musculature are known as the dynamic stabilizers of the shoulder. The rotator cuff muscles, the subscapularis, surpaspinatus, infraspinatus, and teres minor, are responsible for internal rotation and external rotation. They also assist with shoulder abduction. The attachments of the rotator cuff muscles are much closer to the center of rotation of the glenohumeral joint, when compared to the surrounding musculature; which increases their ability to provide dynamic stability to the shoulder (Terry, & Chopp, 2000). The rest of the musculature of the shoulder include the deltoid, biceps brachii, pectoralis major and minor, coracobrachials, latissimus dorsi, teres major, and the serratus. These muscles are responsible for shoulder abduction, adduction, flexion, extension, internal rotation and external rotation.

Shoulder Motion. Shoulder motions can be divided into two groups, physiological joint motion and joint play. Physiological joint motions can be defined as movement that an individual can perform voluntarily; these motions are flexion, extension, abduction, adduction, internal rotation, external rotation, horizontal abduction and horizontal adduction (Houglum, 2005). The shoulder has 180 degrees of flexion, and approximately 60 degrees of extension (Thompson, & Floyd, 2004). There is approximately 180 degrees of abduction available at the shoulder (Thompson, & Floyd, 2004). Shoulder adduction is measured as the return from shoulder abduction. Additionally, there is about 90 degrees of internal and external rotation at the glenohumeral joint (Thompson, & Floyd, 2004). Horizontal adduction is measured at 130 degrees and horizontal abduction is measured at 45 degrees (Thompson, & Floyd, 2004).

As previously defined, joint play is movement of a joint that cannot be performed voluntarily or controlled, but is necessary for normal motion to occur (Greenman, 2003). Joint play can be broken down into accessory motion and component motion. Component motions are not capsular, but they accompany physiologic motion (Houglum, 2005). An example of component motion would be the rotation of the clavicle during shoulder flexion (Houglum, 2005). Accessory motion occurs within the joint's capsule (Houglum, 2005). There are five motions that occur in the joint's capsule, roll, slide, spin, compression, and distraction. The directions of these motions are determined by the convex-concave rule. The convex-concave rules states that for a concave joint surface the accessory joint motions occur in the same direction as the bone movement; and that for a convex joint surface the accessory joint motions occur in the opposite direction of the bone movement (Houglum, 2005).

Joint Mobilizations. Abnormal shortness of muscles, tendons and the joint capsule can restrict joint mobility (Threlkeid, 1992). One of the principle uses of manual therapy is to produce elongation of structures that may be abnormally restraining joint motion (Threlkeid, 1992). Movements performed passively to increase a range of motion include both physiological movements and accessory movements (Maitland, 1983). As, Maitland (1991) describes, the goal of joint mobilizations is to restore normal accessory motion to the joint. Joint mobilizations can be divided into grades. According to Maitland, grade one joint mobilizations are a small amplitude movement performed at the beginning of the range of motion. Grade two joint mobilizations are large amplitude movements performed within a resistance-free part of the range of motion (Maitland, 1991). Grade three joint mobilizations are large amplitude movements performed into resistance or up to the limit of the joint range of motion (Maitland, 1991). Grade four joint mobilizations are small amplitude movements performed into the end range of the joint range of motion (Maitland, 1991). Graded mobilizations applied at the end of the available range of motion are intended to elongate tissue (Threlkeid, 1992).

Joint mobilizations can also be graded according the Kaltenborn (Andrews, Harrelson, & Wilk, 2004). Kalenborn's grades are described in stages of traction. Stage one is traction of the joint without actual separation of the joint, which the purpose is to relieve pain. Stage one can be compared to Maitland grade one mobilization (Andrews et al., 2004). Stage two of Kaltneborn is traction that effectively separates the joint surfaces and takes up the slack and eliminates play in the joint capsule. Stage two is used relieve pain and can be compared to Maitland grade four mobilizations (Andrews et al., 2004). Stage three is traction that actually stretches the surrounding soft tissue and has a purpose of increasing mobility (Andrews et al., 2004). This study will implement the Maitland grading system.

A study done by Yang et al. (2007) looked at the use of joint mobilizations in treatment of 28 subjects with frozen shoulder syndrome. The treatments consisted of different combinations of mid range joint mobilizations (MRM), end range joint mobilizations (ERM), and mobilizations with movement (MWM) (Yang et al., 2007). MRM were defined as mobilizations within the available joint play of the joint. End range joint mobilizations were performed in a position of maximal shoulder motion and mobilizations were applied at the end of the available joint play within the shoulder (Yang et al., 2007). The MWM techniques used in the study, developed by Mulligan, involved an application of force to the glenohumeral joint while the participant actively moved their shoulder. (Yang et al., 2007). No other rehabilitation techniques, such as ice, modalities, or electrotherapy were used or allowed during the duration of the study (Yang et al., 2007). The study saw a significant increase in arm elevation (group ABAC 106 ±26, group ACAB 116±15), humeral lateral rotation (group ABAC 45.8 ±16.2, group ACAB 38.2 ±13.6), and humeral medial rotation (group ABAC 13.4 ±7.6, group ACAB 13.1±9.7) The study concluded that a combination of end range mobilizations and mobilizations with movement were the most effective in increasing shoulder mobility and functional ability (Yang et al., 2007).

Vermeulen et al. (2006) conducted a study that looked at the effect of end range joint mobilizations on increasing shoulder motion. The study consisted of 100 participants with adhesive capsulitis of the shoulder, who each received interventions of joint mobilizations over the course of three months. Forty-nine subjects received high-grade joint mobilizations and 51 subjects received low-grade joint mobilizations (Vermeulen et al., 2006). The study defined high-grade mobilizations as grades 3 and 4 joint mobilizations, according to Maitland; and the low-grade joint mobilizations as grades 1 and 2 joint mobilizations, according to Maitland (Vermeulen et al. 2006). The subjects in both groups saw significant improvements regardless of the type of joint mobilizations used. Active external rotation was significantly higher in the group that received high grade joint mobilizations (20.8° ± 17.4-24.3) (Vermeulen et al. 2006). The high-grade mobilization group also saw a greater increase in passive shoulder abduction when compared to the low-grade mobilization group (72.4° ± 64.0 – 80.9) (Vermeulen et al., 2006).

A study done by Senbursa, Baltaci and Atay (2007) compared conservative treatment with and without manual therapy techniques for patients with shoulder impingement syndrome. The purpose of the study was to compare joint mobilization and soft tissue techniques to a self training program. The study consisted of 30 participants, which were divided into two experimental groups. All participants were tested on a visual analog pain scale and their range of motion was measured with a goniometer (Senbursa et al., 2007). Group one consisted of the self-training intervention and the participants completed stretching and strengthening exercises at home at least seven times a week for 10-15 minutes, for four weeks. Group two received 12 sessions of joint mobilizations, deep tissue friction massages, ice application, stretching and strengthening exercises, and patient education sessions. The results showed that patients in both groups experienced decreased pain and overall increased shoulder function, but there was a more significant increase in the subjects that received treatments of joint mobilizations and soft tissue mobilizations (Senbursa et al., 2007). Group two also showed a significant increase in range of motion with shoulder flexion, abduction, external rotation and internal rotation. The study concluded that manual therapy techniques can be very useful in restoring neuromuscular control and motion; however, more research needs to be done (Senbursa et al., 2007).

A study done by Johnson, Godes, Zimmerman, and Ounanian (2007) compared anterior joint mobilizations versus posterior joint mobilizations on increasing shoulder external rotation in patients with adhesive capsulitis. The study looked at 20 patients between the ages of 37 and 66 years; which were assigned to one of two groups that either received anterior joint mobilizations or posterior joint mobilizations. Range of motion was measured using a goniometer (Johnson et al., 2007). Before the intervention, the capsule was preheated with thermal ultrasound, and grade three joint mobilizations were used, according to Kaltenborn. Each participant completed six sessions, and after each session used an upper body ergometer to decrease soreness (Johnson et al., 2007). After six sessions the anterior mobilization group's external rotation increased by a mean of 3 degrees (± 10.8°) and the posterior mobilization group's external rotation increased by a mean of 31.3 degrees (± 7.4°). The study concluded that multiple treatments are needed to increase range of motion. Additionally, the study purposed that patients should be carefully evaluated to determine the source of the external rotation deficit, and treatment should be selected to address that specific deficit (Johnson et al., 2007). The study also suggested that the direction of joint mobilizations should be selected based on the resting position of the humeral head on the glenoid fossa (Johnson et al., 2007).

Neurological Basis of Muscle Energy. Muscles function as pairs, there is always an agonist and an antagonist muscle for joint motion (Roberts, 1997). The agonist muscle contracts to produce the desired movement and the antagonist muscle opposes the desired movement (Roberts, 1997). Muscle spindles and golgi tendon organs (GTO) are receptors that are located in a muscle and the muscle tendons. The muscle spindles and GTO are sensitive to changes in muscle length and muscle tension. As a protective mechanism, when a muscle is stretched the muscle spindles are activated, and signals are sent to the muscle, to cause a contraction (Prentice, 2003). This stretch reflex is to prevent muscle strains. Autogenic inhibition is when the GTO is activated though a contraction of the agonist muscle, causing the antagonist muscle to relax (Prentice, 2003). Muscle energy utilizes autogenic inhibition to increase the range of motion at a joint. During muscle energy a slight stretch is applied to the agonist muscle of the joint to determine the joint's motion barrier, followed by an isometric contraction (Greenman, 2003). The slight stretch and the isometric contraction during muscle energy, activates the muscle spindles and the GTO, causing a relaxation. (Andrews et al., 2004; Roberts, 1997, Prentice, 2003). The inhibition of the antagonist muscle allows for a smooth and increased motion at the joint (Greenman, 2003).

A study done by Davis, Ashby, McCale, McQuain, and Wine (2005) compared the effectiveness of three stretching techniques on hamstring flexibility. During a four week training program 19 subjects received one of three stretching protocols or was placed in a control group. They received either a self-stretching protocol, a static stretching protocol, or a proprioceptive neuromuscular facilitation (PNF) protocol (Davis et al., 2005). The PNF protocol incorporated the theory of autogenic inhibition and reciprocal inhibition. Each group stretched three days a week for four weeks. Knee extension was measured before the start of the protocol, at two weeks and again at four weeks. A post hoc analysis showed that all three stretching techniques increase hamstring flexibility; and there were significantly greater increases with static stretching and the PNF stretching (Davis et al., 2005).

