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The Effectiveness of a Specialized Upper Body Stretching Protocol on NCAA Division I Athletes

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THE EFFECTIVENESS OF A SPECIALIZED UPPER BODY STRETCHING PROTOCOL ON NCAA DIVISION I ATHLETES

by

Brandon Michael Howard

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of the requirements for the degree

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ABSTRACT

The Effectiveness of a Specialized Upper Body Stretching

Protocol on NCAA Division I Athletes

by

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Utah State University, 2009

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Department: Health, Physical Education and Recreation

Previous studies with college athletes determined that the shoulder girdle plays a vital role in a variety of athletic activities. The previous research showed that a decrease in shoulder range of motion (ROM) was associated with a higher risk injury. Decreased shoulder ROM was shown to be a primary reason that many athletes were unable to perform many overhead lifting variations within their strength and conditioning programs.

The purpose of this research was to evaluate a group of athletes by means of a postural assessment using the overhead squat test. This study consisted of a pretest-post test control group design. The dependent variable that was observed was the goniometric measurement of the shoulder ROM in response to the independent variable, which was a specialized upper body stretching protocol.

Current NCAA Division I male athletes from a university in the south, who competed in a variety of different intercollegiate sports, volunteered for this study (N = 27). For the purpose of the current study the athlete was asked to perform three trials of the overhead squat test. For each of the trials goniometric data were collected. After the data were collected the athletes were taught the joint-specific stretching protocol that was to be used as the intervention for this study.

When the pretest and posttest data were observed, the intervention group had an average decrease of 14.7 degrees over the course of the study, while the control group only showed an average decrease of 1.6 degrees. A one-way ANOVA showed that the means of the two groups were not statistically different at the posttest but were significantly different at the pretest. To check the interaction between the grouping factor and the trial factor, a 2 x 2 ANOVA, at a p-value of 0.05, was used to determine the between measurement interactions. From the data that were collected it was determined that there was a statistically significant time factor as well as interaction effect when comparing the two conditions.

(59 pages)

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I would like to thank all the coaches and teachers that have mentored and inspired me along this journey. I would also like to thank my parents for believing in me, and my late grandfather. Even though you did not get to see me finish, you were always right there beside me.

Brandon M. Howard

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CHAPTER I

INTRODUCTION

The shoulder joint plays a crucial role in a variety of athletic activities such as throwing movements and overhead resistance training exercises. The movements associated with the shoulder complex consist of protraction, retraction, elevation and depression. Terry and Chopp (2000) stated that the bony architecture of the glenoid cavity is the main reason for the shoulder having the greatest range of motion (ROM) of any joint in the body. This wide range of motion allows for an athlete to perform a great deal of athletic movements, but with this extensive range of motion comes an increased likelihood of injury (Terry & Chopp).

The shoulder girdle can be seen as a complex joint composed of a variety of musculoskeletal structures. These components can be broken down into the bony anatomy (humerus, clavicle and scapula), articulations (glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic), stabilizers (labrum, capsule, ligaments), and musculature (rotator cuff, deltoid, scapular stabilizers) (Delavier, 2006). All of the components of the shoulder girdle will be further defined later in this introduction. Being able to understand the functional anatomy of the shoulder will allow for the strength and conditioning professional to be able to prescribe corrective exercises and stretching protocols that will allow for not only rehabilitation, but injury prevention as well.

The glenohumeral joint (GH) is the primary joint of the shoulder, which unites the head of the humerus with the glenoid cavity. The surface area of the humerus is two to three times larger than that of the glenoid cavity, and it is for this reason that shoulder joint is extremely mobile, but also making it much less stable (Calais-Germaine, 1993).

There are a wide variety of mechanisms that can contribute to this decreased ROM of the glenohumeral joint. The primary cause for a majority of the cases involves a condition called subacromial impingement syndrome (SAIS) (McClure, Michener, & Karduna, 2006). Subacromial impingement syndrome is one of the most common disorders of the shoulder resulting in functional loss and disability in the patients that it affects.

Subacromial impingement syndrome accounts for 44-65% of all complaints of shoulder pain during a physicians visit (Bigliani & Levine, 1997; Vecchio, Kavanagh, Hazleman, & King, 1995). This form of impingement syndrome has two predominant mechanisms of injury. The first mechanism is known as intrinsic impingement, which theorizes the partial or full tendon tears as a result of overuse, tension overload and trauma of the tendons. The second mechanism that seems to be a cause of SAIS is extrinsic impingement. Extrinsic impingement is when degradation of the joint occurs as a result of compression by some structure external to the tendon. Two of the primary causes of extrinsic impingement are altered scapular and glenohumeral kinematics (Michener et al., 2003). It is these two causes of SAIS that will be further discussed within this study.

There are several different muscles that can lead to an extrinsic impingement of the glenohumeral joint. The muscles that are closely associated with the SAIS are the lattissimus dorsi, the pectoralis minor, trapezius, and the rhomboids. Imbalances in these particular muscles can be associated with a decreased ROM within the glenohumeral joint, and thus may lead to an increased likelihood of injury (Andrews, 2005).

The strength and conditioning program at a state university uses a functional assessment that has allowed trainers to determine flexibility imbalances that athletes may possess. Determining these imbalances has allowed the staff to be able to prescribe the proper exercise and stretching protocols to athletes, and correcting these imbalances might allow for improved scapular and glenohumeral kinematics and a decrease in SAIS risk.

The overhead squat test is the primary test that is used to determine overall muscle flexibility. Using this one assessment method, strength and conditioning professionals may determine a wide variety of anatomical imbalances. The information that is gathered from this assessment method may provide the basis for exercise recommendations for stretching of potentially overactive and tight muscles (Hirth, 2007). The overhead squat can show imbalances of the ankle, shoulder, knee, and hip (Tucker, 2006). With regard to the current study the author will concentrate on the movement of the shoulder while performing this exercise. Tucker has observed that “assessment of the overhead deep squat may provide an analysis of stability and mobility of the shoulder complex. An exercise program based on the assessment can be implemented to achieve stability and mobility”. The mechanism that the researcher will be looking for will be “arms falling forward”; this observation was noted by Hirth. When the arms are observed “falling forward”, the article noted the cause of this movement, are the lattissimus dorsi, trapezius, rhomboids, pectoralis minor and posterior deltoid (Hirth).

Purpose of the Study

The purpose of this research was to evaluate a group of athletes by means of a postural assessment using the overhead squat test. This study was a quantitative quasi-experimental study. This study consisted of a pretest-posttest control group design. The dependent variable observed in this study was the goniometric measurement of shoulder ROM in response to the independent variable, which was a specialized upper body stretching protocol. The information that was gathered from this test might allow the strength and conditioning professional to be able to determine who among his/her athletes showed signs of anterior shoulder tightness. From these observations the strength and conditioning specialist might be able to prescribe a corrective stretching protocol to these athletes that allowed the athletes to effectively change their shoulder position during the overhead squat test. Goniometric measurements were taken to determine any substantial gains in ROM associated with this overhead squat test. These measures may allow us to determine if specific shoulder and chest stretching protocols might result in an increased functional ROM.

