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A Correlation of Strength, Range of Motion, and Shoulder Pathology in the Dominant Arm of Division I Athletes

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To the Dean of the Graduate School:

We are submitting a thesis written by Laura Carrell entitled A CORRELATION OF STRENGTH, RANGE OF MOTION, AND SHOULDER PATHOLOGY IN THE DOMINANT ARM OF DIVISION I ATHLETES

We recommend acceptance in partial fulfillment of the requirements for the degree of Master of Science in Sport and Fitness Administration through the Richard W. Riley College of Education.

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A CORRELATION OF STRENGTH, RANGE OF MOTION, AND SHOULDER PATHOLOGY IN THE DOMINANT ARM OF DIVISION I ATHLETES

A Thesis
Presented to the Faculty
Of the
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May, 2015

By Laura Carrell
Abstract

Division I overhead athletes put themselves at risk for injury due to factors such as fatigue, instability, range of motion difficulties, and strengthening deficits and hypertrophies throughout their careers. Injuries that occur at the collegiate level can have a permanent effect on an athlete’s way of life. Because the shoulder is one of the most commonly affected by overuse in collegiate sports, the purpose of this study was to determine if strength and range of motion correlated with injury. Determining whether or not there are correlations to injury, strengthening and stretching programs could be valuable preventative treatments to implement on overhead Division I teams.

In order to obtain an athlete’s demographic and injury history, a survey was completed to determine factors such as injury type, number of years played, and what types of stretching techniques, if any, were being implemented. The athlete’s internal and external rotation strength was then measured using a Biodex, with the elbow and shoulder flexed at 90 degrees. The athlete’s range of motion was obtained through goniometer measurements, with the athlete lying supine and the shoulder and elbow flexed at 90 degrees.

Results showed significant values between external rotation strength at 180 degrees/second and injury type and significance between external rotation strength at 300 degrees/second and injury type. These results determined that external rotation is a leading factor in relation to injury in these athletes. A positive correlation between external rotation peak torque and injury type shows that external rotation strength could be a risk factor for injuries. Although there were no correlations or significance between
internal rotation range of motion and internal rotation peak torque values, a larger sample size could produce alternate results.

This information can help determine if the amount of injury or injury risk can be reduced by adding stretching programs to daily practice routines and targeting different shoulder muscles to train based on muscle imbalances.
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Chapter 1

Overhead athletes at the collegiate level subject themselves to rigorous training programs with high frequency and volume. These training programs were implemented to keep athletes at the appropriate levels to compete. While many athletes excel under these conditions, they also put themselves at high risk for injuries. According to Friery and Bishop (2007), repetitive micro trauma to limbs associated with sport specific skills is one of the leading causes of overuse shoulder injuries. Although there is evidence that muscle degeneration in athletes progresses later and more slowly than that of non-athletes, injuries that occur at the collegiate level can permanently affect an individual’s way of life (Friery & Bishop, 2007). Ong, Sekiya, and Rodosky (2002), state that the shoulder is one of the most common joints to be affected by overuse activity in sports, accounting for 8-13% of total athletic injuries. While the shoulder is effective in terms of mobility, its stability is often lacking due to difficulty in strengthening and stretching certain areas (Ong, Sekiya, & Rodosky, 2002). Coaches and athletes need to be educated on the risks being taken when overusing the muscles of the shoulder in relation to injuries that can be sustained if proper strengthening and stretching is not practiced.

Over 20% of NCAA Division One athletes are involved in overhead sports, such as baseball, swimming, tennis, volleyball, and softball (Ong et al., 2002). An overhead throw requires both mobility and stability at the shoulder joint to prevent injury. The shoulder is made up of four articulations; the glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic joints, and the overhead throwing motion places large amounts of stress on the shoulder joint (Ong et al., 2002). Shoulder strength and
stability are more of a focus than flexibility, because many strength coaches are focused on the power an athlete can produce, especially in an overhead sport. According to Spigelman (2008), posture training and strengthening of the rhomboid, middle and lower trapezius, and serratus anterior muscles can contribute to decreasing injury because strengthening the surrounding muscles decreases stress on the shoulder directly. A common overhead injury, shoulder impingement, is often treated with a resistance training program. Evidence supports this practice because scapular dyskinesis is typically a contributor to the symptoms and strengthening of the shoulder girdle can help correct this (Mey, Danneels, Cagnie, and Cools, 2012). Because it can lead to an increase in external shoulder rotation and a decrease in shoulder internal rotation, the overhead throwing motion puts athletes at a high risk for injury (Borsa, Laudner, and Sauers, 2008). A decrease in internal shoulder rotation motion can be caused by adaptations to repetitive stress and overhead activities. By increasing internal rotation through aggressive stretching programs, injury rate can decrease (Spigelman 2006).

**Statement of the Problem**

Overhead sports require shoulder strength and range of motion to perform functional skills. The overhead throwing motion can lead to a decreased range of motion of the shoulder, and inhibit flexibility. Altered mobility and strength can cause structural changes in the shoulder girdle, increasing risk of injury (Borsa et al., 2008). This study was to determine and analyze whether there was a correlation between strength, range of motion, and injury presence and history.
Hypothesis

H1. An increase in shoulder external rotation range of motion negatively correlates with shoulder internal rotation range of motion.

H2. Greater external rotation range of motion positively correlates with presence of injury

H3. A decrease in shoulder external rotation strength positively correlates with presence of injury.

H4. A decrease in internal range of motion correlates with type of injury.

Delimitations

- All participants were female volleyball or tennis players or male baseball players from a NCAA Division I university in the southeastern United States.
- Data were collected from one Division I school in the southeast United States.
- Data were limited due to sample size available.

Limitations

- The results were limited due to cooperation of coaching staff and athletes.
- The results relied on effort put forth by the athlete during testing.
- The results relied on the honesty of the athlete being surveyed.

Definitions
1. **Foot Pounds.** The amount of energy required to move one pound the distance of one foot (Isokinetic Testing and Data Interpretation, 2015).

2. **Max Rep TOT Work.** Total muscular force output for the repetition with the greatest amount of work (Isokinetic Testing and Data Interpretation, 2015).

3. **Peak Torque.** The highest muscular force output at any moment during a repetition (Isokinetic Testing and Data Interpretation, 2015).

4. **Overhead Athlete.** An amateur or professional athlete who participates in an overhead sport and is thus at risk of traumatic or degenerative injuries to the shoulder girdle (Seegan’s Medical Dictionary, 2011).
Chapter 2

Review of Literature

Factors Related to Injuries in Overhead Sport Athletes

According to Hurd and Kaufman (2012), injuries in the dominant throwing shoulder are common in baseball athletes, with an estimated 131,555 injuries reported during the 2005-2006 and 2006-2007 academic years in high school play. The most common injuries are ligament sprains and muscle strains, rotator cuff tendinitis, superior labrum anterior-posterior lesions, and internal impingement (Hurd & Kaufman, 2012). Reports stated that over 50% of youth pitchers experienced shoulder or elbow pain over the course of a single season. Contributing mechanisms that can cause degenerative injuries in adult baseball players are believed to begin in the early playing years (Hurd & Kaufman, 2012). While there are non-modifiable factors, such as age, height, and mass, modifiable factors can include an increase in pitching volume, throwing breaking pitches such as curveballs, inadequate rest periods, and fatigue. Because of these risk factors, USA Baseball provided pitch limit and age limits on breaking pitch recommendations, but these have not shown great effectiveness in injury reduction (Hurd & Kaufman, 2012).