Muscle Energy Technique. The term manual therapy techniques are also known in osteopathic medicine as osteopathic manipulative treatments (OMT). Muscle energy is a type of OMT. A study done by Wells et al. (1999) compared the effect of OMT on the gait of individuals with Parkinson's disease. The researchers investigated this effect due to the risk of falling and associated injures from an abnormal gait. Some of the signs and symptoms of Parkinson's disease includes muscular rigidity (Wells, et al., 1999). Muscle rigidity is due to a muscle tone disturbance, muscle spasm, pain and muscle contraction. The OMT interventions used in the study primarily consisted of passive range of motion techniques. The study hypothesized that the treatments would improve the participants' flexibility, strength, balance, and physical function (Wells et al., 1999).

The study included 20 subjects with Parkinson's disease and 8 normal control subjects (Wells et al., 1999). There were 10 subjects that received OMT, 10 subjects received a sham treatment and the control subjects also received the OMT interventions. The methods consisted of a baseline gait analysis that analyzed stride length, cadence, shoulder velocity, arm movement velocity, and lower limb velocity of the hip, knee and ankle (Wells et al., 1999). The participants then received their treatment intervention followed by a post-test gait analysis. All OMT interventions were done bilaterally. The interventions consisted of 14 osteopathic techniques, which included muscle energy techniques applied to the cervical spine, psoas muscles, hamstring muscles, ankle dorsiflexors, and the ankle plantar flexors. The interventions also included myofascial release, and active range of motion. The sham procedure consisted of a range of motion exam to each joint that the OMT intervention was applied to (Wells et al., 1999).

The results concluded that the subjects' with Parkinson's that received the OMT intervention saw the greatest improvement in gait. There was a significant increase in stride length with the experimental OMT group ($p < 0.02$) (Wells et al., 1999). The group that received the sham treatment saw a decrease in stride length and the control group saw a small increase in stride length, as well. In regards to cadence, the experimental

OMT group also saw an increase ($p<0.005$), the sham group saw a significant decrease, and there was a small decrease with the control group (Wells et al., 1999). There was also an increase in upper limb velocity and lower limb velocity for the experimental OMT group and the control group; the sham treatment group saw a decrease in both the upper and lower limb velocities. The study concluded that there was a significant improvement in gait for subjects with Parkinson's disease after receiving various osteopathic manipulation treatments (Wells et al., 1999).

A study done by Licciardone et al., (2004) looked at the effect of OMT on reducing pain, and improving ambulation following knee and hip arthroplasty. A total of 42 women and 18 men were randomly assigned to groups that either received an OMT intervention or a sham treatment. The OMT intervention consisted of a combination of muscle energy, myofascial release, high-velocity and low-velocity manipulation, and craniosacral manipulation. The subjects received 2 to 5 sessions of the OMT intervention weekly, with no more than 2 days between sessions; the sessions lasted between 10-30 minutes (Licciardone et al., 2004). The sham treatment consisted of range of motion activities with a light touch. The study used medical health questionnaires to assess physical function, physical limitations, pain, general health perceptions, social functioning, and mental health (Licciardone et al., 2004). The study found that there was an overall increase in the questionnaire scores for the group that received the OMT intervention and the group that received the sham treatment. There was no significant difference between the groups (Licciardone et al., 2004).

Review of Method Literature

Joint Mobilizations. This study implemented the use of passive grade 4 joint mobilizations, according to Maitland; which has been used in previous studies and shown to increase range of motion (Senbursa et al., 2007; Vermeulen et al., 2006; Yang et al., 2007). The joint mobilization technique that was chosen for this study was based on the convex-concave rule; which states that if the convex surface of a joint moves on the concave surface of the joint, rolling and gliding movements of the joint will occur in the opposite direction (Hsu, Hedman, Chang J, Vo, Ho, Lo,& Chang G, 2002). According to this rule a ventral, or anterior, joint mobilization is used to increase external rotation (Hsu et al., 2002). A study done by Hsu et al. (2002) used end range dorsal and ventral joint mobilizations on 14 cadaver shoulders to increase range of motion. The results of the study showed that the two procedures produced small increases in shoulder range of motion. Lateral rotation increased the most after ventral joint mobilizations (x=90degrees, SD= 0.92 degrees, t=3.65, p=0.026) and medial rotation increased the most after the dorsal joint mobilizations (x=97 degrees, SD= 1.45 degrees, t=2.51, p=0.026). The article concluded that the posterior and anterior translation of the humeral head was affected by the length of the posterior capsule in medial rotation and the anterior capsule in lateral rotation; thus according to the convex-concave rule medial rotation is improved by dorsal joint mobilizations and lateral rotation is improved by ventral rotations (Hsu et al., 2002).

As previously mentioned, the article by Vermeulen et al. (2006) compared high-grade joint mobilizations to low-grade joint mobilizations. In this article high-grade joint mobilizations were defined as grades three and four, according to Maitland. Grade three mobilization techniques are defined as large amplitude oscillations reaching the limit of the range of motion (Vermeulen et al., 2006) Grade four joint mobilization techniques are small amplitude oscillations at the end of the range of motion. The results of the study showed that the high-grade joint mobilizations, grades three and four, showed a greater improvement in range of motion, when compared to grades one a two joint mobilizations (Vermeulen et al., 2006)

Muscle Energy Technique. A study done by Burns and Wells (2006) looked at the range of motion in the cervical spine and the effects of muscle energy in asymptomatic subjects. The investigators in the study used isometric muscle contractions to increase gross cervical range of motion. The study consisted of 18 adults who received muscle energy treatments and were compared to 14 participants who received a sham treatment (Burns, & Wells, 2006). The subjects had cervical flexion, extension, lateral bending and rotation measured. The investigators localized the joint and determined the motion barrier. From this position the subjects were instructed to perform an isometric contraction of the targeted muscles for 3 to 5 seconds (Burns & Wells, 2006). The participants were then asked to relax while a new motion barrier was determined. Three repetitions of the muscle energy protocol were performed. With lateral bending the control group showed a decrease in range of motion (-3.1 degrees, ± 1.4 degrees, $p=.04$) and the muscle energy group showed an increase in lateral bending (3.9 degrees, ± 1.4 degrees, $p=.03$) (Burns, & Wells, 2006). The subjects who received the muscle energy treatment saw an overall increase in cervical motion; while the control group saw and overall decrease in cervical motion. The investigators concluded that it is possible to increase cervical motion with the use of muscle energy (Burns, & Wells, 2006).

A study done by Lenehan, Fryer, and McLaughlin (2003) looked at the effect of muscle energy techniques on gross trunk range of motion. The study used 59 asymptomatic subjects that were placed in either a control group or an experimental group. Both groups received pre and post-test measurements, while only the experimental group received one intervention of the muscle energy technique (Lenehan et al., 2003). The intervention was applied in the direction of restricted motion that was determined by the pre-test measurements. The intervention consisted of determining the motion barrier followed by a five second isometric contraction; which was repeated three more times, for a total of four repetitions. The results showed that gross trunk range of motion increased on the restricted side that was treated with muscle energy (10.66°, SD 9.80°) (Lenehan et al., 2003). Whereas, the un-restricted side for the experimental group (1.02°, SD 4.88°) and the control group saw minimal increases. The study concluded that the muscle energy technique was effective in increasing trunk range of motion (Lenehan, Fryer, & McLaughlin, 2003).

Another study done by Ballantyne, Fryer, and McLaughlin (2003) looked at the effect of muscle energy on hamstring extensibility. The purpose of the study was to determine if one treatment of muscle energy created immediate changes in hamstring flexibility (Ballentyne et al., 2003). The study included 40 participants which were split up into a control or experimental group. Both groups had pre and post-test measurements of passive knee extension, which was analyzed by digital photos (Ballentyne et al., 2003). The experimental group received one intervention of the muscle energy technique on the hamstrings, for knee extension. The study concluded that both the control group and the experimental group saw increases in passive knee motion, however, these increases were minimal (Balentyne et al., 2003).

Instrumentation

Goniometer. Goniometry is the use of instruments to measure the range of motion of a joint (Andrews et al., 2004). Full circle universal goniometers are the most popular and versatile, and are designed to measure a single range of motion for a specific joint (Andrews et al., 2004). A study done by Lintner, Mayol, Uzodinma, Jones, and Labossiere (2007) used a goniometer to measure shoulder motion. The purpose of the study was to evaluate internal rotation deficits in professional baseball players and determine the impact of an internal rotation stretching program. The study included eighty-five healthy adult male professional baseball pitchers; 44 of the pitchers had been involved in an internal rotation stretching program for three or more years, and 41 players had been involved in a stretching program for three or less years (Lintner et al., 2007). All measurements were made by the same experienced orthopedic surgeon using a goniometer. For external rotation, the athlete lay supine on a treatment table and the humerus was abducted to 90 degrees, and the elbow was flexed to 90 degrees (Lintner et al., 2007). The glenohumeral joint was externally rotated until an end feel was obtained and a measurement with the goniometer was taken. Internal rotation was measured with the same protocol. Range of motion measurements were taken before and after the athletes completed a stretching protocol (Lintner et al., 2007).

Intraobserver reliability for measuring both internal and external rotation was determined in a pilot study on minor league athletes (Lintner et al., 2007). The measurements were performed by the same examiner and used the same goniometer. The kappa values were calculated at > 0.96 for external and internal rotation. The study found that the athletes who had been on a stretching program for three or more years had a greater range of motion, and the internal rotation deficit was significantly less in this group as well (6.22 degrees vs. 18.3 degrees, $p < .01$). The study concluded that an internal rotation stretching program can decrease the deficit of internal rotation that is seen in baseball players (Lintner et al. 2007).

Another study by Reinold et al. (2008) also used a goniometer to measure shoulder range of motion. The purpose of the study was to examine the acute effects of baseball pitching on range of motion of the shoulder and elbow in professional athletes. The study used 67 professional baseball pitchers. Shoulder internal rotation, external rotation, horizontal adduction, elbow flexion, and elbow extension were bilaterally measured with a universal goniometer (Reinold et al., 2008). To measure internal and external rotation the subjects laid supine on a treatment table with a towel placed between the arm and the table, and the arm was at 90 degrees of shoulder abduction. The subjects then internally rotated and externally rotated their shoulders until the end of available range of motion was reached, and a measurement with the goniometer was taken (Reinold et al., 2008). While the subject was in a supine position, the axis of the goniometer was placed over the olecranon process, the stationary arm was aligned perpendicular to the ground and the movement arm was aligned parallel to the ulna. All measurements were taken before and after a warm up and throwing program, and one day after the initial measurements were taken. The results showed that there was a significant reduction ($p < 0.001$) in shoulder internal rotation (-9.5 degrees), total motion (-10.7

degrees) and elbow extension (-3.2 degrees) of the dominant shoulder after pitching and remained for 24 hours (Reinold et al., 2008).