Significance of the Study

The ability for strength and conditioning specialist to assess and determine imbalances in athletes is a key component to being successful at his/her occupation. With the use of a postural assessment the strength and conditioning specialist will be able to prescribe specific exercise and stretching protocols that might allow the athlete to remedy anatomical imbalances. With the shoulder complex being one of the most commonly injured areas of the body this study will hopefully allow the strength and conditioning specialist to increase the functional ROM of the shoulder. Functional range of motion is of primary concern to anyone competing in athletic competition. This study does not relate to the normal population who may not need the entire functional range of motion of the shoulder girdle; however to the athletic population proper range of motion can be critical to athletic success.

Assumptions

1. An upper extremity injury, primarily those of the shoulder, within the collegiate athlete populations has increased.
2. Muscular imbalances of the shoulder girdle are the primary cause of decreased shoulder mobility, and anterior shoulder tightness.
3. That a joint specific stretching protocol will allow for a decrease in the muscular imbalances of the joint, and allow for an increased range of motion.

Limitations

1. The results that will be collected will only be generalized to high-level collegiate athletes, but these athletes will come from a variety of sports.
2. The study will be limited only to one joint of emphasis, though this type of test may be used to evaluate a wide variety of anatomical imbalances.

3. The corrective exercises that are going to be prescribed to the athletes do not represent the only means of correcting this problem, but were the best and easiest options for the athletes to learn at this given time.
4. The athletes will not engage in any extra strength exercises primarily due to the amount of training that they will be doing over the summer; thus the intervention that each athlete will be engaging in will be joint specific stretching.
5. The muscles of the rotator cuff will not be evaluated as a part of this study. With the lifting programs that the athletes will be subject to, the rotator cuff muscles will be trained.

CHAPTER II

REVIEW OF LITERATURE

This study will examine how a specialized upper body stretching protocol may allow for an increased ROM of the glenohumeral joint (GH), as well as decrease the incidence of anterior shoulder stiffness. Due to the nature of this study anatomical knowledge of the shoulder girdle will be helpful. The literature review will begin with the conceptual literature describing the applicable anatomy to the present study, namely the muscles associated with the shoulder girdle.

Next the review will examine research based studies that investigate scapular and glenohumeral kinematics. To construct a justification for this study, observations of specific mechanisms of impingement to the surrounding musculature will be reported. Specific musculature imbalances will be noted, as well as their location and relationship to the movement in question.

Within the scapular and glenohumeral kinematics section of this review the researcher will also include studies that involve subacromial impingement syndrome (SAIS). Since this is the main mechanism for decreased ROM in the tested subjects it is vital to this study that this form of impingement be discussed. This form of impingement is the main mechanism that causes the decreased ROM that is trying to be remedied as part of the present study. For this section all causes of this form of impingement will be discussed. Following this section of this review research based studies involving postural assessment and detection of upper extremity imbalances will be noted.

The purpose of this chapter is not only to provide a literary basis of information essential to the present study, but to also justify the need for a study that will quantitatively measure upper body flexibility as a means to detect SAIS, and will prescribe a specialized stretching protocol. The lack of research involving high-level collegiate athletes lends support for the need for this study.

Conceptual Literature

Kinesiology of the Shoulder Girdle

Regarding the present study one must understand the functional anatomy of the shoulder girdle. Many of the muscles that are responsible for shoulder movement originate at the humeral head and insert at either the vertebral column or the scapula. Many of these muscles can be associated with the causes of SAIS and anterior shoulder tightness.

A complex system of muscles and tendons is responsible for the large ROM associated with the shoulder, so a brief review of shoulder anatomy and kinesiology is helpful when considering the present study. A concise description will be given to (a) bony anatomy, (b) joint articulations, or (c) muscle that is either responsible for glenohumeral or scapular movement.

As stated by Terry and Chopp (2000) the bony anatomy of the shoulder consists of:

1. Humerus – the largest bone of the upper extremity, with its proximal portion consisting of the half spheroid articulating head and the proximal humeral shaft.
2. Scapula – is a large, thin triangular bone lying on the posteriolateral aspect of the thorax, overlying ribs 2 through 7, and serves mainly as a site for muscle attachment.
3. Clavicle – serves as the sole bony connection of the shoulder to the trunk via the sternoclavicular joint.

As the shoulder begins to move three main articulations are described by Calais-German's book *Anatomy of Movement Exercises* (1996):

1. Glenohumeral joint – the primary joint of the shoulder, which unites the head of the humerus with the glenoid fossa of the scapula.
2. Acromioclavicular joint- is the diarthroidial joint between the lateral border of the clavicle and the medial edge of the acromion.
3. Sternoclavicular joint – represents the only true articulation of the shoulder girdle and the axial skeleton. It is a stellar saddle joint that is formed by the articulation of the medial end of the clavicle and the smaller articular surface of the sternum.

The movements that are associated with these joints are coordinated by a variety of different muscles that allow for the shoulder girdle to maintain its great ROM; these muscles are described in some detail by another Calais-German book titled, *Anatomy of Movement* (1993).

For the purpose of the present study, only the affected musculature will be discussed:

1. Rhomboids – originate at spinous processes of the C7 and T1-T4 and insert on the medial border of the scapula. This muscle adducts the scapula and rotates it downward.
2. Trapezius – large diamond shaped muscle. Its origin is on the occiput, nuchal ligament and the spinous process of the cervical vertebrae and the thoracic vertebrae down to T-12. This muscle adducts the scapula, as well as acts in upward rotation and elevation of the scapula.
3. Latissimus Dorsi – means the "widest back muscle". It originates from the sacral and iliac crest, thoracolumbar fascia, spinous processes of T7-T12, and the posterior surfaces of the four lower ribs. This muscle is responsible for the extension, adduction and medial rotation of the arm.
4. Deltoid – this is a superficial muscle which gives the shoulder its characteristic shape. It contains three groups of fibers:
    a. Middle fibers – attach to the lateral border of the acromion. These fibers are responsible for abduction of the arm.
    b. Posterior fibers – attach to the spine of the scapula. These fibers are responsible for arm extension.
    c. Anterior fibers- attach at the clavicle. These fibers are responsible for flexion and medial rotation of the arm.

5. Serratus Anterior – is a broad, thick muscle covering the lateral rib cage. It originates in the upper ten ribs, and inserts along the entire medial border of the scapula.

6. Pectoralis Minor – originates from the lateral border of the scapula and inserts on the greater tubercle below the insertion of the infraspinatus.

Delavier (2006) stated that the three divisions of the deltoid create a multipennate muscle whose different fibers converge on the humerus to allow the upper extremity to move through its entire range of motion.