Variables of interest included passive internal and external rotation of the pitching arm and peak isometric external and internal rotator strength. Internal and external range of motion was measured passively, and a handheld dynamometer was used to measure internal and external strength of the throwing arm (Hurd & Kaufman, 2012). External
rotation motion predicted peak elbow adduction and the peak internal shoulder rotation moment due to greater motion being associated with small movements. Shoulder internal rotation strength predicted the peak external rotation moment, as greater strength was associated with larger movements. A relationship between peak shoulder and elbow movements also occurred in the throwing arm during pitching. The results suggest that as internal rotation strength increases, stress on the posterior muscles increases (Hurd & Kaufman, 2012). Because greater strength provides greater acceleration, shoulder internal and external rotation can represent the demand placed on the posterior portion of the rotator cuff that is used to counter the internal rotation motion of a throw (Hurd & Kaufman, 2012).

Greater measures of external rotation were associated with lower peak elbow-adduction movements, which suggests that greater external rotation could decrease stress on the anterior shoulder and minimize anterior glenohumeral instability. If an athlete has greater external rotation motion, the peak motion would not be as limited, resulting in lower demands on joint stabilizers (Hurd & Kaufman, 2012).

Motions such as throwing, serving, spiking, and the overhead swimming stroke require high levels of mobility and stability to participate at the collegiate level (Laudner & Sipes, 2009). Microtrauma is a result of highly repetitive motions, large forces, and use of arms, and overhead injury is common. The microtrauma can cause a deficit in functional stability and decrease athletic performance (Laudner & Sipes, 2009).
Data were collected from 371 male and female collegiate athletes from baseball, softball, women’s swimming, men’s and women’s tennis, and women’s volleyball teams. Information collected regarded sport participation at the time of injury and diagnosis of injury, as well as specific surgical procedures, time lost from competing, and rehabilitation methods. Injuries included were periscapular strain, impingement syndrome, SLAP lesions, rotator cuff tendonitis, biceps tendonitis, and various directional instabilities (Laudner & Sipes, 2009). Injuries were documented in 30% of the overhead athletes at some point during their collegiate careers. The high rotational forces necessary for the overhead throw, spike, and tennis serve compromise the integrity of the soft tissue structures during the acceleration and deceleration phases (Laudner & Sipes, 2009). The transition of high school to collegiate training can be a risk factor for overhead injuries, as the volume of training increases. Soft tissue contraction, muscle weakness, postural abnormalities, and neuromuscular coordination are all risk factors. History of injury is also associated with an increase of injury (Laudner & Sipes).

According to Wilk, et al. (2011), shoulder internal rotation while pitching is the fastest human movement recorded. Repetitive torques on the shoulder joint can contribute to the high injury rate in professional baseball, in which 28% of all injuries sustained to professional pitchers occur at the shoulder joint (Wilk, et al., 2011). There are reports that state upper extremity injuries in collegiate baseball players accounted for 75% of the time lost from the sport due to injury, with the pitcher being the most commonly injured player (Wilk, et al., 2011). The most common injury observed was
rotator cuff tendinitis, with injuries occurring more frequently in pitchers than field players.

Wilk, et al. (2011) used data on glenohumeral joint passive range of motion that was collected once a year. Shoulder internal and external rotation were assessed at 90 degrees of abduction by two examiners; one with a goniometer and one without. Participants determined to have glenohumeral internal rotation deficit if their dominant shoulder showed 20 degrees or more loss of range of motion when compared with the non-dominant shoulder (Wilk et al., 2011). Injured pitchers had slightly less internal rotation than non-injured pitchers and 28% of the pitchers with glenohumeral internal rotation deficit were injured. Of the 40 pitchers with glenohumeral internal rotation deficit, 11 developed an injury that resulted in a loss of playing time. Most throwers display excessive external range of motion and loss of internal range of motion, typically at 90 degrees of abduction (Wilk et al., 2011). It has been discussed that stretching can be the most beneficial treatment to treat glenohumeral internal rotation deficit, and if that does not work, possibly a posterior capsular release. It has been noted that many pitchers exhibit a posterior translation rather than an anterior translation. Loss of internal rotation was due to muscular tightness (Wilk et al., 2011).

Although the water polo stroke differentiates from typical overhead sports such as baseball, volleyball, and swimming, the overhead motion places stress on the shoulder girdle (Mota & Ribeiro, 2012). Pain in water polo athletes is the result of instability, muscle imbalance of the rotator cuff, and lack of shoulder proprioception. All of these factors can increase the risk of shoulder injury (Mota & Ribeiro, 2012). Shoulder
stability for functional purposes comes from static and dynamic factors. For effective motor control, proprioception along with strength is very important. A decrease in proprioception can lead to a decrease in motor control, causing functional instability (Mota & Ribeiro, 2012).

Water polo players from two teams were tested for proprioception on a dynamometer, stopping the machine when they thought their arms were at a certain position in the overhead movement. Strength was assessed on the dynamometer as well, with the shoulder and elbow at 90 degrees of flexion and 65 degrees of abduction (Mota & Ribeiro, 2012). The main finding was a negative correlation between proprioception, suggesting that athletes are more susceptible to injury. Because the proprioception is distorted, muscular reaction can be delayed and the muscle contraction timing could fail to protect the joint from excessive movement (Mota & Ribiero, 2012).

Overhead sports show proprioception deficits because of the greater range of motion the shoulder has compared to other joints. The internal and external motion strength of the shoulder rotators were measured, and internal strength was greater than external strength. The muscle imbalance can contribute to injury, as eccentrically the external rotators need to balance the internal rotators to decelerate the movement (Mota & Ribeiro, 2012).

The shoulder girdle is placed under large amounts of stress in overhead sports. Cools, Witvrouw, Mahieu, and Danneels (2005) compared isokinetic performance and impingement symptoms in overhead athletes to determine if strength and stability caused
injury. Because the glenohumeral joint is unstable, stability must be provided by surrounding musculature. If the musculature is weak, injury is an inherent threat.

Shoulders of 60 overhead athletes were tested bilaterally, with half having one sign of impingement in a shoulder. There was a decrease in peak torque of the injured shoulder when compared with the dominant shoulder of the non-injured group. The values suggested a lack of strength in the serratus anterior, a stabilizing muscle of the shoulder and overhead function. Weakness in the serratus anterior can decrease the force of shoulder protraction, decreasing fluidity of movement during the throwing motion (Cools, et al., 2005). To decrease risk of injury, the dominant shoulder needs to be supported by the surrounding musculature to ensure fluidity in the overhead throwing motion. When a shoulder is lacking stability, the muscles around it need to be strengthened in order to avoid injury (Cools, et al.)

Overuse and Fatigue in Overhead Collegiate Athletics

The involved shoulder in female college volleyball players who had repetitive, activity-related pain without prior trauma was examined using magnetic resonance arthrography (Taljovic, Nisbet, Huner, Cohen, & Rogers, 2011). Over a five-year period, five division-one college volleyball players were recorded with this description. One of the athletes was excluded due to history of a car accident, and the remaining four went on to have surgery for a humeral avulsion of the inferior glenohumeral ligament, involving the axillary pouch. After completion of a rehabilitation program, all four
players returned to normal play within six to eight months. Requirements for return to play involved overhead strength measurements comparable to the uninvolved shoulder.