The study also included a reliability study that was performed prior to data collection to assess test-retest intertester reliability of the goniometer (Reinold et al., 2008). The range of motion was measured on ten asymptomatic subjects in all four positions by the same examiners that conducted the measurements in the original study. The measurements were randomly repeated on five consecutive days and the order of measurements were all randomized (Reinold et al. 2008). Intraclass correlations coefficients were calculated for shoulder external rotation, internal rotation, and elbow flexion and extension. The single measure intraclass correlation results were 0.8115 for shoulder internal rotation, 0.8740 for shoulder external rotation, 0.9053 for elbow flexion, and 0.9740 for elbow extension (Reinold et al., 2008).

Dartfish Software. A study done by Heath and Sather (n.d.) used Dartfish software to analyze the biomechanical positioning of cyclists' for optimal performance. The subjects were placed on a stationary bike, and video footage was captured after the cyclists were able to achieve a comfortable endurance cadence. Video footage was captured for 2-3 minutes from a frontal and sagittal view. Reflective markers were placed on the wrist, elbow, hip, knee, ankle, base of the neck, and the base of the fifth metatarsal (Health, & Sather, n.d). The Dartfish software was used to analyze angles of the hip, knee, ankle, torso, and the shoulder. The study concluded that the Dartfish software was able to provide quantitative data to more precisely examine important angles (Heath, & Sather, n.d.).

Another study done by Upjohn, Keir, and Dumas (n.d.) used Dartfish software to examine the upper body posture during tree planting work. The purpose of the study was to define upper body and trunk postures during tree planting work that contribute to musculoskeletal symptoms (Upjohn et al., n.d.). The study filmed fourteen subjects for fifteen minutes during work. Trunk flexion, shoulder flexion, shoulder abduction, and elbow flexion were analyzed with the Dartfish software. The study was able to effectively measure upper body posture, and attributed the large amount of musculoskeletal symptoms to the large amount of trunk flexion that is seen with this type of work (Upjohn et al., n.d.).

Psychometric Properties of the Instrumentation

Goniometer. A study done by Brosseau et al., (2001) also looked at the reliability and validity of the goniometer. The purpose of the study was to examine the intertester reliability, the intratester reliability, and the criterion validity of the universal goniometer and the parallelogram goniometer. The study included 60 subjects with a residual musculoskeletal impairment of the right or left knee (Brosseau et al., 2001). During a 45 minute session each participant had their knee flexion and extension measured with the universal goniometer, the parallelogram goniometer, and a radiograph was taken. Range of motion measurements were also taken of the hip and ankle. The measurement protocol consisted of a visual estimation of the range of motion of the joint; verification of the end feels of the joint, and identification of the bony landmarks for placement of the goniometers, and finally measurement of the joint range of motion (Brosseau et al., 2001). Each participant was asked to maximally flex and extend their knee; next they were placed in a Velcro device which allowed the participant to maintain the same position for each measurement. Measurements were taken with the universal goniometer, the parallelogram goniometer, and radiographs were taken. Lines were drawn on the radiograph films along the axis of the femur and the tibia, and the joint angle was measured with a protractor (Brosseau et al., 2001).

An analysis of variance was used to calculate intertester and intratester reliability of both goniometers, and a Pearson's product-moment correlation coefficients (r) were used to compare the universal goniometer, the parallelogram goniometer and the radiographs (Brosseau et al., 2001). The intratester reliability of goniometric measurements for knee flexion using both the universal goniometer and the parallelogram goniometer were 0.997 and 0.996; knee extension ranged from 0.893 to 0.926 for the universal goniometer. The criterion validity showed *r* values for the universal goniometer for knee flexion from 0.975 to 0.997. The *r* values for knee extension were lower, and ranged from 0.390 to 0.442 (Brosseau et al., 2001). The study determined that there were no statistical differences between the radiograph and the universal goniometer. The study concluded that the goniometer is a reliable instrument for measuring range of motion in the knee, but the measurements should be taken by the same therapist every time (Brosseau et al., 2001).

Dartfish Software. A study done by Womersley and May (2006) used Dartfish to look at the sitting posture of subjects with postural backache. The study conducted a pilot study to determine the validity of the instruments used in the study. A mini digital video camera was used to record the participants' sitting posture for 11 minutes (Womersley, & May, 2006). The video footage was then downloaded onto the computer and a quantitative angle of the lumbar spine was obtained using the Dartfish software. To test the reliability the same researcher superimposed the digital points over the markers and took the average of two readings. The readings had an average discrepancy of 0.31 degrees. To test the intertester reliability the readings from the researchers were compared to the readings of an experienced technician, which had a discrepancy of 0.99 degrees (Womersley, & May, 2006).

Summary

Joint mobilizations and muscle energy are often used to increase joint range of motion (Hsu et al., 2002; Senbursa et al., 2007; Vermulen et al., 2006; Yang et al., 2007; Burns, & Wells, 2006). Some articles claim that there are only minor increases in range of motion with the use of joint mobilizations (Hsu et al., 2002); while others showed a large increase in motion when joint mobilizations were used (Vermeulen et al., 2000). The article by Burns and Wells (2006) showed that muscle energy is effective in increasing cervical range of motion, yet there is little to no research on the effectiveness of muscle energy on the shoulder. There is some research that supports the use of manual therapy techniques, such as joint mobilizations and muscle energy, yet the efficacy of these treatments is still a debate among athletic trainers and therapists. Many studies also show that the universal goniometer is reliable when used to measure shoulder internal and external rotation (Lintner et al., 2007; Reinold et al., 2008; Brosseau et al., 2001). Dartfish software has also been shown to measure angles at the shoulder and is a reliable measuring device (Heath, & Sather, n.d.; Upjohn et al., n.d.; Womersley, & May, 2006).

CHAPTER 3

Method

The methodology of this study was designed to measure shoulder range of motion before and after an intervention of manual therapy. Each participant had an initial measurement of shoulder motion taken with a universal goniometer and video analysis, the experimental groups received an intervention of either joint mobilizations or muscle energy, and then a final measurement of shoulder motion was taken. The control group had pre and post measurements of shoulder motion, but did not receive a treatment intervention.

Participants and Sampling Methods

Selection Criteria. The inclusion criteria for this study required the subjects to have no current shoulder injury, no previous history of shoulder injuries, no previous history of shoulder surgery, and no multidirectional instability of the glenohumeral joint. A sample size of 35 participants was used for this study. This sample size was based on previous research, where sample sizes range from 10 to 30 participants per group (Dower, & Sauers, 2005; Rundquist, & Ludwig, 2005; Tyler, Nicholas, Roy, & Gleim, 2000). A power analysis using a two factor between subjects (sex * treatment) ANOVA was performed. Literature indicated a pooled standard deviation of 5 degrees in shoulder capsular range of motion. The effect size used in the calculation is 4 degrees of shoulder capsular range of motion. The power analysis demonstrated that our subject size of 35 provided a greater than 80% power.

Sampling methods. A convenience sample was used in this study. Participants were recruited through word of mouth, e-mails and presentations to undergraduate classes. Participation in this study was voluntary and only those subjects who qualified for the study participated in the testing sessions. Participant mortality and those who did not qualify for the study were documented.

Institutional Review Board Approval. The study was approved by the Michigan State University Institutional Review Board, and informed consent was obtained from all participants. Prior to participation, all subjects read and signed a consent form describing all inclusion and exclusion criteria, procedures for measurements and interventions, and all possible benefits and risks for the study. Participants were able to withdraw from the study at any time without consequence. Researcher(s) also had the right to withdraw any participant at any time with or without cause.

Assignment of participants to groups. All participants were randomly assigned to one of three groups using the fishbowl method. This consisted of writing group A, group B and group C on three pieces of paper. The participants then closed their eyes and chose one of the three pieces of paper. When one of the groups reached the sample size before the others, that sheet of paper was removed. Fifteen participants were placed in group A and received the joint mobilization intervention. Group B also consisted of 15 participants and received the muscle energy intervention. Group C consisted of 5 subjects and was the control group in which the participants did not receive an intervention.

The first participant in groups A and B had their dominant arm receive an intervention. To determine the participants' dominant arm, they were asked what hand they wrote with. The non-dominant arm did not receive a treatment, but did receive pre and post-test range of motion measurements. The second participant in groups A and B had their non-dominant arm receive an intervention, while their dominant arm only received pre and post-test measurements. The interventions applied alternated between dominate and non-dominate arms for each of the participants in group A and group B. The participants that were assigned to group C only received pre and post-test range of motion measurements for both arms. For a diagram of this selection see Appendix A (table 1, table 2, and table 3). This selection process eliminated the effect of arm dominance on the results. In the event that a participant was ambidextrous they were automatically assigned to the control group. If more than 5 participants were ambidextrous they were documented and randomly assigned to either group A or group B. The arm chosen to receive the intervention was based on the previous participant.

Research Design

Independent and dependent variables. This study had three levels of independent variables; the intervention treatment of joint mobilizations, the intervention treatment of muscle energy, and the control group with no treatment intervention. The dependent variable was the change in the amount of shoulder internal rotation and external rotation, which was measured in degrees.

Research design. This study was a quantitative experimental research design. The study could also be classified as a strong quasi-experimental design. For a diagram of the research design see Appendix A (table 1, table 2, and table 3). The research design was not a true experimental design because a convenience sample was used.

The strong quasi-experimental design was due to having a control group. Random assignment and equivalence of the groups at the start were also included in this design. In order for the experiment to be classified as a true experiment it must include random selection, and this research did not. Having no random selection created some weaknesses in the research design, increasing possible threats to internal and external validity.

Minimizing threats to internal validity. The study did posses threats to internal validity and efforts were made to minimize these threats. The threat of instrumentation existed in the reading of the goniometer measurements and the placement of the goniometer. The measurements were taken and read by a Certified Athletic Trainer, who has been trained in the usage and reading of a goniometer. The anatomical landmarks were also marked on the participants to ensure that the goniometer was placed in the same position each time a measurement was taken. The range of motion measurements were also taken by the same researcher each time and analyzed by Dartfish software (Dartfish, Inc., Alpharetta, GA); which is a more accurate measuring device. Each measurement done with the Dartfish software (Dartfish, Inc., Alpharetta, GA) was also done by the same researcher. A testing reactivity threat could be seen with the participants trying harder to achieve a greater range of motion during the post- test measurements. This was minimized by taking an average of two measurements for both internal rotation and external rotation. Also, during the pre and post-test measurements the participants were also instructed to stop when they felt their own motion barrier and to try and not move past that barrier. A mortality threat also existed, and this was minimized by the participants completing the pre and post-test measurements and the interventions in one testing session.