Functional Anatomy of Shoulder Girdle Musculature

The latissimus dorsi is mainly responsible for the movement of the shoulder joint, where the other muscles are responsible for the scapular kinematics that can be a cause of SAIS. Several studies have supported a relationship between altered scapular kinematics and subjects with SAIS. The latissimus dorsi is a triangular, flat muscle, which covers the lumbar region and the lower half of the thoracic region. This muscle is responsible for extension, adduction, transverse extension, and internal rotation of the shoulder joint. Exercises that involve the latissimus dorsi have been shown to provide muscle balance to the chest (Lehman, Buchan, Lundy, Myers, & Nalborczyk, 2004). If this muscle is under utilized in training it will become weaker, and thus lead to impingement. Another muscle that can lead to SAIS is an underdeveloped pectoralis minor.

The pectoralis minor is a thin, triangular muscle, situated at the upper part of the chest, beneath the pectoralis major. The pectoralis minor depresses the point of the shoulder, drawing the scapula downward and medially toward the thorax, and throwing the inferior angle backward. Underdevelopment of this muscle can lead to decreased scapular mobility, thus causing an impingement of the glenohumeral joint. Borstad (2006) stated that an underdeveloped pectoralis minor had a decreased posterior scapular tilt, which is consistent with individuals who have been shown to have an impingement.

The rhomboids are a small group of muscles located in the upper thoracic region that are associated with the scapula, and are mainly responsible for its retraction. The rhomboids also help to hold the scapula (and thus the upper limb) onto the ribcage. It also acts to retract the scapula, pulling it towards the vertebral column (Lukasiewwicz, McClure, Michener, Pratt, & Sennett 1999).

The trapezius is a large superficial muscle which extends from the neck to a person's back. It lies on the pectoral girdle, which are the bones that make up a person's shoulder. The pectoral girdle has three parts: the upper, middle, and lower; the upper dealing with extending the neck, the middle adducts the scapula, and the lower depresses it (Calais-German, 1993).

The final muscle that will be discussed in this section will be the serratus anterior. The serratus anterior is largely responsible for the protraction of the scapula—that is, the pulling of the scapula forward and around the rib cage that occurs when someone throws a punch. The serratus anterior also helps to stabilize the scapula. In addition, it assists in rotating the scapula upward (Calais-German, 1993).

Research-Based Literature

Glenohumeral Kinematics

The ability to understand the muscles and joints discussed in this review will allow the investigator to gain a better understanding of the specific kinematics that are associated with the movement of the glenohumeral joint. The studies that will be discussed in this portion of the review will allow the investigator to better understand the need for the earlier described intervention.

Hopkins, Amis, Hansen, Taylor and Emery (2007) stated in their study that osseous geometry of the GH joint is naturally nonconforming and minimally constrained, and the joint's stability is maintained by action of the rotator cuff muscles. Damage to these muscles is often associated with joint degeneration.

The resting position of a joint is the position in which the joint tissues are under the least amount of stress and in which the joint capsule has the greatest laxity. This position is also regarded as “the position of minimal congruence between the joint surfaces allowing for the greatest separation between the articulating surfaces” (Magee, 1997). This resting position allows for an investigator to be able to observe normal, as well as abnormal shoulder movement giving a basis for comparison for further research.

In the study done by Lin et al. (2007), 15 volunteers with no previous shoulder injuries were recruited. The aim of this study was to define the resting position of the GH joint by quantifying the humeral translation and axial rotational ROM. The researchers stated that the “clinical relevance of this study was to provide physical information regarding the resting position of the GH joint as well as translational and rotational mobility of this joint at different abduction positions" (Lin et al.). This information is important during the evaluation and treatment of patients with GH joint problems. The results of this study suggest that the GH joint should be assessed at different resting positions that will allow for different movement criteria such as accessory and physiological movement.

The GH joint is one of the most mobile joints in the body with the humeral head supported partially by the relatively small glenoid cavity. Soslowsky, Malicky, and Blaiser (1997) noted that the passive structures include the joint capsule, ligaments, labrum and the articulating surfaces function together with the muscles crossing the GH joint to maintain the stability of it. Many studies (Blaiser, Soslowsky, Mailicky & Palmer, 1997; Halder et al., 2001; Soslowsky et al; Weiser, Lee, McMaster & McMahon, 1999) claim that one or more of those structures may be the cause of various shoulder problems resulting in altered GH stability and stiffness in the anterior, posterior and/or inferior directions.

Ticker and Warner (2000) noted that joint stability and laxity have been assessed by evaluating the ROM during passive manual movement. This joint laxity depends on the force applied. These investigators also noted that this relationship between joint stiffness and altered kinematics provides an objective measure of the stability of the joint.

The purpose of the study done by Makhsous, Lin, and Zhang (2003) was to investigate the contributions of the capsuloligaments and the muscle tendon complexes crossing the GH joint to GH stiffness along the four anatomical axes of the glenoid. They hypothesized the following:

1. GH capsuloligament stiffness in the superior, anterior and posterior directions are different from each other but are correlated to each other.
2. The lateral shift of the humerus increases GH joint stiffness in all four directions.
3. Moderate loading of the muscles crossing the GH joint increases the joint stiffness in all four directions.

This study concluded that glenohumeral stiffnesses are different within all axes, but are correlated to each other and contribute to joint stability. The author also stated that muscle contractions could increase glenohumeral stiffness significantly (Makhsous et al., 2003).

Scapular Kinematics

Studies that involve scapular kinematics are quite prevalent within the literature, but few relate to the experimental purposes that are needed for this study. Researchers have stated that the motion of the scapula on the thorax is essential for the normal function of the upper extremity (Kibler & McMullen, 2003). The orientation of the scapula relative to the thorax and the position of the scapula on the thorax are used to describe scapulothoracic motion (Karduna, McClure, & Michener, 2000).

The first study that will be discussed was conducted by Ebaugh, McClure, and Karduna (2005). This study dealt primarily with subjects who had no history of shoulder injuries. Three-dimensional scapular motion was determined by the use of electromagnetic sensors attached to the scapula, thorax, and the humerus during active and passive arm elevation. Muscle activity was recorded from the sensors that were attached to the upper and lower trapezius, serratus anterior, anterior and posterior deltoid, and the infraspinatus muscles. From these data the differences in the scapular motion were calculated for both passive and active arm elevation. This study found that there was more upward rotation of the scapula, external rotation of the scapula, clavicular retraction, and clavicular elevation during active arm movements. The major point that this study stated was that decreased levels of muscular activity results in altered scapulothoracic kinematics, which can be a cause of SAIS.

Two studies (McClure, Biakler, Neff, Williams, & Karduna, 2004; McClure et al., 2006) that will now be discussed deal primarily with altered scapular kinematics as it relates to SAIS. These studies were conducted with the purpose of allowing the investigator to gain a better understanding of the mechanisms that will lead to this form of impingement syndrome.