On average, a collegiate female volleyball player performs 40,000 spikes a season, leading to extensive research in the kinetics of the overhead throwing motion. It is believed that humeral avulsion of the glenohumeral ligament is a result of repetitive micro trauma, although this injury has not been reported before in English literature (Taljnovic et al., 2011). Because of the shoulder’s dominance, reports have shown that attackers build different muscular and capsular qualities in the playing shoulder when compared with the opposite shoulder (Taljnovic et al., 2011). Repetitive trauma can lead to injury in the dominant shoulder. A limitation included a small population, but with further research, overhead throwing could be modified to avoid injuries such as this (Taljnovic et al., 2011).

According to Thomas, Swanik, Swanik, and Kelly (2010), anterior shoulder instability is one of the most common injuries in baseball players. These injuries have been attributed to a decrease in internal rotation and increase in external rotation (Thomas et al., 2010). There have also been recordings of changes in scapular upward rotation. Repetitive forces have been thought to have been the cause of changes to bony alignment and soft tissue adaptations to the shoulder (Thomas et al., 2010). The purpose was to examine glenohumeral internal and external rotation, total range of motion, and scapular upward rotation in regards to repetition throughout a division one baseball season.
When combined, preseason and postseason measurements showed that there was less internal rotation and more external rotation, as well as less total motion in the dominant arm when compared to the non-dominant arm. There were no significant effects found for the non-dominant arm in any of the measurements. Previous studies have shown that decreases in scapular upward rotation can increase risk of shoulder injury, such as impingement syndromes, supraspinatus weakness, and can affect glenohumeral internal rotation deficits. Shoulder adaptations typically start at a young age, which can make identifying underlying issues difficult. Shoulder adaptations should be monitored over several seasons to find a correlation with injuries among players (Thomas et al., 2010).

Shoulder injuries made up over half the injuries found in baseball players in a single season (Ouellette et al., 2008). Awareness of the phases of the overhead throw is important to have when examining the root of these injuries. Tensile overload and impingement are what make baseball players prone to rotator cuff tears. In addition to the rotator cuff, glenoid labrum degeneration, internal impingement, and micro trauma were also common due to overuse and instability (Ouellette et al., 2008). Because of the compromising positions the throwing phase put on the dominant shoulder, Ouellette et al. states that baseball pitchers were more likely to have muscular hypertrophy, increased external range of motion, and increased anterior capsular laxity (2008). External impingement is the result of joint instability, and is the most frequent cause of pain. The repetitive shear force across the shoulder happens during the late cocking phase as well as the early acceleration phase. Because baseball pitchers throw at such a high volume, the
anterior capsule eventually fatigues, causing anterior joint laxity and increased movement. Rotator cuff injuries usually appear with a significant increase in pitching intensity or frequency. Stress at the rotator cuff during the deceleration phase is usually responsible for tendon tears because of its eccentric motion. By pitching at the collegiate level, the stress put on the dominant shoulder deteriorates the rotator cuff faster, which can lead to early onset tendinosis. Infraspinatus atrophy is caused from excessive tension on the suprascapular nerve. The stress a baseball pitcher puts on his dominant shoulder and increased ligament laxity leads to tears of the rotator cuff much more easily than a non-athlete. Specific patterns categorize rotator cuff injuries into impingement and tensile overload syndromes, and labral injuries into instability syndrome. It is important that the pathophysiology is understood when classifying these injuries, to determine if the source is from overuse, fatigue, or muscle tightness (Ouellette et al., 2008). Because strength can play a significant role in overhead injuries, it is important to regularly assess the shoulders for signs of weakness and what musculature may need to be evaluated (Ouellette et al., 2008). The shoulder can be difficult to train for strength due to the placement of the muscles. Along with strength and the mobility of the shoulder and how it affects injury, the ball and socket joint is known for instability (Ouellette et al., 2008).

Shoulder fatigue in glenohumeral external rotation can contribute to shoulder injuries in overhead athletes. Scapular kinematics and muscle activation during functional movement patterns have not been correlated with the fatigued muscles of the shoulder nearly enough (Bunn, Joshi, Karas, Padua, & Thigpen, 2004). The effects of glenohumeral external rotation muscle fatigue on the upper and lower trapezius, serratus
anterior, and infraspinatus muscle activation was examined, as well as the scapular kinematics during a diagonal movement in overhead athletes.

There were 15 men and 10 women participating, all of whom were involved in overhead activities for at least 30 minutes, three times a week (Bunn, et al.). The muscles chosen were significant because of their role in scapular positioning, with the infraspinatus the muscle that shows the greatest change when activated with repeated elevation and external rotation tasks. Bony landmarks were used for coordinates to screen anatomical axes during movement. The fatigue protocol consisted of the subjects lying prone with the shoulder positioned in 90 degrees of abduction, and the subject was instructed to move the shoulder through 75 degrees of external rotation using the same weight as the diagonal pattern (Bunn, et al.).

Results concluded that there were no significant effects on scapular internal or external rotation. The upper and lower trapezius were also unaffected when compared pre-and post-fatigue. Shoulder external rotation had a greater impact on altered scapular muscle activation. The interdependence between the infraspinatus and lower trapezius muscle was significant; determining that they cause greater scapular movement after shoulder is fatigued in overhead functional movement athletes (Bunn, et al.).

The rotator cuff is one of the most commonly injured sites of overhead athletes (Ong et al., 2002). Focusing on stabilizing the rotator cuff is important because the shoulder is a shallow ball-and-socket joint, and prone to instability (Ong et al., 2002). The location of the muscles requires them to be isolated to be properly strengthened.
When the rotator cuff is fatigued, it is less likely to stabilize the shoulder and more likely to strain or tear. By increasing the strength of the rotator cuff, the incidence of injury and instability can be reduced.

**Shoulder Range of Motion in Overhead Athletes**

Increased anterior glenohumeral laxity and posterior shoulder tightness is not uncommon in baseball pitchers due to the forces created in the throwing motion. Baseball pitchers can average up to 100 throws per game or practice with minimal rest. The late cocking and acceleration phases create the most stress on the shoulder joint, mainly in the anterior portion. This repetitive micro trauma can cause anterior glenohumeral laxity in the shoulder joint (Laudner, Meister, Noel, & Deter, 2012). The purpose was to determine whether that as posterior shoulder flexibility decreases, anterior laxity increases.

There were 58 professional baseball players used from one Major League Baseball team during spring training (Laudner et al., 2012). Glenohumeral laxity and range of motion was measured for comparison. There was one testing session for each participant before spring training during a regular physical examination. Anterior glenohumeral laxity was measured with the throwing arm in external rotation, and glenohumeral horizontal adduction range of motion was measured in a supine position. Glenohumeral rotation was measured in a supine position, with the shoulder and elbow at 90 degrees of flexion and abduction (Laudner et al., 2012).
The results showed a negative correlation between anterior glenohumeral laxity and combined glenohumeral horizontal adduction and internal rotation range of motion. The results also showed that decreased glenohumeral horizontal adduction and changes in glenohumeral internal rotation range of motion could predict increased glenohumeral laxity in the throwing arm (Laudner et al., 2012).