Minimizing threats to external validity. There were also threats to external validity in this research design. Reaction to an experimental setting was the biggest threat to external validity seen in this study. This was minimized by using a goniometer. A goniometer is and can be readily available to clinicians to measure motion. When measuring range of motion in a clinical setting both passive and active ranges of motion are assessed and this study only measured active range of motion. Also, range of motion is typically assessed over a period of time. The sample population was also not a true representation of the population that is seen in a rehabilitative setting. Manual therapy techniques are typically used in a rehabilitative setting which includes a population that has sustained an injury or shows signs of somatic dysfunction.

Instrumentation

The instruments used to measure range of motion were a universal mechanical goniometer and Dartfish software (Dartfish, Inc., Alpharetta, GA). In a clinical environment the universal goniometer is the most common way to measure range of motion (Clarkson, 2000). A goniometer is a protractor that ranges from 180 degrees to 360 degrees, with one axis that connects two arms (Clarkson, 2000). One arm is stationary while the other arm moves about the axis. The goniometer provided ratio measurements. For this study the goniometer was used by placing the axis of the goniometer over the olecranon process, the stationary arm was positioned parallel to the ground, and the moveable arm is placed parallel to the ulna. The goniometer was also fixed to a tripod. This allowed for the goniometer to remain parallel with the ground while being adjusted to the height of the participants' arm, and a more accurate placement of the goniometer. With the subjects in a supine position, the goniometer was raised or lowered, depending on the height of the subjects, to line up with the olecranon process and the ulna. See Appendix B (figure 2, figure 3) for a picture of the goniometer.

Dartfish software (Dartfish, Inc., Alpharetta, GA) was also used to analyze data. The video images were captured using a JVC digital video camera, which was also fixed to a tripod as well, and the data was transferred to the computer using a FireWire cable. Before the video data was captured, the goniometer was centered in the middle of the video camera and computer screen as to avoid a perspective error. A perspective error is created when the digital image was not directly in the center of the camera lens, if the image was rotated or skewed to the side the digital makers could not be aligned about the axis of rotation of the shoulder. Taking a reading with the goniometer also minimized this error. An image was captured of the participant's shoulder at the end range of motion. The image was instantly transferred to a computer. The Dartfish software (Dartfish, Inc., Alpharetta, GA) contained a quantitative angle program. This program allowed for digital markers to be placed over the marked anatomical landmarks on the subjects, and measured the angle between those marks. The goniometer was only able to provide whole degree measurements. The Dartfish software (Dartfish, Inc., Alpharetta, GA) provided degree measurements to the tenth of the decimal point. The Dartfish (Dartfish, Inc., Alpharetta, GA) readings were compared and confirmed with the goniometric measurements.

Intervention

Intervention for group A. In this study, group A received grade 4 anterior joint mobilizations, according to Maitland. The participant laid prone on a treatment table; and the glenohumeral joint that was receiving the treatment hung off the side of the table. A towel was placed under the clavicle for support and clavicle. The participant was then asked to relax their shoulder while the researcher supported the arm at the elbow. The participant's arm was abducted to 90 degrees and the elbow was flexed to 90 degrees, which was visually estimated. Refer to Appendix C (figure 1) for similar positioning. The researcher then placed their other hand on the humerus at the glenohumeral joint. The hand that was supporting the arm at the elbow then applied a slight outward pressure, causing joint distraction. Next, the researcher applied a downward pressure with the hand that was on the humerus, translating the humerus anteriorly. Refer to Appendix C (figure 1) for visual representation of forces that were applied to the glenohumeral joint. Grade four joint mobilizations were used, which applied small amplitude oscillations at the end range of motion (Vermeulen et al., 2006; Maitland, 1991). The oscillation was maintained for 30 seconds, followed by a 5 second rest. A total of five sets of oscillations were performed.

Intervention for group B. Group B received a muscle energy treatment to increase shoulder external rotation. The participant sat on the side of the treatment table with their legs hanging off the edge. The researcher then stood behind the participant. Refer to Appendix D (figure 1) for participant positioning. The researcher then stabilized the glenohumeral joint with one hand, while the other hand supported the arm at the wrist. The participant's arm was passively moved in approximately 90 degrees of glenohumeral abduction; which was visually estimated. The external rotation motion barrier was then determined by the researcher. At the motion barrier, the participant was asked to "pull down" causing the shoulder to internally rotate. Using the hand that was supporting the shoulder and arm at the wrist the researcher provided resistance to produce an isometric contraction (Greenman, 2003). The contraction was held for five seconds. After this the participant was asked to relax for 5 seconds and a new external rotation motion barrier was determined. This was repeated four more times for a total of five repetitions.

Control group. Group C did not receive an intervention. The participant's initial internal and external rotation was measured. After the initial measurement they sat for a period of 5 minutes. This was the time period that it took to apply the joint mobilizations and muscle energy interventions. After this time period the post-test range of motion measurements were taken.

Data Collection Procedures

Testing schedule. Data collection began in March 2009. Testing sessions were scheduled based on the participants' and researchers' schedules.

Testing sessions. The participants only participated in one testing session. Before each testing session started the participant was provided with information on the research study and signed an informed consent. The subjects self-reported that they had no current or previous history of shoulder injuries, no history of shoulder surgery, no glenohumeral multidirectional instability. First, demographic data was collected. The participant's height, weight, age, gender, current physical activity, and what hand they write with were documented. The participants were asked to either wear a tank top or a loose fitting t-shirt. If the participant was wearing a loose fitting t-shirt, the sleeves of the shirt were rolled up to expose the glenohumeral joint. Using washable marker, a mark was then placed on the olecranon process and the ulnar styloid process. See Appendix B (figure 1) for placement of the marks. The marks were made to ensure the exact alignment of the goniometer each time the participant's range of motion was measured. Next, that participant was asked to lay supine on a treatment table. With their arm fully supported by the table, the participant's arm was placed in approximately 90 degrees of abduction and 90 degrees of elbow flexion, which was visually estimated. A towel was placed under the upper arm to accommodate for the natural position of the glenohumeral joint. A block was also placed just superiorly and inferiorly to the participant's upper arm; this was to prevent the participant's arm from abducting and adducting while their range of motion was measured. See Appendix B (figure 1, figure 2, and figure 3) for exact positioning of the participants.

Next, the goniometer was aligned with the marks that were placed on the participant's forearm. The goniometer was fixed to a tripod so that the stationary arm was not able to move while the participant's motion was measured. It also assured that the goniometer was placed in the exact location each time range of motion was measured. The goniometer was adjusted so that the axis was placed over the mark on the olecranon process and the stationary arm was aligned parallel to the ground. The movable arm was aligned with the mark that was placed on the ulnar styloid process and was parallel to the ulna. The participant's arm was then placed in a neutral position, of zero degrees of internal or external rotation, which was also visually estimated, and the video camera was centered and focused. Refer to Appendix B (figure 2, figure 3) for exact goniometer alignment. The initial measurements were then taken for internal and external rotation. The participant was first asked to externally rotate their arm until the end of active range of motion. The moveable arm of the goniometer was realigned with the ulnar styloid process and parallel to the ulna, and the measurement was read and recorded. While maintaining their position, an image of the participant with their arm externally rotated was captured with the video camera. The image was then instantly transferred to the computer, and the range of motion was measured with the Dartfish software (Dartfish, Inc., Alpharetta, GA), and recorded. The participant then returned their arm to the neutral position and the goniometer was rechecked for the proper alignment. External rotation was then measured again for a total two trials. Internal rotation was measured with the same protocol in which external rotation was measured. A total of two measurement trials were also taken for internal rotation.

After the initial shoulder ranges of motions were measured, the participant received the appropriate intervention. Group A received the joint mobilization protocol, group B received the muscle energy protocol and group C received no treatment. Before any intervention is applied, an explanation of what the participant may feel was given. It was explained to the group A participants that they would feel a slight tug at the shoulder and may feel the humeral head shifting inside the joint. It was explained to the group B participants that they would feel a slight stretch of the shoulder during the intervention. If at any time during the testing session the participant began experience any discomfort with the interventions, the interventions were stopped. The participant was then given the option to continue with the testing session. If the participant decided to continue with the study, the intervention positioning was modified to eliminate any discomfort. Any change in positioning during the intervention was documented. Finally, the participant's post-test measurements were taken. The post-test range of motion measurements followed the same protocol as the initial measurements.

Data Analyses. All data was analyzed using the SPSS software (SPSS, Inc., Chicago, IL). Demographical data, such as age, gender, height, weight and current physical activity level was summarized using descriptive data. The SPSS software was also used to analyze the average means, standard deviations and frequencies of the demographical data. All data was analyzed at a significant level of $p \leq 0.05$. A paired t-test, one-way ANOVA and multivariate tests were run to analyze all measurements. Post hoc tests were not run because there were fewer than two experimental groups.

Data Management. All data were collected and kept in a confidential location. The data sheets were kept in a locked cabinet inside the kinesiology building and were only available to the researchers. The computer data was kept on a computer that requires a password to access the information. As per, Michigan State University and Federal regulations, data will be kept by the primary investigator for three years beyond the end of the study. All data were kept confidential and protected to help protect the privacy of the participants' sensitive information.

Key personnel, qualifications, and responsibilities. Certified Athletic Trainers performed all intervention protocols and placed the marks on all anatomical landmarks. Through the National Athletic Training Board of Certification, certified athletic trainer are educated and qualified to perform manual therapy techniques such as, joint mobilizations and muscle energy. All interventions and measurements were performed by the same researcher for each participant.

CHAPTER 4

Results

This study analyzed the effects of joint mobilizations versus muscle energy techniques on increasing shoulder motion. Data results for the goniometer and Dartfish (Dartfish, Inc., Alpharetta, GA) were both recorded and analyzed. The Dartfish software (Dartfish, Inc., Alpharetta, GA) measured shoulder range of motion in degrees to the tenth of the decimal point. Due to the Dartfish software (Dartfish, Inc., Alpharetta, GA) providing a measurement to the tenth degree, as opposed to the whole degree with the goniometer, these results are presented in the study. Pre and post-test measurements consisted of an average of two trial measurements for both internal and external rotation. For groups A and B, one arm did not receive an intervention and was considered the non-intervention arm and the arm that did receive an intervention was considered the experimental arm. Group A received a joint mobilization intervention, group B received a muscle energy intervention, and group C did not receive an intervention. The difference between the mean pre-test and mean post-test measurements were also calculated and analyzed.

Subject Demographics

All subjects completed the study, making the mortality rate zero. Also, all of the subjects who volunteered for the study met all of the inclusion criteria. The study consisted of 35 participants (23 females, 12 males). The mean age of the participants was 22 years (± 2.296). There was a mean height of 67.03 inches (± 3.709), and there was a mean weight of 164.95 pounds (± 34.323). Thirty-three subjects were right hand dominant, 1 subject was left hand dominant, and one subject considered herself to be ambidextrous.