The first study discussed how shoulder impingement syndrome is a common condition and is often managed by a specialized exercise program (McClure et al., 2004). The purpose of this study was to examine how an exercise program would affect patients with shoulder impingement syndrome. Primarily the researchers wanted to identify the changes that might occur in three-dimensional scapular kinematics, physical impairments, and functional limitations. The subjects that volunteered for this study were assessed before and after a 6-week intervention period. Pain, satisfaction, and function were measured. Range of motion, isometric muscle force, and three-dimensional scapular kinematic data were also collected. The exercise program that the individuals were exposed to was a progressive program that included a variety of exercises that were done daily at home. The exercises that were given to the subjects were designed to:

1. Strengthen the muscles of the rotator cuff and scapular stabilizers.
2. Enhance the flexibility of the glenohumeral posterior capsule and the pectoralis minor muscle, and upper thoracic spine.
3. Improve upper quarter postural awareness.
4. Enhance patient understanding of environmental and workplace factors that place high loads on the shoulder and are associated with overuse.

The results from this study showed that passive ROM increased for both internal and external rotation but not for elevation. Abduction, external, and internal rotation force also increased as a result of the intervention, but there was no change in scapular kinematics. The exercise intervention that was used in this study may have had a positive impact on a patient's impairment and functional limitations. The findings suggest that a relatively simple exercise program combined with patient education may be effective and thus this type of study merits more research.

The next study was done by McClure et al. (2006). These researchers state that there are several factors that contribute to shoulder impingement; these include posture, muscle force, ROM, and scapular dysfunction. The primary form of impingement that is associated with this study is SAIS. Many studies (Bigliani & Levine, 1997; Michener, McClure, & Karduna, 2003; van der Windt, Koes, de Jong & Bouter, 2005) have proposed that there are multiple factors that contribute to the development of this form of impingement. The purpose of this study was to compare three-dimensional scapular kinematics, shoulder ROM, muscle force and posture in subjects with and without shoulder impingement syndrome. The impingement group demonstrated a slightly greater scapular upward rotation and clavicular elevation during flexion and slightly greater scapular posterior tilt and clavicular retraction during scapular plane elevation as compared to the control group. The impingement group also showed a decrease in force and ROM in all directions compared to the control group. The researchers concluded that the kinematic differences found in the subjects with impingements may be the reason for why the subjects in the impingement group will tend to have glenohumeral weakness or motion loss. From this study it was determined that a specialized exercise program focusing on strengthening and restoring flexibility to the affected musculature would be a means to alleviate shoulder impingement.

The serratus anterior muscles are key contributors to normal and abnormal scapular motion and control (Dvir & Berme, 1978). There have been a variety of studies that have dealt with this mechanism, which will be the next portion of this review.

In the study conducted by Cools et al. (2007), the author noted that strengthening exercises for the scapular muscles can be used for treatment of scapulothoracic dysfunction related to shoulder injury. It was also stated by Urwin et al. (1998), that shoulder pain and dysfunction are common complaints among individuals seeking care from physical medicine and rehabilitation specialists. The purpose of the Urwin et al. study was to determine the muscle ratios for a number of commonly used shoulder girdle exercises to determine which were appropriate to optimize scapular muscle balance. The conclusion that was drawn from this study indicated that these exercises would decrease the activation of the upper trapezius, and thus increase the activation of the serratus anterior, and lower and middle trapezius. With these muscles being activated the observer was able to see an increase in scapular balance.

CHAPTER III

METHODS

The purpose of this study was to evaluate a group of athletes by means of a postural assessment using the overhead squat test. The information that was gathered from this test might allow the strength and conditioning professional to be able to determine who among his/her athletes shows signs of anterior shoulder tightness. From these observations the strength and conditioning specialist might able to prescribe a corrective stretching protocol to these athletes that will alleviate this problem. Goniometric measurements were taken to assess any substantial gains that resulted from this specialized stretching protocol. These measurements may allow us to determine if specific shoulder and chest stretching protocols will result in an increased ROM.

Participants

Current NCAA Division I athletes, who compete in a variety of different intercollegiate sports volunteered for this study. Each athlete was injury free and participated in a minimum of 5 hours per week of strenuous physical activity under the supervision of a Strength and Conditioning staff member. To be allowed to participate in this study the athlete must have had a minimum displacement of 7 degrees from the predetermined 0 degree mark, anything less was grounds for exclusion from the study. The 0 degree reference point was determined by using a standard inclinometer. All participants were asked to complete an informed consent from USU (Appendix A).

Procedures

The participants reported to the athletics weight room prior to their arranged lifting time set forth by the Strength and Conditioning staff. The athletes performed a 5-minute warm up on an exercise bike prior to performing the postural assessment. The postural assessment in this particular case was the overhead squat. The overhead squat test involved a two legged squat with the arms raised over the head with the hands at a minimum of 24 inches apart. The athlete was instructed to stand with the feet hip width apart, the toes pointing straight ahead, and the arms raised overhead (Figures 1, 2, 3, 4, 5).

For the purpose of this study the athlete used a 3 ft long PVC pipe that was previously filled with sand to an exact weight of 5 lbs. The weight of the PVC was measured using a calibrated bodyweight scale (Mettler-Toledo, USA, Columbus, Ohio). To assure that there is a standard of measurement for all of the athletes a standard inclinometer was used to determine the 0-degree position. The primary purpose for using the inclinometer was to assure that the person taking the measurements was as accurate as possible, primarily due to the fact that the person taking the measurements was not an expert. The 0-degree position was the complete overhead locked position of the overhead squat from which all other measurements were taken. From this position the athlete was instructed to squat down into a full squat position where the hip joint is below the knee joint (Figure 4). The primary observation that showed anterior shoulder tightness will be the “arms falling forward” (Figure 6); this standard for observation was shown by Hirth (2007). Once the athlete reached the required depth, an angle measurement was taken at

Figure 1. Hand position.

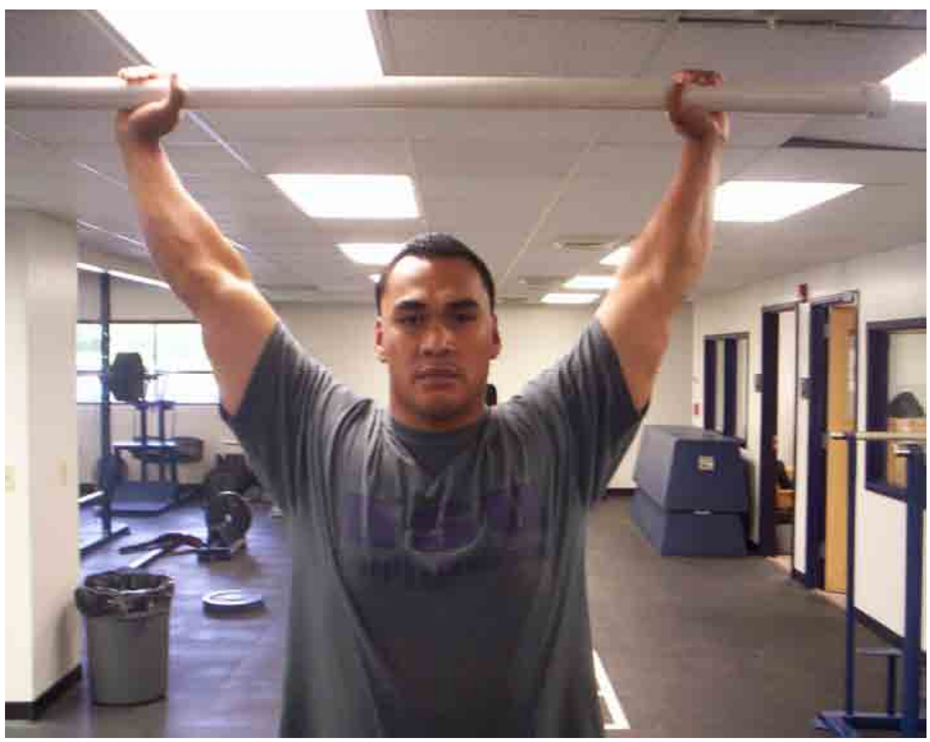

Figure 2. Overhead position.