According to Polster, et al. (2013), humeral torsion is the motion that allows baseball pitchers to reach maximum external rotation in the late cocking phase of a pitch. The shearing forces mainly target the long head of the biceps tendon as well as the rotator cuff tendons. (Polster et al., 2013). Injuries to these structures are often the result of the body’s adaptation to the high velocity of an overhand baseball pitch. High angular velocity and large amounts of internal rotation of the humerus are necessary for an accurate and effective baseball pitch. The rotator cuff and greater tuberosity are responsible to limit the degree of shoulder external rotation during a throw. In baseball pitchers, it is common to see a shift of the center of rotation to decrease the amount of internal impingement on the posterior-superior glenoid, which allows maximal external rotation. Humeral torsion is the rotational relationship between the proximal and distal surfaces of the humerus. In overhead throwing, humeral torsion is typically asymmetrical, with a higher degree in the dominant arm. This is caused by the soft tissue and osseous adaptations from the repetitive stress of pitching. The purpose was to determine the relationship between injury severity with dominant humeral torsion and torsion difference between dominant and non-dominant throwing arms.
Over a period of three years, 27 professional baseball pitchers were used to record torsion (Polster et al., 2013). Torsion was measured by recording greater degrees of external rotation of the distal humeral articular axis in relation to the humeral head articular axis. For the next two years, the subjects were followed and monitored for upper extremity injuries. To mark injury severity, the number of days missed from pitching were recorded, with a threshold of 30 days. If fewer than 10 days were missed, the injury remained unmarked, and the subjects had data showing scapular and humeral injury involvement. Impingement was measured by using bone markers to identify a best-fit conforming sphere on the articular surface of the humeral head to display the rotational motion of the humerus.

In 22 of the 25 participants, dominant humeral torsion was greater than non-dominant humeral torsion. During the two-year follow up, 11 of the pitchers were injured and three had more than one injury. The results showed that lower degrees of dominant shoulder humeral torsion correlated with more severe injuries. There was a significant inverse relationship between dominant humeral torsion and injury severity as well as a correlation between torsion differences and injury severity (Polster et al., 2013).

A reduction of the acromial space is common in baseball players and has been linked to subacromial impingement. Subacromial impingement is entrapment of soft-tissue structures in the shoulder during elevation. Common symptoms are decreased upward rotation, increased anterior tilting, protraction, and internal rotation. A decrease in scapular upward rotation can also lead to decreases in the subacromial space and impingement syndrome (Thomas et al., 2010). This study was designed to examine the
correlation between acromiohumeral distance and scapular upward rotation in college baseball players.

Participants in the study included 24 healthy baseball players on a college team. A posttest assessed two dependent variables and one independent variable, which was arm dominance. The average of three measurements of the acromiohumeral distance and scapular upward rotation at rest and 90 degrees glenohumeral abduction were taken for analysis. Testing showed no significant difference between dominant and non-dominant arm for acromiohumeral distance at zero and 90 degrees. Results showed that healthy college baseball players did not have bilateral differences in acromiohumeral distances. There were no correlations between acromiohumeral distance and scapular upward rotation (Thomas et al., 2010).

H.K. Wang, Juang, Lin, T.G. Wang, and Jan (2004) found shoulder internal range of motion was affected by gender and arm dominance. Males had a decrease in the range of shoulder internal rotation when the dominant arm was compared to non-dominant arm. Females did not have the same differences in shoulder internal rotation. Males had greater strength in all areas except internal rotational concentric and eccentric strength of the dominant arm in 180 degrees per second. The shoulder mobility was significantly affected by arm dominance. Males had greater decreased ROM of internal rotation in the dominant shoulder when compared to the non-dominant shoulder. Results indicated that males have less mobility than females, leading to conclude that they need greater amounts of stretching to avoid injury (Wang et al., 2004).
The stress placed on the shoulder when playing water polo is similar to those found in baseball and swimming (Witwer & Sauers, 2006). Repetitive overhead motion can lead to shoulder injury, but not many studies have focused on water polo athletes. The most common shoulder injuries found in water polo players are typically a result of overuse and are usually internal impingement, secondary impingement, instability, rotator-cuff tendinitis, and damage to the posterosuperior labrum. It is unclear whether water polo players suffer unilateral injuries like baseball or bilateral injuries like in swimming. The purpose of this study was to determine shoulder mobility adaptations in collegiate water polo athletes.

There were two NCAA Division I water polo teams used in the study, totaling 31 athletes (Witwer & Sauers 2006). Scapular upward rotation was measured in five positions of humeral elevation. Increased distance can indicate a less flexible posterior shoulder. The average of the measurements were used in the analysis. Passive isolated glenohumeral joint internal and external range of motion was measured with a goniometer (Witwer & Sauers, 2006).

Scapular upward rotation was not significantly different between shoulders, but there were significant differences between humeral elevations (Witwer & Sauers 2006). The findings in this study showed isolated external humeral rotation in the dominant shoulder of both male and female collegiate water polo athletes. The unilateral increase observed was most likely the result of the overhead throw used in water polo (Witwer & Sauers, 2006). While water polo involves swimming and overhead throwing, it is throwing that most commonly contributes to injury. Posterior shoulder tightness was not
significantly different in bilateral comparisons. This tight posterior capsule was the result in loss of internal rotation. Because water polo players use both shoulders for swimming and for smaller amounts of throwing, impingement is decreased because of an increase in upward rotation. Water polo players have greater dominant shoulder glenohumeral joint external rotation, which can lead to a greater range of motion (Witwer & Sauers, 2006).

According to Giugale, Jones-Quaidoo, Diduch, and Carson (2010), glenohumeral internal rotation deficit, involves restricted shoulder range of motion due to muscular and capsular tightness. Because it is believed internal rotation motion deficit leads to injury in overhead athletes, this condition is of particular importance.

Two groups of high-level tennis players were observed for injuries with the control group not participating in a postero-inferior capsular stretching program. The group that participated in a stretching regimen had a 38% decrease in shoulder injury and an increase in internal rotation (Giugale et al., 2010).

The ideal difference in internal rotation range of motion is less than 25 degrees between throwing and non-throwing arms. Stretches including the Sleeper and Cross Arm should be utilized to increase internal rotation range of motion and decrease injury (Giugale et al., 2010).

Repetitive stress can cause changes to the glenohumeral joints in both the internal and external rotation. It is common for increases in external rotation and decreases in internal rotation to be noticed, and regular range of motion testing should be practiced, especially in young athletes (Spigelman, 2006). Glenohumeral internal rotation deficit
disorder can develop before any other motion adaptation in an athlete and is often associated with an increase in external rotation. Tightening of the anterior shoulder can also lead to a deficit in internal rotation (Spigelman, 2006). Bony adaptations have also been blamed as the cause of GIRD, developed from the change in velocity during the late cocking and deceleration phases of the throwing motion. Humeral retroversion can be a result from the stress placed on the humeral head (Spigelman, 2006).

Internal and external rotation ranges of motion were tested both supine and seated, and compared between shoulders for bilateral sports and compared to normative values for unilateral sports. As a result, glenohumeral internal rotation deficit appeared to be a result of the overhead throwing motion, due to increases in external rotation and decreases in internal rotation (Spigelman, 2006). Because these adaptations can begin in the early days and result in injury, regular assessment and proper technique teaching is important. Athletes with internal rotation deficit can benefit from aggressive stretching programs as well as posture and strength training (Spigelman).