Group A consisted of 15 subjects (11 females and 4 males), with a mean age of 22 years (± 2.330), a mean height of 66.80 inches (± 5.031), and a mean weight of 158.53 pounds (± 33.732). Group B also consisted of 15 subjects (8 females, 7 males). For group B, the mean age was 22 years (± 2.449), the mean height was 67.60 inches (± 2.772), and the mean weight was 171.60 pounds (± 35.902). Group C consisted of 5 subjects (4 females, 1 male), with a mean age of 20 years (± 1.713), a mean height of 66.50 inches (± 2.708), and a mean weight of 164.60 pounds (± 34.458).

Control group

Group C was considered the control group, in which neither arm received an intervention. For the subjects in group C, both their right and left arms were entered as separate data sets; creating 10 different data sets for group C. A t-test was performed for group C analyzing the mean pre-test results versus the mean post-test results for both external rotation and internal rotation (see table 4-1). For external rotation, there was no significant difference between the mean pre-test measurement and the mean post-test measurement ($t = 1.360$, $p = 0.207$). There was a mean increase of approximately 2 degrees, but this was not considered statistically significant. For internal rotation, there was also no significant difference between the mean pre-test measurement and the mean post-test measurement ($t = 0.080$, $p = 0.938$).

Table 4-1 Mean pre-test versus mean post-test measurements for internal and external rotation for Control (Group C)

Range of Motion	Pre-Test Mean	Post-Test Mean	Mean Difference	DF	T	Sig.
External Rotation N=10	82.6° (± 13.9°)	84.5° (±14.4°)	1.9°	9	1.360	0.207
Internal Rotation N=10	52.5° (±15.8°)	52.7° (±16.6°)	0.2°	9	0.080	0.938

External Rotation.

T-Test. To determine the effect of the joint mobilization intervention and the muscle energy intervention on external rotation, the mean pre-test measurement for the non-intervention arm were compared against the mean pre-test measurement for the experimental arm (see table 4-2). For the subjects in experimental group (group A), there was no significant difference between the non-intervention arm and the experimental arm with the mean pre-test measurement ($t= -0.259$, $p= 0.799$). For the subjects in group B, there was also no significant difference between the non-intervention arm and the experimental arm ($t= -0.199$, $p = 0.845$). For group A and group B, both the non-intervention arm and the experimental arm were equal at the start. The mean post-test measurements for the non-intervention arm were also compared against the mean post-test measurement for the experimental arm (see table 4-2). For group A, there was a mean difference of approximately 2 degrees, which was not considered statistically significant ($t=0.600$, $p= 0.558$). For group B, there was approximately a 3 degree difference in means between the non-intervention arm post-test measurement and the experimental arm post-test measurement, this was not statistically significant ($t= -1.302$, $p= 0.214$).

Also for external rotation, the mean pre-test measurement was compared against the mean post-test measurement, for the experimental arm (see table 4-3). For group A, there was no significant difference (t= -0.719, p = 0.484). For group B, there was a mean difference of approximately five degrees between the mean pre-test (76.2 ± 13.7) and the mean post-test (82.2 ± 12.9). The t-test showed that this was statistically significant (t = -2.679, p = 0.018). When this difference is compared to the group C, with a mean difference of 2 degrees between the pre-test and post-test measurements for external rotation; this difference is not clinically significant.

A t-test was also done to determine the significance between the mean difference between the mean pre-test and the mean post-test measurements for the non-intervention arm and the experimental arm, for external rotation (see table 4-3). For group A, there was no significant difference (t= -0.416, p= 0.684). There was a difference of approximately 2 degrees for group B, but this was not statistically significant (t= -0.824, p= 0.424).

Table 4-2 External rotation mean pre-test versus mean post-test measurements

Group (Intervention)	Arm	Pre-test Mean	Post-test Mean	DF	Pre-test Vs. Pre-test	Post-Test Vs Post-test	Pre-test E Vs. Post-test E
Group A (JM) N=15	NI	79.9° (±12.5)	80.1° (±13.9)	14	T= -0.259 P=0.799	T= -0.600 P= 0.558	
	E	80.8° (±13.5)	82.4° (±13.2)	14			T= -0.719 P= 0.484
Group B (ME) N=15	NI	75.6° (±14.1)	79.5° (±13.1)	14	T= -0.199 P= 0.845	T= -1.302 P= 0.214	
	E	76.2° (±13.7)	82.2° (±12.9)	14			T= -2.679* P=0.018*

JM = Joint Mobilizations, ME = Muscle Energy, NI= Non-Intervention, E= Experimental

Table 4-3 External Rotation mean pre-test/post-test difference measurements

Group (Intervention)	Arm	Mean Difference	DF	T	Sig.
Group A (JM) N= 15	NI	0.3° (±7.5)	14	-0.416	0.684
	E	1.5° (±2.1)			
Group B (ME) N=15	NI	3.9° (±1.8)	14	-0.824	0.424
	E	5.9° (±2.2)			

JM=Joint Mobilizations, ME=Muscle Energy, NI =Non-intervention, E=Experimental

One-Way ANOVA. For external rotation, a one-way ANOVA was run which compared the mean pre-test measurements for the non-intervention arm to the mean pre-test measurements of the experimental arm, and it was factored by groups (see table 4-4). There was no significant difference between group A and group B for the mean pre-test measurements of the non-intervention arm (f=0.785, p=0.383). There was also no significant difference between group A and group B for the mean pre-test measurements of the experimental arm (f=0.855, p=0.363). A one-way ANOVA was also run to compare the mean post-test measurements for the non-intervention arm to the mean post-test measurements for the experimental arm, which was also factored by groups (see table 4-4). There was no significant difference between groups for the mean post-test measurements of the non-intervention arm (f= 0.014, p=0.9070), or the experimental arm (f=0.001, p= 0.978). Also to determine the effects on external rotation, the difference between the mean pre-test and the mean post-test measurements for the non-intervention arm and the experimental arm were compared and factored by groups (see tables 4-5). There was no significant difference between groups for the non-intervention arm (f=1.954, p=0.173) and there was no significant difference between groups for the experimental arm (f=2.062, p= 0.162).

Table 4-4 External rotation between groups mean pre-test and post-test measurements

Arm	Group (Intervention)	Pre-Test Mean	Post-Test Mean	DF	Pre-Test Vs. Pre-test	Post-Test Vs Post-Test
Non-Intervention	Group A (JM) N=15	79.9° (±12.5°)	80.1° (±13.9°)	14	F =0.785 P= 0.383	F= 0.014 P= 0.907
	Group B (ME) N=15	75.6° (±14.1°)	79.5° (±13.1°)			
Experimental	Group A (JM) N=15	80.8° (±13.4°)	82.4° (±13.2)	14	F= 0.855 P=0.363	F= 0.001 P= 0.978
	Group A (JM) N=15	76.2° (±13.7°)	82.2° (±12.9)			

JM= Joint Mobilizations, ME = Muscle Energy

Table 4-5 External rotation between groups means pre-test/post-test difference measurements

Arm	Group (Intervention)	Mean Difference	DF	F	Sig.
Non-Intervention	Group A (JM) N=15	0.3° (± 7.5°)	1	1.954	0.173
	Group B (ME) N=15	3.9° (± 7.2°)			
Experimental	Group A (JM) N=15	1.5° (± 8.3°)	1	2.062	0.162
	Group B (ME) N=15	5.9° (± 8.7°)			

JM = Joint Mobilizations, ME = Muscle Energy

Multivariate. For external rotation, a multivariate test were run to compare the mean pre-test measurement of the non-intervention arm against the mean pre-test measurement of the experimental arm, it was factored by sex and groups (see tables 4-6, 4-7, and 4-8). There was no significant difference between groups for the non-intervention arm (f= 0.184, p=0.671) and the experimental arm (f= 0.139, p=0.713). The multivariate also showed no significant difference between sexes for the non-intervention arm (f=0.453, p=0.507) and the experimental arm (f=1.821, p=0.189). When looking at the groups factored by sex, there was also no significant difference for the non-intervention arm (f= 0.909, p=0.349) and the experimental arm (f=0.731, p=0.400).

The mean post-test measurement for the non-intervention arm was compared against the mean-post test measurement for the experimental arm, and was factored by groups and sex, to determine the effects on external rotation (see tables 4-6, 4-7, and 4-8). The multivariate test showed that there were no significant differences between groups for the non-intervention arm (f=0.193, p=0.664) and the experimental arm (f=0.057, p=0.813), for the mean post-test measurements. There was also no significant difference between sexes for the non-intervention (f=1.524, p=0.228) arm and the experimental arm (f=2.355, p=0.137). When factored by group and sex, there was no significant difference for the non-intervention arm (f= 1.294, p=0.226) and the experimental arm (f=0.024, p=0.877).

Also for external rotation, multivariate tests were run to compare the differences between the mean pre-test measurement and the mean post-test measurement for the non-intervention arm to the experimental arm, which was also factored by groups and sex (see tables 4-6, 4-7, and 4-8). The results showed that there was no significant difference between groups for the non-intervention arm (f=2.460, p=0.129) and the experimental arm (f=0.942, p=0.341). When looking at the differences between sexes, there was no significant difference between males and females for the non-intervention arm (f=0.994, p=0.328) and the experimental arm (f=0.039, p=0.845). The multivariate also showed no significant differences for the non-intervention arm (f=0.098, p=0.757) and the experimental arm (f=2.623, p=0.117), when factored by group and sex.