Figure 3. Starting position.

Figure 4. Side view – full squat position.

Figure 5. Front view - full squat position.

Figure 6. Arms falling forward position.

the acromio-humeral joint using a standard goniometer. Three measurements were taken and the averages of the three measurements were recorded. The goniometric pretest data were entered into the postural assessment data collection sheet (Appendix B).

Goniometry was selected for this study primarily due to the ease of use and practical application. Owen, Stephens and Wright (2007) stated that a basic prerequisite for clinical measures is that they be reliable, which is defined as the degree of consistency between the measurements under the same conditions. The authors also stated that the assessment of joint motion using goniometry provided consistent results (Owen et al.). Holm et al. (2000) also used goniometric measurements when studying hip ROM. The authors noted a reliability coefficient of 0.77-0.83. This reliability coefficient was determined by the standard agreement index, which was the agreement between the visual agreements of one individual and the goniometric measurements of two experienced physiotherapists (Holm et al.). Thus, a goniometric measure was used as the quantitative measurement for this study.

Once all of the goniometric data were collected, the athletes were taught the stretching intervention that was used throughout the duration of the study. The athletes were exposed to three stretching protocols that concentrated on the affected musculature. The three stretches that were used for this study consist of incline lat stretch (Figure 7 and 8), the power rack U stretch (Figure 9 and10), and the wall shoulder girdle stretch (Figures 11 and 12). All of the stretches that were a part of the intervention were held in a static position for duration of 30 seconds. All of the stretches were conducted at a 1:1 work to rest ratio to allow for the affected musculature to return to a normal resting state.

Figure 7. Side view - incline lat stretch.

Figure 8. Overhead view – incline lat stretch.

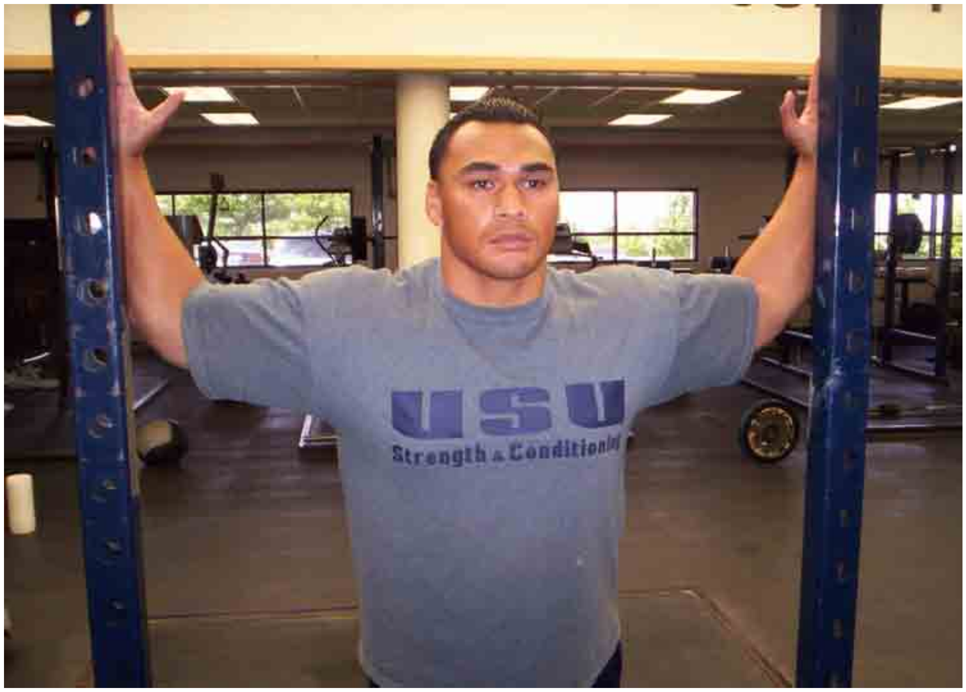

Figure 9. Frontal view – power rack U stretch.

Figure 10. Side view – power rack U stretch.

Figure 11. Start position – wall shoulder girdle stretch.

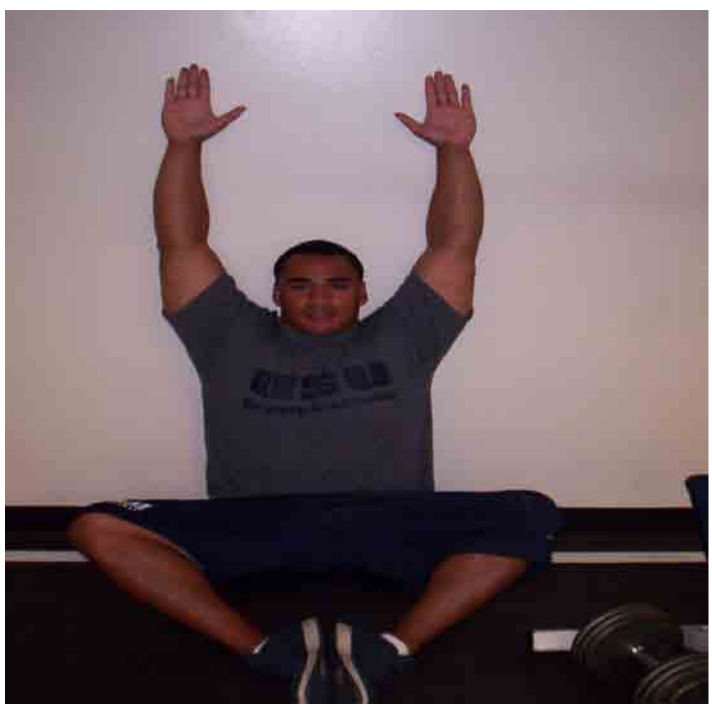

Figure 12. Hold position – wall shoulder girdle stretch.