Posterior shoulder flexibility maintenance can prevent upper extremity injury in overhead athletes (Oyama, Goerger, Goerger, Lephart, & Joseph, 2010). The difference in internal and external rotation range of motion increases with age and years of sport participation, and these changes are due to humeral torsion and flexibility. Tightness of the posterior shoulder can be caused by lack of internal rotation range of motion and can also attribute to shoulder impingement, SLAP lesions, and nonspecific shoulder pain (Oyama et al., 2010). Because humeral torsion is so difficult to change, increasing range
of motion through a stretching program is a more practical treatment method (Oyama et al., 2010).

Oyama, et al. (2010) compared self and clinician practiced stretching programs on collegiate baseball players. Measurements were taken in the supine positions before three stretches were performed (Oyama et al., 2010). The deficit in internal rotation range of motion that was displayed could have been caused by the bilateral difference in the humeral torsion, but bilateral deficit in total range of motion shows that the pitcher’s dominant shoulder had greater soft tissue tightness compared with the non-dominant side. Results showed that all three stretches were needed to increase internal rotation and horizontal adduction range of motion (Oyama, et al., 2010).

The stretches were chosen based on the ability to perform them on the field and without the help of a clinician. With a clinician, there can be scapular stabilization, but that is not always realistic for an athlete who is on the field alone. Without the clinician, there is no scapular stabilization, but there is still an increase in internal rotation range of motion (Oyama et al. 2010).

In a gender comparative study, H.K. Wang, Juang, Lin, T. G. Wang, and Jan (2004) found that the dominant arm had significant mobility implications when compared to the non-dominant arm. Higher torque and reduced mobility of shoulder internal rotation were observed in male and female junior volleyball players were observed. Changes due to muscular imbalance included retroversion of the humeral head, which led to a decrease in range of motion in the dominant arm (Wang et al., 2004). The effect of
arm dominance on reduced mobility was significant when compared to the non-dominant arm, and mechanism for these changes include soft tissue adaptation, stretching of the anterior capsule but shortening of the posterior capsule, and retroversion of the humeral head (Wang et al., 2004). Restriction of shoulder internal rotation was less in females than that of males, with higher strength values in males. This could indicate that larger muscle mass can inhibit range of motion (Wang et al., 2004).

There is debate regarding whether or not altered mobility patterns arise from soft-tissue or osseous adaptations within and around the shoulder. Mobility is characterized by rotational and translational range of motion. (Borsa et al., 2008). Throwing patterns in the dominant shoulder display increased external rotation range of motion and decreased internal rotation range of motion. Lack of posterior mobility in the throwing shoulder could be a result of scarring or contracture of the posterior capsule or rotator cuff. While shoulder tightness is typically greater on the dominant arm, laxity has been shown to be symmetric between the dominant and non-dominant shoulder (Borsa et al., 2008).

According to Borsa, Laudner, & Sauers (2008), the throwing arm typically has greater humeral retroversion and alterations in this movement develop over time beginning at a young age. Overhead athletes can have hypo- or hypermobility in their dominant shoulders, which is thought to be developed secondary to structural change (Borsa et al., 2008) Shoulder stability at the glenohumeral joint is controlled by passive and active movements. Overhead activities require scapular stabilizing and rotator cuff function to maintain control of the humeral head and glenoid fossa. The lack of bony
instability at the glenohumeral joint is compensated by the glenoid labrum that encompasses the entire rim. The shoulder girdle must be strong enough to maintain centering of the humeral head.

Shoulder instability correlates with shoulder strength, because the greater the strength, the greater reduction of instability. Assessing shoulder strength is significant when determining injuries and for examining progress of rehabilitation when compared to the uninjured shoulder. The strength of a shoulder can be affected throughout a collegiate athlete’s career, as well as later in his or her life. By determining strength, adjustments can be made to training programs and repetition of movements (Brooks, 2012).

Shoulder Strength and Stability in Overhead Athletes

Because of its anatomy, the shoulder is commonly associated with instability. The ball-and-socket joint is very shallow, and the tendons can be weak and ligaments are typically lax (Nocera, Rubley, Holcomb, & Guadagnoli, 2006). The shoulder relies mainly on the surrounding musculature for stability, which includes the rotator cuff. For an athlete that is an overhead thrower, rotator cuff strength is imperative for injury prevention as well as performance. The rotator cuff compresses the humeral head, providing stability and proprioception input. This gives the body feedback on extremity position in relation to the body’s center of gravity, giving the athlete awareness to the body part being utilized. Studies have shown that repetitive overhand throwing decreases shoulder muscle strength as well as proprioception (Nocera et al., 2006). This
study examined declines in strength and proprioception following a single bout of repetitive overhead throwing. The study used a pre- and post-test with three groups including varsity baseball players, recreational athletes, and a control group.

The participants included 23 volunteer male college students, six of which were part of a NCAA Division One baseball team (Nocera et al., 2006). The remaining subjects were from the general student population, but all had previous throwing experience measured by having played at least one season of varsity baseball in high school. Both internal and external rotations were tested isotonically in the subjects’ dominant shoulders, using weights to bring them into maximal internal and external rotation.

No significant differences were found between pre- and post-test groups in the isotonic internal and external rotation (Nocera et al., 2006). There were also no differences between pre- and post-tests of internal and external isokinetic testing. Results presented overhand throwing decreased dominant shoulder proprioception using the measurements that had an increase in absolute angular error. Muscle spindle sensitivity decreasing could cause this error. Fatigue also played a role in throwing error, due to a 50% decline in maximum peak torque. Because proprioception plays role in recognizing joint position in extreme ranges of motion, it places additional mechanical stress on the rotator cuff and other surrounding musculature (Nocera et al., 2006).

Overhead activity athletes have an increased risk of glenohumeral joint injuries due to the imbalance of eccentric movements in external rotation and concentric
movements in external rotation at the rotator cuff. While this issue has been brought to the attention of many strengthening coaches, injuries have not decreased, indicating that currently used programs are ineffective to shoulder injury reduction (Niederbracht, Shim, Sloniger, Paternostro-Bayles, & Short, 2008). Increasing eccentric external rotation exercises without increasing concentric internal rotation to determine if this is a factor that can lead to a decrease in shoulder injuries in the overhead athlete was a main focus (Niederbracht et al., 2008).

There were two collegiate women tennis teams recruited for pre-and post-testing on an isokinetic dynamometer used five maximal eccentric external contractions immediately followed by concentric external contractions (Niederbracht et al., 2008). The team serving as the experimental group participated in a shoulder-strengthening regimen in addition to their preseason practice, and the control group did not have any extra strengthening parameters set. Measurements for both teams were taken on concentric internal and eccentric external total work capacity and average peak force in pre-and post-testing. Pre-existing shoulder muscle imbalances were recorded for data analysis. The strengthening program for the experimental group included 90-degree external rotation, scaption, chest press, and external rotation with resistive rubber tubing. Each exercise was performed three times with 15 repetitions per set. There was a one-minute rest period in between each set (Niederbracht et al., 2008).

The experimental group had significant gains in regards to eccentric external total work. Concentric internal total work, concentric internal mean peak force, and eccentric...
external mean peak force did not change, and the control group’s forces decreased. There were three participants in the experimental group with rotator cuff muscle imbalances. The focus on strengthening the eccentric internal rotation resulted in a decrease of shoulder muscle imbalance (Niederbracht et al., 2008).