Table 4-6 External rotation mean pre-test versus mean post-test measurements, factored by group and sex

Sex	Group (Intervention)	Pre-Test Mean		Post-Test Mean		Mean Difference	
		NI Arm	E Arm	NI Arm	E Arm	NI Arm	E Arm
Female	Group A (JM) N=11	82.2° (±12.9°)	83.9° (± 10.9°)	83.4° (± 13.2°)	84.2° (±12.9°)	1.2° (±4.8°)	0.3° (±6.9°)
	Group B (ME) N=8	74.9° (±13.5°)	77.5° (±13.5°)	79.8° (±12.8°)	86.2° (±12.2°)	4.9° (±9.3°)	8.8° (±9.2°)
Male	Group A (JM) N=4	73.6° (± 10.2°)	72.3° (± 17.7°)	71° (± 13.4°)	77.3° (±14.3°)	-2.9° (±13.1°)	4.9° (±11.9°)
	Group B (ME) N=7	76.4° (± 15.9°)	74.8° (± 14.9°)	79.2° (± 14.4°)	77.7° (± 13.1°)	2.9° (±3.9°)	2.9° (±7.4°)

JM = Joint Mobilizations, ME = Muscle Energy, NI = Non-Intervention, E=Experimental

Table 4-7 External rotation multivariate results for the non-intervention arm

Factor	Comparison	DF	F	Sig.
Group	Pre-test JM vs. Pre-test ME	1	0.184	0.671
	Post-test JM vs. Post-test ME	1	0.193	0.664
	Difference JM vs. Difference ME	1	2.46	0.129
Sex	Pre-test JM vs. Pre-test ME	1	0.453	0.507
	Post-test JM vs. Post-test ME	1	1.524	0.228
	Difference JM vs. Difference ME	1	0.994	0.328
Group*Sex	Pre-test JM vs. Pre-test ME	1	0.909	0.349
	Post-test JM vs. Post-test ME	1	1.294	0.226
	Difference JM vs. Difference ME	1	0.098	0.757

JM = Joint Mobilization (group A), ME = Muscle Energy (group B)

Table 4-8 External rotation multivariate results for the experimental arm

Factor	Comparison	DF	F	Sig.
Group	Pre-test JM vs. Pre-test ME	1	0.139	0.713
	Post-test JM vs. Post-test ME	1	0.057	0.813
	Difference JM vs. Difference ME	1	0.942	0.341
Sex	Pre-test JM vs. Pre-test ME	1	0.433	0.189
	Post-test JM vs. Post-test ME	1	2.355	0.137
	Difference JM vs. Difference ME	1	0.039	0.845
Group*Sex	Pre-test JM vs. Pre-test ME	1	0.909	0.400
	Post-test JM vs. Post-test ME	1	0.024	0.877
	Difference JM vs. Difference ME	1	2.623	0.117

JM=Joint Mobilizations, ME=Muscle Energy

Internal Rotation

T-Test. To determine the effects of the joint mobilization intervention and the muscle energy intervention on internal rotation; the mean pre-test measurement of the non-intervention arm were compared against the mean pre-test measurement of the experimental arm (see table 4-9). In group A, there was approximately 5 degree difference between the pre-test measurements, but this was not considered to be statistically significant ($t= 1.080$, $p= 0.298$). There was also no statistical significance between the mean pre-test measurements for the non-intervention arm and the mean experimental arm, for group B ($t= -0.146$, $p= 0.886$). The non-intervention arm and the experimental arm were equal at the start, for both group A and group B. The mean post-test measurement for the non-intervention arm was also compared to the mean post-test measurement for the experimental arm (see table 4-9). With group A, there was approximately 1 degree difference in the means, which was not statistically significant (t= 0.224, p= 0.826). There was also no significant difference for group B, which had a mean difference of approximately 1 degree, as well (t= 0.073, p= 0.943).

Also for internal rotation, the mean pre-test measurement of the non-intervention arm was compared to the mean post-test measurement of the experimental arm (see table 4-9). There was no statistical difference between the mean pre-test measurement and the mean post-test measurement for group A (t= -1.351, p= 0.198). For group B, there was approximately a 3 degree difference between the mean pre-test measurement (54.1°±15.4) and the mean post-test measurement (57.9 ± 16.3); which was considered statistically significant (t=-2.943, p= 0.011). The difference between the mean pre-test and the mean post-test measurements for the non-intervention arm was compared to the experimental arm (see tables 4-10). There was no statistical difference seen for group A (t= -1.286, p= 0.219) or group B (t= 0.308, p= 0.763).

Table 4-9 Internal rotation mean pre-test versus mean post-test measurements

Group (Intervention)	Arm	Pre-Test Mean	Post- Test Mean	DF	Pre-Test vs. Pre-Test	Post-Test vs. Post-Test	Pre-Test E vs. Post-Test E
Group A (JM) N=15	NI	55.6° (±16.7)	54.5° (±14.2)	14	T=1.080 P=0.298	T=0.224 P=0.826	
	E	50.3° (±17.2)	53.5° (±19.8)	14			T=-1.351 P=0.198
Group B (ME) N=15	NI	53.6° (±17.3)	58.2° (±16.8)	14	T=-0.146 P=0.886	T=0.073 P=0.943	
	E	54.1° (±15.4)	57.9° (±16.3)	14			T= -2.943* P=0.011*

JM=Joint Mobilizations, ME=Muscle Energy, NI=Non-Intervention, E=Experimental

Table 4-10 Internal Rotation mean pre-test/post-test difference measurements

Group (Intervention)	Arm	Mean Difference	DF	T	Sig.
Group A (JM) N=15	NI	-1.1° (±7.8)	14	-1.286	0.219
	E	3.2° (±9.2)			
Group B (ME) N=15	NI	4.6° (±1.9)	14	0.308	0.763
	E	3.9° (±1.3)			

JM =Joint Mobilizations, ME=Muscle Energy, NI=Non-intervention, E=Experimental

One-Way ANOVA. For internal rotation, the mean pre-test measurement for the non-intervention arm was compared to the mean pre-test measurement for the experimental arm, and factored by groups (see table 4-11). The ANOVA showed no significant difference between group A and group B for both the non-intervention arm (f=0.100, p=0.755) and the experimental arm (f=0.408, p= 0.528). The mean post-test measurements for the non-intervention arm and the experimental arm were also compared and factored by groups. The comparison showed no significant difference between groups for the non-intervention arm (f= 0.422, p=0.521), and showed no significant difference between groups for the experimental arm (f=0.459, p=0.503) (see table 4-11). Also for internal rotation, a one-way ANOVA was also run that compared the difference between the mean pre-test measurements and mean post-test measurements for the non-intervention arm to the experimental arm, and was factored by groups (see table 4-12). The ANOVA showed a significant difference between groups for the non-intervention arm (f=4.213, p=0.05). Group A, which received the joint mobilization intervention, showed a 1.1 (± 7.8°) degree decrease in shoulder internal rotation between the mean pre-test measurement and the mean post-test measurement. Group B, which received a muscle energy intervention, saw an increase of 4.6 degrees (± 7.3°) of shoulder internal rotation. There was no significant difference between groups for the experimental arm (f=0.064, p=0.802).

Table 4-11 Internal rotation between groups means pre-test and post-test measurements

Arm	Group (Intervention)	Pre-Test Mean	Post-Test Mean	DF	Pre-Test vs. Pre-Test	Post-Test vs. Post-Test
Non-Intervention	Group A (JM) N=15	55.6° (± 16.7°)	54.5° (± 14.2°)	1	F=0.100 P=0.755	F=0.422 P=0.521
	Group B (ME) N=25	53.7° (± 17.3°)	58.2° (± 16.8°)			
Experimental	Group A (JM) N=15	50.3° (± 17.2°)	53.5° (± 19.8°)	1	F=0.408 P= 0.528	F=0.459 P=0.503
	Group B (ME) N=15	54.1° (±15.4 °)	57.9° (± 16.3°)			

JM=Joint Mobilizations, ME=Muscle Energy

Table 4-12 Internal rotation between groups mean pre-test/post-test difference measurements

Arm	Group (Intervention)	Mean Difference	DF	F	Sig
Non-Intervention	Group A (JM) N=15	-1.1° (±7.8°)	1	4.213*	0.050*
	Group B (ME) N=15	4.6° (±7.3°)			
Experimental	Group A (JM) N=15	3.2° (±9.2°)	1	0.064	0.802
	Group B (ME) N=15	3.9° (±5.1°)			

JM = Joint Mobilizations, ME = Muscle Energy

Multivariate. For internal rotation, a multivariate test was run to compare the mean pre-test measurement of the non-intervention arm against the mean pre-test measurements of the experimental arm, which was factored by groups and sex (see tables 4-13, 4-14, and 4-15). When comparing groups, there was no significant difference between group A and group B for the non-intervention arm (f=0.119, p=0.733) and the experimental arm (f=1.357, p=0.255). Also, for the non-intervention arm there was no significant difference between sexes (f=1.905, p=0.179). There was a significant difference between sexes for the experimental arm (f=4.404, p=0.045). For the experimental arm, females (56.6°) had greater internal rotation at the start of the study, when compared to males (43.8°). When factored by group and sex, there was no significant difference for the non-intervention arm (f=1.409, p= 0.246) and no significant difference for the experimental arm (f=0.207, p=0.653).

A multivariate was run to compare the mean post-test measurement for the non-intervention arm against the mean post-test for the experimental arm, and was factored by group and sex, for internal rotation as well (see tables 4-13, 4-14 and 4-15). When factored by groups, there was no significant difference for the non-intervention arm (f=0.654, p=0.426) and the experimental arm (f=1.924, p=0.177). When factored by sexes, there was no significant difference for the non-intervention arm (f=3.803, p=0.062). For the experimental arm there was a significant difference between males and females regarding the mean post-test measurements of internal rotation (f=4.578, p=0.042). Females had a mean post-test measurement for the experimental arm of 60.2 degrees, and males had a mean post-test measurement of 45.9 degrees. When factored by groups and sex, there was no significant difference for the non-intervention arm (f=0.684, p=0.416) and the experimental arm (f=1.172, p=0.289).

Also for internal rotation, the difference between the mean pre-test and the mean post-test measurement for the non-intervention arm and the experimental arm was also analyzed and factored by groups and sex (see tables 4-13, 4-14 and 4-15). When factored by groups there was a significant difference between group A and group B for the non-intervention arm (f=5.370, p=0.029). Group A, which received the joint mobilization intervention, had a mean decrease in internal rotation of approximately -2.3 degrees. Group B, which received the muscle energy protocol, had a mean increase of 4.6 degrees for internal rotation. There was no significant difference between groups for the experimental arm (f=0.580, p=0.453). There was also no significant difference between sexes for the non-intervention arm (f=0.654, p=0.426) and the experimental arm (f=0.282, p=0.600), with internal rotation. When factored by groups and sexes, there was no significant difference for the non-intervention arm (f=0.915, p=0.348) and there was no significant difference for the experimental arm (f=2.439, p=0.130).