Each of the athletes was asked to perform the stretching protocol three times a week for the duration of the study. Each repetition that was performed was timed by the Strength and Conditioning Specialist using a standard stopwatch. The study length involved the athlete performing this stretching protocol for a period of 6 weeks. Throughout the course of the 6-week period, a log was kept to account for the attrition rate of the athletes involved in the study.

The incline lat stretch (Figures 7 and 8) required the athlete to place his forearms on an exercise bench that was set at a 45-degree angle. The athlete kept his back in a flat locked out position. The arms were placed shoulder width apart, and then the athlete was asked to place his head between his arms to a point of slight discomfort. The stretch was held for 30 seconds and then repeated two more times for a total of three repetitions. This stretch focused on the lattisimus dorsi, as well as the teres minor.

The power rack U stretch (Figures 9 and10) was the second prescribed intervention that the athletes encountered during the 6-week period. For this stretch the athlete placed both elbows at a 90-degree angle with the forearms and palms flat against the power rack. The athlete placed the inside of a bent arm on the surface of the rack. The athlete positioned bent elbow at the same height of shoulder. The athletes leaned into the rack to a point of slight discomfort and held the stretch for 30 seconds. The athlete then completed two more repetitions of the stretch for a total of three repetitions. This stretch focused on the pectoralis minor, as well as the sternal and clavicular insertions of the pectoralis major.

The wall shoulder girdle stretch (Figures 11 and 12) was the third prescribed stretch for the athletes in this study. The athlete placed himself seated on the ground with the back and the hips in contact with the wall. The athlete then pushed shoulders, back of arms, and hands into wall and slowly raised his arms as high as possible being sure to maintain contact with the wall as long as possible. Once the athlete reached a point of slight discomfort the athlete then held the position for 30 seconds and then repeated the stretch for two more repetitions for a total of three total repetitions. The wall shoulder girdle stretches the rhomboids and trapezius isometrically while stretching the pectoralis minor and major.

The Strength and Conditioning staff supervised all athletes. The Strength and Conditioning staff maintained the work to rest ratios of each athlete to assure the protocol was done correctly. All members of the Strength and Conditioning staff were instructed on how all stretches were to be done to maintain the continuity of the stretching protocol.

At the end of the 6-week period the goniometric measurements were retaken. The measurements followed the same protocol as the pretest measures. Three measurements were again taken, and the average of the three measurements was recorded. These measurements were then used to calculate any changes in ROM.

Reliability Study

In this study the use of goniometric measurements was the primary means of data collection. To assure that the data that were collected were valid, a reliability study was conducted to test inter-rater reliability. Ten subjects from this study were selected to participate in this small study. The measurements taken by the assessor from this study were compared to the same measurements taken by a certified athletic trainer (ATC). The participants were asked to perform the exact protocol of this study, so that each assessor could take measurements. All ten measurements were taken for both the assessor and the ATC. The data were then put into SPSS to look for inter-rater reliability. From data that were collected it was determined that there was a reliability coefficient of 0.77, which showed good reliability.

Statistical Analysis

This study used one dependent variable, which was the goniometric measurement of shoulder ROM, in response to the independent variable, which was the specialized upper body stretching protocol. This study consisted of a pretest-posttest control group design. For the purpose of this study a paired *t* test was used to examine the effect each of the two conditions had on the dependent variable. A one-way ANOVA was used to determine if the means of the data were significantly different. A 2 x 2 ANOVA was also used, at a *p*-value of .05, to check the interaction between the duration of the experiment and the two groups.

CHAPTER IV

RESULTS

The purpose of this study was to evaluate a group of athletes by means of a postural assessment using the overhead squat test. This study compared the functional range of motion of both the intervention group and a control group. There were a total of 27 participants with a control group (*N* = 13) and intervention group (*N* = 14) serving as comparison groups.

Goniometric measurements for both the intervention and control groups are shown in Table 1, as well as being graphically represented in Figure 13. This table also includes mean and standard deviations for both groups. The pre- and posttest data of the intervention group indicates a decrease of 14.7 degrees whereas the control group only showed a decrease of 1.6 degrees.

A paired *t* test was conducted at a 95% confidence interval. The procedure showed that the two conditions were statistically different between the two conditions from pretest to posttest. Thus we can conclude that the participants in the treatment group were able to greatly increase their ROM by having been exposed to the stretching protocol. A one-way ANOVA was also used to determine if the means were statistically different. From the data that were collected there was no statistically significant difference between the two conditions. However, to check the interaction between the duration of the experiment, and the groups, a 2 x 2 ANOVA was performed at a *p*-value of .05 (Table 2). From the data that were collected there was shown to be a statistical significance.

Table 1

Control and Intervention Group ROM Measurements

Control Group				
Subject #	**Pre #'s (Deg)**	**Pre Avg. (Deg)**	**Post #'s (Deg)**	**Post Avg. (Deg)**
1	19, 23, 18	20.0	19, 18, 19	18.7
2	36, 28, 27	30.3	29, 28, 31	29.0
3	16, 16, 17	16.3	15, 14, 15	14.7
4	14, 15, 14	14.3	16, 14, 14	14.7
5	15, 12, 13	13.3	13, 12, 12	12.3
6	26, 31, 32	29.7	24, 20, 26	25.3
7	15, 17, 16	16.0	13, 12, 16	13.3
8	26, 31, 27	28.0	27, 25, 26	26.0
9	11, 10, 10	10.3	10, 9, 7	8.70
10	10, 11, 10	10.3	10, 11, 9	10.0
11	9, 10, 10	9.70	11, 8, 9	9.30
12	14, 16, 15	15.0	12, 11, 10	11.0
13	20, 21, 19	20.0	22, 19, 18	19.7
	Average Pre	17.9 ± 7.3	Average Post	16.4 ± 6.8
Intervention Group				
Subject #	**Pre #'s (Deg)**	**Pre Avg. (Deg)**	**Post #'s (Deg)**	**Post Avg. (Deg)**
1	37, 36, 37	36.7	11, 11, 13	11.7
2	29, 31, 25	28.3	12, 10, 12	11.3
3	30, 31, 33	31.3	22, 21, 24	22.7
4	20, 23, 19	20.7	9, 9, 11	9.70
5	32, 34, 31	32.3	11, 10, 10	10.3
6	15, 14, 12	13.7	13, 11, 14	12.3
7	30, 26, 24	26.7	18, 15, 12	15.0
8	40, 40, 39	39.7	14, 12, 13	13.0
9	27, 20, 19	22.0	17, 15, 14	15.3
10	40, 31, 30	33.7	20, 22, 23	21.3
11	37, 42, 33	37.3	13, 16, 15	19.7
12	42, 39, 38	39.7	22, 23, 25	23.3
13	39, 36, 36	37.0	22, 20, 20	20.7
14	34, 32, 32	32.7	18, 20, 20	19.3
	Average Pre	30.8 ± 7.8	Average Post	16.1 ± 4.9

Table 2

F Table from 2 x 2 ANOVA

Source	Time	Sum of Squares	*df*	Mean Square	*F*	Sig.
Time	Linear	896.078	1	896.078	68.443	.0001
Time *Group	Linear	582.959	1	582.959	44.527	.0001
Error (Time)	Linear	327.306	25	13.092		