Rotator cuff muscles in the overhead athlete can be difficult to measure for strength. Isokinetic dynamometers are the most commonly used instrument to measure rotator cuff strength (Scoville, Arciero, Taylor, & Stoneman, 1997). The testing position most often used is having the shoulder flexed at 90 degrees with the elbow flexed at 90 degrees, because it best replicates the mechanics of the arm during the late cocking phase of throwing. This position can inhibit maximal effort and produce symptoms in some athletes. The focus is on the end range eccentric agonist/concentric agonist rotator cuff strength. Correlation between these can give more information to a relationship between medial and lateral rotators.

The dominant and non-dominant shoulders were tested at 90 degrees per second. The shoulder was in 90 degrees of abduction and 90 degrees of shoulder flexion (Scoville et al., 1997). The subject performed 10 submaximal practice repetitions before performing 10 repetitions at maximum force. The opposite procedure was conducted for testing lateral rotation. Based on the three best efforts, average force was computed using a percentage of body weight for each motion.

Concentric lateral rotation compared with concentric medial rotation was consistent with previous reports. In the end range of 60-90 degrees lateral rotation,
eccentric antagonists were stronger than the concentric agonists for the dominant and non-dominant shoulders (Scoville et al., 1997). This suggests that the deceleration force must be increased to maintain stability of the glenohumeral joint. The eccentric lateral rotation in relation to concentric medial rotation in the end range was higher than previously reported concentric-lateral, concentric-medial rotations.

The end range eccentric agonist compared to concentric agonist ratios can more effectively measure shoulder muscles strength. Analysis of the end range eccentric agonist compared to concentric agonist can provide data to prevent and treat future shoulder injuries (Scoville et al., 1997).

The agonist-antagonist strength relationship correlates with eccentric shoulder external rotation and concentric internal rotation in terminal range of motion. This study was aimed at finding the range of eccentric antagonist and concentric agonist rotator cuff strength in overhead athletes (Yildiz et al., 2006).

Participants included 40 male cadets from a Turkish Military Academy who were involved in off-campus overhead sports including volleyball, handball, and tennis. None of the subjects suffered from musculoskeletal shoulder injuries during testing (Yildiz et al. 2006). A dynamometer was used to measure maximal concentric and eccentric muscle strength for dominant and non-dominant shoulders at 90 degrees per second. A five-minute warm-up was allowed before testing, followed by a 30-second stretch of the internal and external rotators. Terminal range of external rotation strength in internal rotation on the dominant side was strong than the non-dominant side. The terminal range
of internal rotation’s concentric strength on the dominant side was greater than the non-dominant side. The results indicated that eccentric actions of external rotation possess the ability to provide dynamic joint stability during fast and forceful shoulder internal rotations. The same findings were true for internal rotators during external rotation (Yildiz et al., 2006).

The glenohumeral joint is prone to multidirectional instability, which is instability in two or more directions (Ziaks, Freeman, and Wise, 2010). The three patterns associated with MDI is antero-inferior dislocation with posterior subluxation, posteroinferior dislocation with anterior subluxation, and antero-postero-inferior dislocation (Ziaks, Freeman, and Wise). It is common to see impingement syndrome associated with multidirectional instability, as the shoulder pain is increased by overhead activities. Management includes modification and rehabilitation of the rotator cuff, strengthening scapular stabilizers, and an increase of glenoid humeral joint proprioception. A clinical presentation of an undiagnosed MDI case associated with neurological and functional impairments showed that glenohumeral laxity was the cause (Ziaks, Freeman, and Wise).

An athlete with a history of overhead sports including softball, basketball, swimming, and diving was observed, and presented with glenohumeral laxity. Functional impairments increased when performing overhead activities, especially during active range of motion (Ziaks, Freeman, and Wise 2010). The rehabilitation program implemented strengthening and mobilization of the surrounding musculature in order to support the shoulder girdle more efficiently.
During post-surgical rehabilitation, an increase in stability led to a decrease in pain. Due to an increase in humeral head movement, there was rotator cuff inflammation that became asymptomatic with proper stretching and strengthening rehabilitation techniques. Overhead performance was achieved within four months post surgery, due to the stabilization of the glenhumeral joint and strengthening of surrounding musculature (Ziaks, Freeman, and Wise 2010).

The relationship between labral lesions and humeral dislocation in patients with shoulder instability is an area that is not commonly targeted. When a patient has anterior shoulder instability, they more often than not also have a Bankart Lesion (Kim, Yi, Kwon, & Oh, 2011). There have been studies suggesting that the severity of capsulolabral lesions increases over time and with the number of dislocations. While this is a common finding, there have been cases with extensive lesions after one dislocation, or other cases with many dislocations and an isolated Bankart Lesion. This study uses a null hypothesis stating that subjects with recurring dislocations should have more extensive labral lesions.

Qualifying patients for the study had to present with chronic anterior shoulder dislocation, had previous arthroscopic surgery, had a normal contralateral shoulder, and a Bankart lesion in the affected shoulder, superior labral detachment, or a circumferential labral lesion. The injuries had to have occurred between 2005 and 2008. Out of the 158 patients, 31 were excluded (Kim et al., 2011). All underwent surgery and were divided into three groups for follow-up testing. Patients were examined for two years after surgery and range of motion was assessed periodically.
There were no significant differences in the range of motion between the three groups, and the study suggested the extent of the labral lesion and frequency of glenohumeral dislocation did not correlate to shoulder instability (Kim et al., 2011). No significant differences were found for failure rate and range of motion. Because of the short follow-up period, there could have been results missed that would not be present until later in life, many years after surgery. It was concluded that extensive labral lesions can be sustained regardless of amount of glenohumeral dislocations due to shoulder instability, and treatment options should be based on several evaluations (Kim et al., 2011).

Intense participation in overhead sports plays a large role in internal and external rotation strength of the shoulder. Different techniques control differences of the rotator cuff ratio. In volleyball, ball speed is determined mainly by the rotator cuff muscles, and in this study the focus was on the muscular ratio of the rotator cuff of volleyball players (Dupuis, Tourny-Chollet, Biette, & Blanquart, 2002).

There were 24 athletes in this study; participants included eight volleyball players, eight judokas, and eight non-athletes (Dupuis et al., 2002). An isokinetic dynamometer was used to record data, and each subject was tested with the shoulder abducted to 90 degrees in the scapular plane. Both the dominant and non-dominant shoulders were measured for comparison (Dupuis et al., 2002).

According to Dupuis et al. (2002), results indicated that although there was no statistical difference in strength between non-dominant and dominant shoulders,
volleyball and judokas had higher strength measurements than non-athletes in all assessments (Dupuis et al., 2002). The measurements of volleyball players to non-athletes were close. This study showed evidence that the overhead technique used in volleyball effects the strength and development in the rotator cuff muscles, while still somewhat preserving a muscular balance similar to that of a non-athlete (Dupuis et al., 2002).

Isokinetic strength and mobility assessments based on male and female volleyball players have indicated reduced shoulder internal rotation of the dominant arm and higher internal rotational concentric torque, as well as uneven concentric strength ratios (Wang et al., 2004). There have been many findings in total rotation range of motion decreasing in other overhead athletes as well. The objective of this study was to establish shoulder rotator performance, strength ratios and mobility and to determine whether or not arm dominance plays a role in gender differences existing in elite junior volleyball players.