Table 4-13 Internal rotation mean pre-test versus mean post-test measurements, factored by groups and sex

Sex	Group (Intervention)	Pre-Test Mean		Post-Test Mean		Mean Difference	
		NI Arm	E Arm	NI Arm	E Arm	NI Arm	E Arm
Female	Group A (JM) N=11	55.9° (±18.1°)	54.4° (±17.9°)	56.2° (±15.3°)	59.2° (±19.3°)	0.3° (±6.9°)	4.8° (±9.9°)
	Group B (ME) N=8	61.3° (±12.8°)	58.7° (±9.9°)	65.7° (±11.8°)	61.2° (±13.8°)	4.4° (±5.4°)	2.5° (±6.6°)
Male	Group A (JM) N=4	54.7° (±14.5°)	38.8° (±7.7°)	49.7° (±11.0°)	37.6° (±11.5°)	-4.9° (±9.8°)	-1.2° (±4.9°)
	Group B (ME) N=7	44.8° (±18.3°)	48.7° (±19.4°)	49.6° (±18.4°)	54.2° (±19.2°)	4.8° (±9.5°)	5.5° (±2.2°)

JM=Joint Mobilizations, ME=Muscle Energy, NI=Non-Intervention, E=Experimental

Table 4-14 Internal rotation multivariate results for the non-intervention arm

Factor	Comparison	DF	F	Sig.
Group	Pre-test JM vs. Pre-test ME	1	0.119	0.733
	Post-test JM vs. Post-test ME	1	0.654	0.426
	Difference JM vs. Difference ME	1	0.592	0.449
Sex	Pre-test JM vs. Pre-test ME	1	1.905	0.179
	Post-test JM vs. Post-test ME	1	3.803	0.062
	Difference JM vs. Difference ME	1	0.654	0.426
Group*Sex	Pre-test vs. Pre-test ME	1	1.409	0.246
	Post-test vs. Post-test ME	1	0.684	0.416
	Difference JM vs. Difference ME	1	0.915	0.348

JM = Joint Mobilization (group A), ME = Muscle Energy (group B)

Table 4-15 Internal rotation multivariate results for the experimental arm

Factor	Comparison	DF	F	Sig.
Group	Pre-test JM vs. Pre-test ME	1	1.357	0.255
	Post-test JM vs. Post-test ME	1	1.924	0.177
	Difference JM vs. Difference ME	1	4.063	0.054
Sex	Pre-test JM vs. Pre-test ME	1	4.404	0.045*
	Post-test JM vs. Post-test ME	1	4.578	0.042*
	Difference JM vs. Difference ME	1	0.282	0.600
Group*Sex	Pre-test JM vs. Pre-test ME	1	0.207	0.653
	Post-test vs. Post-test ME	1	1.172	0.289
	Difference JM vs. Difference ME	1	2.439	0.130

JM = Joint Mobilization (group A), ME = Muscle Energy (group B)

CHAPTER 5

Discussion

The results of this study showed that both the experimental groups and the control group saw minimal increases in range of motion, which were not considered to be significant. Neither the joint mobilization intervention nor the muscle energy intervention significantly increased shoulder internal or external rotation in healthy males and females. Even though there was no significant range of motion gains with either intervention, similar results were seen with both the joint mobilizations intervention and the muscle energy intervention. The results of this study also supported all three hypotheses. The hypotheses stated that males and females would not see an increase in shoulder internal and external rotation after an intervention of either joint mobilizations or muscle energy, and that there would be no difference between both of the experimental groups and the control group.

There is little research that looks at manual therapy and the differences between males and females. When looking at the differences between genders, this study found that there was no difference between males and females for shoulder external rotation with both the joint mobilization and muscle energy intervention. For internal rotation, females started with a greater range of motion when compared to males. Also, the males actually saw a small decrease in shoulder internal range of motion after the joint mobilization intervention; which was not considered statistically significant.

Although this study did not produce any statistically significant results, both interventions saw similar results in changes of the range of motion. There are also many future research considerations that can be taken from this study. For future research, clinicians should consider previous sport involvement, applying the interventions to subjects that are experiencing a loss in range of motion, and using multiple treatment sessions.

The Effects of Joint Mobilizations

According to the results of this study, the participants did not see an increase in shoulder internal or external rotation after an intervention of grade four anterior joint mobilizations. This is inconsistent with the results of a study done by Hsu et al. (2002). Hsu et al. (2002) suggested that end range of motion anterior joint mobilizations do increase shoulder external rotation and that end range of motion posterior joint mobilizations increase shoulder internal rotation. Hsu et al. (2002) used frozen cadaver shoulders for their study, which was recognized as a limitation due to the effects of the tissue temperature on the tissues' elasticity.

The in-vivo subject population used in this study did not report any current shoulder dysfunction or a previous history of shoulder dysfunction, which may have decreased their range of motion. The majority of the subjects demonstrated nearly full range of motion; when joint motion is close to its full range of motion there is very little motion that can be gained. This could be a reason as to why the subjects did not gain a significant amount of range of motion with the joint mobilization intervention. The specimens that were used in the study by Hsu et al. (2002) showed a decrease in shoulder motion due to the temperatures of the tissue; which is a possible reason for the significant changes in motion they found with joint mobilizations. Another difference is that the frozen shoulders used by Hsu et al. (2002) did not have any restrictions from the surrounding musculature. The only restrictions for the frozen specimens were the joint capsule. In live subjects, a major joint restriction is seen from muscular spasms and restrictions from the surrounding musculature. For this study the surrounding musculature must be taken into account. The participants were not experiencing any muscle spasms or tightness at the time they participated in the study; which may also be another reason for the lack of any significant changes in range of motion.

Hsu et al. (2002) included a mechanical device which applied the joint mobilization intervention to the shoulders. The device was set to progressively increase the humeral head displacement during the intervention (Hsu et al. 2002). In the current study the researcher attempted to maintain the same amount of humeral head displacement during the intervention due to the possible discomfort that the subjects could possibly experience. When using cadavers there is no concern for causing discomfort, so the force that is applied to the shoulder can be much greater, when compared to live subjects.

As previously mentioned, a study done by Johnson et al. (2007) compared anterior joint mobilizations versus posterior joint mobilizations on increasing shoulder external rotation. The results of the current study are inconsistent with the results from the study done by Johnson et al. (2007). Johnson et al. (2007) used an older sample population that had adhesive capsulitis; both the increased age and adhesive capsulitis greatly decrease range of motion. This study used a population with the mean age of 22 years, which demonstrated close to full shoulder range of motion. Johnson et al. (2007) also pre-treated the subjects with therapeutic ultrasound before the intervention. The increased temperature from the ultrasound could have increased the effects seen with joint mobilizations. The subjects in the current study did not receive any pre-treatments before the interventions were applied. Another difference between the two studies is that Johnson et al. (2007) applied multiple treatment sessions and this study only applied one treatment session. Multiple treatment sessions could be the reason for the large increases in range of motion that their subjects experienced.

The Effects of Muscle Energy

There is little research on the effects of muscle energy techniques on the shoulder; however other joints have been studied. A study done by Lenehan et al. (2003) looked at the effect of muscle energy techniques on gross trunk range of motion. Similar to Lenehan et al. (2003), the current study only applied one muscle energy treatment to the joint. Lenehan et al. (2003) applied the muscle energy intervention to the range of motion that was restricted, and in the current study the intervention was applied to the shoulder regardless of whether there was a current restriction or not. Due to not knowing if the subject's shoulder was restricted or not, could be why there were no significant changes in shoulder range of motion following the muscle energy intervention in the current study.

Another study done by Ballantyne et al. (2003) looked at the effect of muscle energy on hamstring extensibility. The purpose of the study was to determine if one treatment of muscle energy created immediate changes in hamstring flexibility (Ballentyne et al., 2003). The results of the study done by Ballentyne et al. (2003) are similar to the results of this study. Although there were small increases in shoulder range of motion seen after the muscle energy intervention, both the experimental and the control groups saw increases. The results of the study done by Ballentyne et al. (2003)

also saw small increases in range of motion with the control and experimental groups as well.

Clinical Significance

Although the current study did not show any significant changes in shoulder range of motion, it can be used as a starting point for further research on the efficacy of manual therapy. From previous research, most of the participants saw increases in range of motion after multiple treatments (Johnson et al., 2007). The subjects in this study did not experience a significant increase in range of motion after one intervention of either joint mobilizations or muscle energy. This possibly indicates that one treatment of manual therapy may not be enough to significantly affect range of motion, and clinicians may want to consider multiple treatment sessions to increase range of motion.

Also, the subjects in the current study demonstrated nearly full range of motion and experienced small increases in shoulder motion after the interventions. This may suggest that the joint mobilizations and muscle energy could be more effective on subjects who are experiencing a loss in range of motion. It is possible that the minimal increases may be due to the stretching of the shoulder that was seen from multiple trials when measuring range of motion. This may indicate that stretching before the application of either joint mobilizations or muscle energy may eliminate any restrictions due to the surrounding structures of the joint, allowing the interventions to be more effective.

Even though there were no significant increases in range of motion, both the joint mobilization group and the muscle energy group did see approximately a 2-3 degree increase in internal and external rotation. With a subject population that does not have a shoulder dysfunction 2-3 degrees is not considered significant. In a population that does have a significant decrease in range of motion; a 2-3 degree increase in internal and external rotation may be clinically significant. In addition, this increase was seen with only one treatment of joint mobilizations or muscle energy. If a 2-3 degree increase in range of motion occurs after each treatment, over time and after multiple treatments patients would see a significant increase in range of motion.

Limitations

There are a few limitations to this study. One limitation is the accuracy of the measuring device. Although previous research has shown that the goniometer and the Dartfish software are reliable (Brosseau et al., 2001; Womersley, & May, 2006) and commonly used in a clinical setting, a more precise measuring device, such as high speed cameras that utilize a preset kinematic marker system, would have measured range of motion more accurately. The muscle energy protocol that was used in the current study was taken from a technique that was developed by Dr. Greenmen (2003). Greenman's technique requires the patient to be in a sitting position. In a sitting position the researcher noticed that the subjects did not fully relax their shoulders. In order for autogenic inhibition to work properly the muscles must be relaxed. While sitting, the participants were involuntarily contracting stabilizing muscles. With the arm at 90 degrees of abduction some of those stabilizing muscles included muscles at the shoulder. The inability of the participants to fully relax could have affected the results seen from the muscle energy technique. One more limitation to the study would be the sample population. The sample population is not typically seen in a clinical environment. Joint mobilizations and muscle energy are often used on patients with a shoulder dysfunction, which affects range of motion at the shoulder. The subjects in this study were required to have no shoulder dysfunction, no previous shoulder injury, and no previous shoulder surgery; which makes it difficult to see any gains they may have been experienced with the interventions.

Confounding Variables

During data collection there were a few variables that were not foreseen and could have possibly affected the outcome of this study. One variable was that many of the participants voluntarily reported that they had previously participated in an overhead sport. Overhead sports require a greater range of motion at the shoulder. These participants met all the inclusion criteria for the study; however, their previous sport involvement could have affected the outcome of the study. Another variable that was discovered was that during the pre-test and post-test range of motion measurements, the participants had a tendency to abduct and adduct their arms while internally and externally rotating. This was attempted to be controlled by placing blocks on either side of the arm to prevent the additional motion, but sometimes the participants were too strong for the blocks. The additional movement also could have affected the results of the study.

Future Research Considerations

Future research considerations would include studying a population with limited shoulder range of motion; which is most likely to be seen in a clinical setting. In a population with limited range of motion, there is a possibility that a greater change in the range of motion could be seen. Also, future research may want to eliminate participants who have previously participated in an overhead sport; as this also affects range of motion. Another consideration would be to study the effects of multiple treatments. Many of the studies have shown that the major increases in a range of motion are seen after multiple treatments (Johnson et al., 2007). Further research could also look at measuring all ranges of motion at the shoulder. This study only looked at internal and external rotation. Different results may be seen if shoulder abduction, flexion, and extension were included.