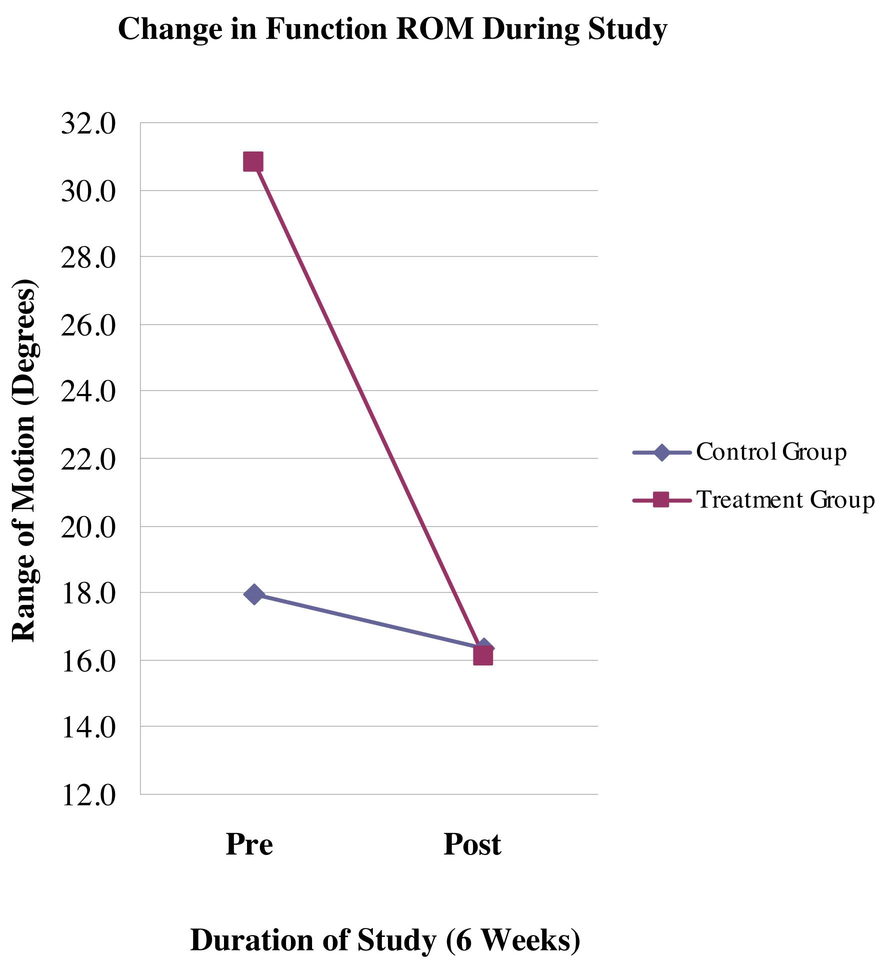

Figure 13. This is a graphical representation of the change in shoulder ROM for each of the groups during the duration of the study.

CHAPTER V

DISCUSSION

The purpose of this study was to evaluate a group of athletes by means of a postural assessment using the overhead squat test. This study examined how a specialized upper body stretching protocol would allow for an increase in ROM of the glenohumeral joint, as well as decreases the incidence of anterior shoulder stiffness. This discussion will first consider several limitations that should be considered along with the results of this study. Next, a comparison of the results will be made to the results of the previous research, and finally the implications of this study will be presented.

Limitations

Limitations existed within the present study and each should be considered along with the results of the present study. First, this study dealt primarily with a specialized population, that being NCAA Division I athletes. The idea of functional ROM plays a greater importance to the athletic population, than that of a normal noncompetitive population. The idea of functional ROM may greatly increase the athletic population's ability to excel in his/her given sport. This is where this study differs from a lot of the previous research. Most of the research that was presented previously within this thesis dealt with a normal noncompetitive population.

Another limitation to this study was the fact that the present study only dealt with one joint of emphasis. For the present study the joint of emphasis was the glenohumeral joint, and its adjoining musculature, but other studies with similar methodologies could possibly be used to study other joints that would be specific to athletic performance. Also, due to the time of the year in which this study was being implemented, no extra strength training exercises were supplemented to the intervention protocol. The athletes that were part of this study were in an offseason training program. Offseason training for these athletes, consisted of a large amount of strength training exercises, so trying to account for overtraining was the key component for not having any additional strength training exercises present during the intervention.

Another limitation that was present was the choice of exercises used for the intervention protocol. These exercises chosen for the intervention emphasized the affected musculature. These exercises were just a few of a variety of exercises that could have been used for the intervention. Another limitation that was present in this study was the decision not to concentrate on the muscles of the rotator cuff. The reason these muscles were not concentrated on was that these muscles were constantly trained as a part of the offseason training program and that each of these athletes were exposed to this type of training during the course of the study.

The final limitation to this study can be attributed to the data collection process. When the data were collected the pretest means were greatly skewed. The intervention group had a much greater pretest mean than the control group, due to nonrandom assignment procedures.

Comparison to Previous Research

Previous studies have observed that the passive structures of the shoulder include the joint capsule, ligaments, labrum and articulating surfaces function together with the muscles crossing the GH joint to maintain stability. These studies also claim that one or more of these structures may cause various shoulder problems resulting in altered GH stability and stiffness (Blaiser et al., 1997; Halder et al., 2001; Soslowsky et al., 1997; Weiser et al., 1999).

The primary form of impingement that is associated with the present study was SAIS. Many studies (Bigliani & Levine, 1997; Michener et al., 2003; van der Windt et al., 2005) proposed that there are multiple factors that contribute to the development of this form of impingement. The group that was studied that had impingements was shown to have a loss of not only strength, but also a decrease in ROM from that of the control group. The researchers concluded that the kinematic differences might be the reason for loss of ROM. From this study it was determined that a specialized exercise program that focuses on strengthening and flexibility to the affected muscles may be a means to alleviate shoulder impingement.

Ticker and Warner (2000) completed a similar study in which they also assessed joint stability and laxity by evaluating the ROM. These investigators also noted that the relationship between joint stiffness and the altered kinematics provided an objective measure of stability of a joint, which is consistent to the measures taken in the present study.

The specialized exercise program used in this study was similar to the program used by McClure et al. (2004). The purpose of both of these studies was to observe how an exercise program would affect patients with shoulder impingements. Both of the exercise programs that the individuals were exposed to were designed to implement a variety of exercises that would enhance flexibility of the posterior capsule, the pectoralis minor, and the upper thoracic spine. The findings from this study suggest that a relatively simple exercise program combined with patient education may be effective (McClure et al.).

Implications

Results from the present study indicate that there is need for further research in detecting and alleviating decreased shoulder functional ROM in athletes. Also, more effective methods may be found for assessing goniometric data. Likewise, testing different combinations of flexibility and/or strengthening exercises might further determine whether these types of exercises are helpful to athletes in alleviating ROM difficulties.