Two national junior volleyball teams were recruited for the study during the 2001-2002 seasons (Wang et al., 2004). Testing was conducted in the supine position, with the shoulder at 90 degrees of abduction and the elbow flexed at 90 degrees. Angular velocities of 60 degrees and 180 degrees per second were recorded on a Biodex. Single and average peak torque values were recorded and gravity compensation was not included.
Summary

The shoulder joint is prone to injury because of instability, overuse, and range of motion characteristics. Collegiate athletes are subject to high volumes of repetitive trauma, putting them at risk of overuse injury every season (Friery & Bishop 2007). Injuries such as ligament sprains, muscle strains, internal impingement, rotator cuff tendinitis, and SLAP lesions are all results of repetitive microtrauma, which can also lead to fatigue (Hurd & Kaufman, 2012). Athletes who have fatigued a muscle risk compromising proper form and technique, as well as strength, which can lead to injury. Because injuries occur with an increase in training volume, it is necessary for coaches and healthcare providers to be aware of the risk they are putting their athletes in while implementing training programs (Ouellette et al., 2008). Injury can cause problems with range of motion mechanics of the shoulder. Posterior tightness, and a decrease in shoulder internal rotation are not uncommon. According to Witwer and Sauers (2006), posterior shoulder tightness is often the result of a lack of internal rotation range of motion. The repetitive stress on the shoulder joint can cause changes in the range of motion, attributing to an increase in external range of motion and lack of external rotation strength (Spigelman 2006). Overhead motions in sports such as throwing, swimming, spiking, and serving require the proper strength to maintain stability, as the shoulder girdle is a shallow socket that is easily compromised (Laudner & Sipes 2009). The rotator cuff is one of the most important structures on providing stability, and in many times it is overused and cannot function properly to prevent injury. A decrease in proprioception is also a result of fatigue, which can lead to muscle spindle inactivity.
This is problematic as the shoulder needs to be able to counteract the force of a throw in the deceleration phase, and if the muscles are fatigued, they are not able to withstand the force (Nocera et al., ). To prevent injury in overhead athletes, coaches and healthcare providers need to decrease the amount of trauma placed on the shoulder, create strengthening programs for the musculature surrounding the shoulder girdle, and implement stretching exercises to maintain proper range of motion.
Chapter 3

Methods and Procedures

Participants

Overhead athletes from a United States southeastern NCAA Division I university were used in the study. Participants included 30 varsity baseball players, nine male tennis players, six female tennis players, and 15 female volleyball players. Present red-shirted players, regardless of reason, were excluded from the study.

Context of the Setting

The context of the study was a public state university in the southeast conducted in the varsity athletic department. The testing took place in the rehabilitation room of the athletic training room.

Research Design

The type of research included correlational and linear in regards to range of motion, strength, and overuse injuries. Statistical analysis of strength, range of motion, and injury data were used to establish relationships between strength, range of motion, and injury. The independent variables were range of motion and strength. The dependent variable was the presence of an overuse injury.
Procedures

Before receiving consent from athletes who would participate in the study, permission was given by the institution (IRB). A letter requesting permission to use specific teams was sent to the athletic director prior to testing. After obtaining permission from the athletic director, a letter requesting athlete participation was sent to the head and assistant coaches of teams involved. Athletes were informed that participation would be voluntary and confidentiality was assured verbally and in writing prior to any testing. A demographic survey was administered prior to the testing, including, but not limited to, questions concerning history of sport participation, history of injury, and information involving stretching techniques. Participants were informed that testing would last approximately 30 minutes.

Dominant shoulder internal and external rotation strength were measured using the biodex at 90 degrees of shoulder and elbow flexion. The validity and reliability were acceptable for both clinical and research purposes. Concentric velocity measures were valid up to 300 degrees/second. According to Tunstall, Mullineaux, and Vernon (2005), the Biodex is recommended for research purposes. Data were recorded as measurements were taken. The data were obtained personally without any outside assistance. Dominant shoulder internal and external rotation range of motion was measured and recorded using a standard goniometer. According to Kolber and Hanney (2012), the goniometer is 95% reliable, although when clinically used, measurements can differ due to placement of
bony landmarks on different subjects. After testing was completed, athletes were given a debriefing waiver ensuring confidentiality and contact information if they were interested in seeing the results of the study. Confidentiality of participants was protected by using a code to indicate individuals according to their sports. The data were kept in a locked filing cabinet in a locked office and only removed when results were analyzed. Athletes were able to see the overall results upon the completion of the study, but not individual results.
Chapter 4

Results

IBM Statistics SPSS version 22 (Pyrczak Publishing, Glendale, California 2012) was used to analyze all collected data. Bivariate Spearman and correlation determined if variables were linearly related to each other. A Biodex (Biodex Medical Systems, Shirley, New York) was used to collect strength values. A standard goniometer was used to collect range of motion values. Descriptive statistics are listed in Table 1.

Greater external rotation range of motion positively correlates with presence of injury

There were significant values between external rotation strength at 180 degrees/second and injury type (R= .034, p<.05). There was significance between external rotation strength at 300 degrees/second and injury type (R=.034, p<.05).

An increase in shoulder external rotation range of motion negatively correlates with shoulder internal rotation range of motion.

There was no significance between internal and external range of motion values. External range of motion could not be correlated to presence of injury because the presence of injury variable was constant. There was no significance between external range of motion and type of injury.

A decrease in shoulder external rotation strength positively correlates with injury type.
External rotation peak torque (strength) at 180 degrees/second (R=.034, p<.05) correlated positively to injury type in a one-tailed spearman’s correlation. External rotation peak torque at 300 degrees/second (R=.034, p<.05) positively correlated to injury type.

**A decrease in internal range of motion correlates with type of injury.**

There was no correlation between internal rotation range of motion and injury type.
Table 1

Descriptive Statistics

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Chapter 5

Discussion

This study was designed to determine if there was a correlation between dominant shoulder strength, range of motion, and presence of injury in overhead Division I athletes. Stress, fatigue, inadequate rest periods, and lack of range of motion contribute to injury presence in the dominant shoulder of athletes (Hurd & Kaufman, 2012). Muscle fatigue can cause joint laxity and increase shoulder external rotation, because the anterior capsule is not able to maintain enough strength to resist the force of the opposing muscles (Ouellette et al., 2008). Shoulder instability can be the result of muscle and range of motion imbalances and lead to injuries. Because Thomas et al. (2010), found that a lack of internal range of motion and an increase in external range of motion increased an athlete’s risk of injury over the course of their playing career, beginning this study with incoming athletes and obtaining data throughout their collegiate playing years could provide greater results.

According to the results of the analyzed data, external rotation strength determined injury type in the athletes tested. These findings could be a result of anterior and posterior muscle imbalances discussed previously (Ouellette et al., 2008). While there was no significance between internal and external range of motion values, a larger sample size could have provided more data to correlate, as previous literature has stated that there is typically a negative correlation between internal and external rotation ranges of motion (Giugal, et al 2010). In the data collected, there was no significance between
external range of motion values and type of injury, possibly due to limitation of sample size. The findings of this study differed from the literature in that there was no correlation between internal rotation range of motion, injury type, or the presence of injury.