Also with this study, it was seen that the control subjects gained approximately 2 degrees of motion just from having their range of motion measured. Applying a stretching protocol before the intervention may decrease that effect. Another consideration would be to apply the muscle energy intervention while the subject is in a supine position. This would allow for the subject to completely relax and the researcher would have more control over the subject's arm. The supine position would also allow for the subject's body weight to stabilize the scapula, allowing for motion to occur only at the glenohumeral joint. One last consideration for future research would be to implement a more fixated device to control abduction and adduction while measuring internal and external rotation.

Conclusions

The findings of the current study conclude that the sample population did not see an increase in shoulder internal or external rotation after one application of joint mobilizations or muscle energy. The results of the study supported all three hypotheses, in which there would be no increase in internal and external range of motion after an intervention of either joint mobilizations or muscle energy; and there would be no difference between groups. The study also showed that joint mobilizations and muscle energy produced similar results, in the sample population that was used in this study. It is recommended that clinicians carefully evaluate their patients for any motion restrictions before the application of a manual therapy technique. It is also recommended that future research consider the motion restrictions of their participants and multiple treatments sessions when studying the effects of manual therapy on the shoulder. It was also determined from this study that there is a lack of research on the effects of manual therapy and more research needs to be done.

Appendix A

Research Design

Group A				
Subject	**Arm**	**Pre-test**	**Intervention**	**Post-test**
1	D	X	X	X
	N	X		X
2	D	X		X
	N	X	X	X
3	D	X	X	X
	N	X		X
4	D	X		X
	N	X	X	X
5	D	X	X	X
	N	X		X
6	D	X		X
	N	X	X	X
7	D	X	X	X
	N	X		X
8	D	X		X
	N	X	X	X
9	D	X	X	X
	N	X		X
10	D	X		X
	N	X	X	X
11	D	X	X	X
	N	X		X
12	D	X		X
	N	X	X	X
13	D	X	X	X
	N	X		X
14	D	X		X
	N	X	X	X
15	D	X	X	X
	N	X		X

Table A-1. Research design for group A, Dominant (D), Non-Dominant (N)

Group B				
Subject	**Arm**	**Pre-test**	**Intervention**	**Post-test**
1	D	X	X	X
	N	X		X
2	D	X		X
	N	X	X	X
3	D	X	X	X
	N	X		X
4	D	X		X
	N	X	X	X
5	D	X	X	X
	N	X		X
6	D	X		X
	N	X	X	X
7	D	X	X	X
	N	X		X
8	D	X		X
	N	X	X	X
9	D	X	X	X
	N	X		X
10	D	X		X
	N	X	X	X
11	D	X	X	X
	N	X		X
12	D	X		X
	N	X	X	X
13	D	X	X	X
	N	X		X
14	D	X		X
	N	X	X	X
15	D	X	X	X
	N	X		X

Table A-2.Research design for group B, Dominant (D), Non-Dominant (N)

Group C				
Subject	**Arm**	**Pre-test**	**Intervention**	**Post-test**
1	D	X		X
	N	X		X
2	D	X		X
	N	X		X
3	D	X		X
	N	X		X
4	D	X		X
	N	X		X
5	D	X		X
	N	X		X

Table A-3. Research design for group C, Dominant (D), Non-Dominant (N)

Appendix B

Goniometer and Participant Positioning

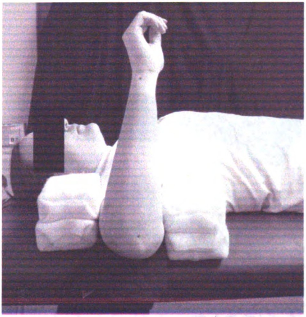

Figure B-1. Participant positioning

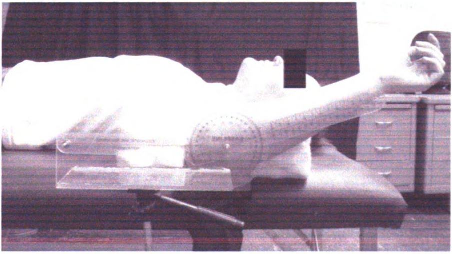

Figure B-2. Goniometer and participant positioning for measuring External Rotation

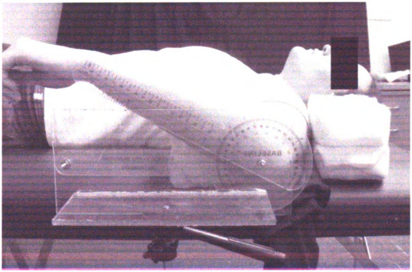

Figure B-3. Goniometer and participant positioning for measuring Internal Rotation

Appendix C

Joint Mobilization Positioning

Figure C-1. Anterior or ventral joint mobilizations of the shoulder

Appendix D

Muscle Energy Positioning

Figure D-1. Muscle energy technique to increase shoulder external range of motion

Appendix E

Data Collection Sheet

Subject: __________ Gender: Male Female

Age_____________ Height_____________ Weight_________________

What hand do you write with? Right Left Both

Have you every injured your shoulder? Yes No

Do you have a current shoulder injury or receiving treatment? Yes No

Have you ever had shoulder surgery? Yes No

How many hours a week do you participate in physical activity?
0-3 4-6 7-10 Greater than 10

Group: Group A Group B Group C

Intervention applied to which shoulder: Right Left

Pre-Test Range of Motion Measurements:

External Rotation

Goniometer

1) R_________ L___________

2) R_________ L___________

Dartfish

1) R_________ L___________

2) R_________ L___________

Internal Rotation

Goniometer

1) R_________ L___________

2) R_________ L___________

Dartfish

1) R_________ L___________

2) R_________ L___________

Post-Test Range of Motion Measurements:

External Rotation

Goniometer

1) R_________ L__________

2) R_________ L__________

Dartfish

1) R_________ L__________

2) R_________ L__________

Internal Rotation

Goniometer

1) R_________ L__________

2) R_________ L__________

Dartfish

1) R_________ L__________

2) R_________ L__________

Appendix F

Informed Consent

A Comparison of Joint Mobilizations versus Muscle Energy on Increasing Shoulder Range of Motion

For questions regarding the research study, please contact:

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This research is designed to study the effects of two different hands on therapy techniques on increasing shoulder motion. The study will investigate how gender, sports involvement, and current physical activity affect shoulder motion. Researchers will apply the information gained in this study to aid in rehabilitation of shoulder injuries. The study will be conducted during 2009 year. As, a participant you will be asked to come to the testing site for one testing session that will last approximately 1 hour.

When you first arrive to the testing site you will fill out a demographic questionnaire that will include your age, height, weight, what hand you write with, previous sport involvement, and current physical activity level. After your demographic data is collected, you will be assigned a confidential identification number. Next, you will be randomly assigned to one of three groups; group A, group B, or group C. A baseline measurement of your shoulder motion will then be taken. The baseline measurement includes placing reflective markers on your skin. In order to properly place the markers, males will be asked to remove their shirts and females will be asked to wear a sports bra or tank top. These markers will be placed on specific anatomical landmarks with double-faced adhesive tape. You will then be asked to perform specific arm movements that will be recorded by a static goniometer and a video cameras. You cannot participate in this study without being videotaped. The baseline testing will take approximately 20 minutes and both of your shoulders will be measured.

After the baseline testing you will receive one of three treatment interventions to one of your shoulders based on which group you are assigned to, which will last approximately 5 minutes. Group A will receive a joint mobilization intervention, group B will receive a muscle energy treatment, and group C will receive a 5 minute intervention. During group A's intervention of joint mobilizations, you will lie on your stomach on a treatment table, and the researcher will apply gliding movements to your shoulder in a forward direction. During the joint mobilization intervention you may feel a "tug" or a "shifting" in your shoulder. During group B's intervention of a muscle energy treatment your shoulder will be placed in a position of 90 degrees to the side and your elbow will be bent to 90 degrees. From this position you will contract your muscles attempting to bring your hand forward and down while the researcher provides resistance. During this intervention you may feel a slight stretching at your shoulder. If you are placed in group C you will receive a treatment intervention that will last approximately 5 minutes.

Finally, your post test measurements will be taken. Any markers that were removed during the intervention process will be replaced. Your post test measurements will be conducted in the same manner as your baseline testing. The post test measurements will last approximately 20 minutes.

As with any type of physical activity, there is a risk of injury. The activities in this study are carefully monitored and designed to obtain the necessary information with a minimum amount of risk of injury. In the event you sustain an injury there will be a certified athletic trainer on site to provide first aid assistance. If you are injured as a result of your participation in this research project, Michigan State University will assist you in obtaining emergency care, if necessary, for your research related injuries. If you have insurance for medical care, your insurance carrier will be billed in the ordinary manner. As with any medical insurance, any costs that are not covered or are in excess of what are paid by your insurance, including deductibles, will be your responsibility. The University's policy is not to provide financial compensation for lost wages, disability, pain or discomfort, unless required by law to do so. This does not mean you are giving up any legal rights you may have.

Participation in this study is voluntary. Your identity and information recorded during the study will remain confidential. Confidentiality will be protected by; (a) results will be presented in aggregate form in any presentations and publications; (b) all data will be stored in a computer that has a password necessary to see confidential data; and (c) your identity will be protected when the video recording is used for public presentations of the research findings. Your privacy will be protected to the maximum extent allowable by law. You may also discontinue participation at any time without penalty. Researcher(s) have the right to withdraw any participant at any time with or without cause.

The data collected are used for research purposes only. You will not benefit from your participation in the research study. All subject identities and recorded information collected during this research study will remain confidential and will be analyzed with individual identification numbers. Participants will remain anonymous in any reporting of the data from this study. As per, Michigan State University and Federal regulations data will be kept for 3 years.

Any questions you may have concerning your participation in this study should be directed to Dr. John W. Powell at the Department of Kinesiology at Michigan State University, 517-432-5018. If you have additional questions or concerns about your rights in this research study, please feel free to contact the Director of Human Research Protections, (517)355-2180, fax (517)432-4503, e-mail irb@msu.edu, mail 202 Olds Hall, Michigan State University, East Lansing, MI 48824-1047

Thank you for your time and cooperation.

I have read the above description of this study and I voluntarily agree to participate in this study.

Please Print: ____

First Name Initial Last Name

______________________________ ______________

Signature Date

This consent form was approved by the Biomedical and Health Institutional Review Board (BIRB) at Michigan State University. Approved 3/16/09 – valid through 2/3/10. This version supersedes all previous versions. IRB # 09-002

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