Conclusion

The result of the data analysis has shown that there was a significant difference in the effect of stretching protocols between the two groups. The analysis indicated that the participants in the treatment group were able to greatly increase their functional ROM by having been exposed to the stretching protocol. However, this gain was mitigated by the pretest differences between the initial ROM measurements due to group membership.

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APPENDICES

Appendix A
Informed Consent

Appendix A. Informed Consent

Introduction/Purpose: Dr. Richard Gordin and graduate student Brandon Howard from the Health, Physical Education, and Recreation Department at Utah State University (USU) are conducting a study to observe the effectiveness of a specialized upper body stretching study. Justification for the present study will stem from several factors.

The shoulder is an essential joint in the body that plays a crucial role in many athletic activities. Without full range of motion (ROM) of the joint, ability and activity are greatly limited. Some research has shown that a decreased ROM is associated to a higher risk of injury. Specifically, research has shown that increased shoulder tightness can contribute to shoulder injuries. The movement that is associated with the human shoulder consists of a variety of complex movements. These movements consist of a well orchestrated movement pattern consisting of muscles, ligaments, tendons, and bones. These tissues form the many articulations that allow for the shoulder to have the greatest ROM of any joint in the body. This wide range of motion allows for an athlete to perform a great deal of athletic movements, but with this extensive range of motion comes an increased likelihood of injury.

The shoulder girdle can be seen as a complex joint composed of a variety of musculoskeletal structures. These components can be broken down into the bony anatomy (humerus, clavicle and scapula), articulations (glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic), stabilizers (labrum, capsule, ligaments), and musculature (rotator cuff, deltoid, scapular stabilizers). Being able to understand the functional anatomy of the shoulder will allow for the strength and conditioning professional to better be able to prescribed corrective exercises and stretching protocols that will allow for not only rehabilitation, but injury prevention as well. There have been a variety of studies that have dealt with decreased ROM in the upper extremities, but there have been little if any studies that have focused on high level collegiate athletes.

To qualify as a participant for this study you must be: 1) between the ages of 18-23, 2) a current athlete at NCAA Division I athlete at USU, 3) participating in your summer strength and conditioning program under the supervision of the USU Strength and Conditioning Staff, 4) injury free and 5) participating in a minimum of 5 hours per week of strenuous physical activity.

Procedures: If you consent to participate in this study, you will attend a 20 minute test session conducted in the Athletics weight room at USU. During your initial test session you will be asked to take some preliminary measurements, including bodyweight and height. You will perform a five minute warm up on an exercise bike prior to performing the postural assessment. The postural assessment in this particular case will be the overhead squat.

The overhead squat test involves a two legged squat with the arms raised over the head, with the hands at a minimum of 24 inches apart. You will be instructed to stand with the feet hip width apart, the toes pointing straight ahead, and the arms raised overhead. You will be instructed to squat down into a full squat position, where the hip joint is below the knee joint. Once you reached the required depth, a blinded assessor will take an angle measurement at the acromio-humeral joint using a standard goniometer.

Three measurements will be taken, and the average of the three measurements will be recorded. The goniometric pretest data will be entered into the postural assessment data collection sheet. Once all of the goniometric data has been collected you will be taught the stretching intervention that will be used throughout the duration of the study. You will be exposed to three different stretching protocols that will concentrate on the affected musculature. The three stretches that will be used for this study consist of incline latissimus dorsi stretch, the power rack U stretch, and the wall shoulder girdle stretch. At any point during the data collection process you have the right to ask for any further information.

New Findings: During the course of this study, you will be informed of any significant new findings, such as changes in the risks or benefits resulting from participation in the research, or new alternatives to participation, which may cause you to change your mind about participating in this study. If new information is provided to you, your consent to continue participating in this study will be re-obtained.

Risks: Participation in this study will not contain any physical risks beyond those included in the performing of the overhead squat and the stretching intervention. In the event that you sustain any injury from your participation in this research project, USU can reimburse you for emergency and temporary medical treatment not otherwise covered by your own insurance. If you believe that you have sustained an injury as a result of your participation in this research project, please contact the IRB Office at (435) 797-0567.

Benefits: There is no direct benefit to you in participating in this study; however, researchers may increase their understanding of how a specialized stretching protocol may contribute to your performance as an athlete. We will provide, upon request, a summary of your results and a summary of the study's findings.

Explanation & Offer to Answer Questions: Brandon Howard or Dr. Gordin have explained this study to you, and answered your questions. If you have any other questions or research related problems, you may reach Dr. Gordin at (435) 797-1506.

Voluntary Nature of Participation and Right to Withdraw Without Consequence: Participation in this research project is entirely voluntary. You may refuse to participate or withdraw at any time without consequence. You may be withdrawn from this study by the investigator without your consent, for the following reasons:

1. In the event of physical injury (i.e., muscle or ligament) should occur that is perceived by the investigator as threatening to the safety of the participant.
2. If you fail to follow the research protocol.

Confidentiality: Research records will be kept confidential to be consistent with federal and state regulations. Only the investigators will have access to the data, which will be kept in a locked file cabinet in a secure room. The results of the study may be presented at professional meetings and published in professional journals but only quantified data obtained will be used.

IRB Approval Statement: The Institutional Review Board for the protection of human participants at USU has approved this research study. If you have any pertinent questions or concerns about your rights or a research-related injury, you may contact the IRB Administrator at (435) 797-0567. If you have a concern or complaint about the research and you would like to contact someone other than the research team, you may contact the IRB Administrator to obtain information or to offer input.

Copy of Consent: You have been given two copies of this Informed Consent. Please Sign both copies and retain one of these copies for your records.

Investigator Statement: "I certify that the research study has been explained to the above individual, by me or the student researcher. The individual understands the nature, purpose and the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

______________________________ ________________________

Dr. Richard Gordin
Principle Investigator
Telephone: (435) 797- 1506

Brandon Howard
Student Investigator

Signature of Participant: By signing below I agree to participate

______________________________ ____________________________________

(Signature of Participant) Date

Appendix B
Postural Assessment Data Collection Sheet

Participant #: ______
Age: ________ **Ht: ________** **Wt.: ________**

Sport in Which You Participate: ____

<u>Test Set Up</u>

Feet Hip Width Apart	Yes ☐	No ☐
Toes Pointed Straight Ahead	Yes ☐	No ☐
Arms Positioned 24 Inches Apart	Yes ☐	No ☐
Arms Raised Overhead	Yes ☐	No ☐
Reached Full Squat Position	Yes ☐	No ☐

<u>Positive Test for Decreased UB ROM:</u>

Arms Falling Forward	Yes ☐	No ☐

<u>Data Collection:</u>

<u>Prestest Data:</u>
Angle 1:_______
Angle 2:_______
Angle 3:_______
Average:______

<u>Post Test Data:</u>
Angle 1:_______
Angle 2:_______
Angle 3:_______
Average:______