When compared to normal values (90 degrees), participants had similar external rotation range of motion values at mean of 88.5 degrees. When compared to internal rotation range of motion norms, participant values displayed a mean of 64 degrees, which is slight less than normal values which are typically 70 degrees. Because the mean values are slightly lower than the normal range, it could be beneficial to implement more stretching programs for these athletes. Beneficial techniques would include assisted and unassisted stretches. Unassisted stretches would be the most practical as players could do them on their own time, on or off the field as needed.

Limitations to this study were the participation cooperation put forth by the coaches and athletes, effort put forth by the athlete during testing, and the honesty of the athlete while completing the survey. Limitations could have been improved with greater athlete participation, and encouragement from the coaches as this could be a study that would potentially decrease the risk of injury for their players. Delimitations were sample size, number of schools being tested and surveyed, and testing procedures. Given more time and resources, more universities could have participated, providing a larger population to study as well as more data to correlate. Due to time and participation restrictions, only the dominant arms were tested for data collection.
For future studies, a larger sample size would allow for more data to be analyzed, leading to different results. Because of the sample size of this study, analysis was difficult because there were not enough participants provide sufficient data for valid correlation. For a greater understanding of the effects of volume and fatigue on the dominant shoulder, future studies could include testing the non-dominant arm in addition to the dominant arm for comparison. Because adaptations result from skeletal, muscular, and capsular adaptations, taking a baseline test of ranges of motion and strength when athletes begin their career at a university could assist in keeping these values stable while increasing strength and range of motion if necessary to performance.
Dear [Name],

My name is Laura Carrell, and I am a graduate student pursuing my Master’s of Science in Sports and Fitness Administration. I also obtained my Bachelor of Science degree in Athletic Training and had a great experience learning from and working with the athletic trainers and athletic teams. As a part of my degree, I am completing a thesis study on the correlation between dominant shoulder strength and range of motion and shoulder injuries in Division I athletes. I am writing to request permission to use the student athletes as subjects for the study. The teams I am hoping to test include baseball, volleyball, and men’s and women’s tennis. Upon your approval, the coaching staff of each team will be contacted directly for approval as well. Once the approval of the coaches has been obtained, I will administer Biodex and goniometer testing on the subjects. The student athletes will be informed about the purpose of the study, and if they agree to participate, they will have their dominant shoulder strength assessed using the Biodex and dominant shoulder flexion, extension, internal, and external rotation measured using a goniometer. The testing will take approximately 30 minutes to complete. The raw data will be kept confidential.

Please sign and return this form if your approval is granted. If you have any questions or concerns, please contact me at, or I can come to your office and we can meet and discuss the parameters. The faculty chair member for this thesis study is Dr. Alice
McLaine. Dr. McLaine can be contacted at mclainea@winthrop.edu. Thank you for your consideration.

Sincerely,

Laura Carrell, Researcher

Dr. Alice McLaine, Faculty Chair Member
Appendix B
Winthrop University
Informed Consent Agreement

Researcher: Laura Carroll
☐ Graduate Student  ☐ Undergraduate Student

Faculty Advisor: Dr. Alice McLaine  Faculty Advisor’s Position: Athletic Training Education Program Director

Title of Study: The Correlation Between Dominant Shoulder Strength and Range of Motion and Shoulder Pathologies in Division I Athletes

You are invited to take part in a research study. Before you decide to be a part of this study, you need to understand the risks and benefits. This consent form provides information about the research study. I will be available to answer your questions and provide further explanations. If you take part in this research study, you will be asked to sign this consent form. Your decision to take part in this study is voluntary. You are free to choose whether or not you will take part in the study. If you should decide to participate, you may withdraw from the study at any time.

Purpose of the research study:
To find a relationship between dominant shoulder strength and range of motion (flexibility) and injuries to the shoulder.

Procedures or methods to be used in the study:
Athlete will be asked to sign informed consent form before participation, if they choose to do so. Before participation, athletes will be informed that all information gathered will be voluntary and confidentiality will be assured verbally and in writing. Any data provided to coaches will be in aggregate so that each participant's anonymity will be preserved. They will be told testing will take about 30 minutes and will use injury history and current status as well as Biodex testing for strength and goniometer measurements for range of motion. Biodex testing involves a machine that will put the shoulder through shoulder flexion, extension, internal rotation, and external rotation at fixed speeds that are less than or equal to force used in daily activities or in the athlete’s sport. Speeds conducted at 180 degrees/second and 300 degrees/second will be collected for data. The goniometer measurements will be taken in active range of motion in shoulder flexion, extension, internal rotation, and external rotation, and will not exceed normal limits and no additional pressure will be added to the shoulder to increase range of motion during measurements.

Possible Risks/Benefits Associated with Participating in Study:
Athletes can gain insight to repetitive motions and movements that may be causing injury. The Biodex will require athletes to move through speeds that are less than or equal to speed and force used in daily activity or sport. Speeds used are well-documented in current literature and will be conducted at 180 degrees/second and 300 degrees/second. There are no goniometer risks beyond normal daily activity risks. Patient range of motion will be measured on what they can do actively, and no abnormal positioning or external pressure will be applied.

Possible Costs/Compensation Associated with Participating in Study:
No foreseeable costs
Number of questions in the survey/questionnaire and anticipated time to complete the survey/questionnaire: No survey

Right to withdraw from the study:
You may withdraw from the study at any time without consequence.

Privacy of records or other data collected in the study:
Any data collected in the study and provided to coaches will be aggregated as to preserve the anonymity of the athlete.

Questions – contact information:
If you have any questions about this study, you may contact me using my Winthrop email account: carrell32@winthrop.edu
Or through my faculty advisor:
Address: mclainsa@winthrop.edu
Work Phone: (843) 385-2809 Email: carrell32@winthrop.edu

You may also contact:
Teresa Justice, Director 803-323-2460 justice.t@winthrop.edu
Sponsored Programs and Research
Winthrop University
Rock Hill, SC 29733

Signatures:
By signing this consent agreement, you agree that you have read this informed consent agreement, you understand what is involved, and you agree to take part in this study. You will receive a copy of this consent form.

________________________________________  ______________________________________
Signature of Participant                     Date

________________________________________  ______________________________________
Signature of Researcher                      Date
Appendix C

Survey of Shoulder Injuries

Dear Athlete,

This survey requests information regarding your experience, practice time, and recent shoulder injuries. Please answer every question by encircling the appropriate number (1,2,3…), circling the appropriate response (yes or no), or neatly filling in the blanks. If you are unsure about how to answer a question, please give the best answer you can and make a comment in the margin. ALL OF YOUR ANSWERS WILL BE KEPT CONFIDENTIAL. Please do not fill in your I.D. number.

Please read the definitions below. It is important that you understand how these terms are used in the survey.

DEFINITIONS:

Rotator Cuff Tendinitis: Typically deep shoulder pain involving the rotator cuff muscles supraspinatus, infraspinatus, teres minor, and subscapularis, that presents after activity and slowly progresses to inhibiting activities of daily living. Most common causes are decreased muscle balance between the internal and external rotators, capsular laxity, poor scapular control, and impingement.

Rotator Cuff Impingement: Compression of the acromion process and the humeral head caused by a reduction in the space below the coracoacromial arch.

Glenoid Labrum Tear: Tear in the superior glenoid labrum located near the attachment of the long head of the biceps brachii tendon, as well as compression and inferior traction.

Other

Not Known

Part I: Personal Data

1. Male   Female
2. Year in school: ........................................ Fr So Jr Sr Grad

3. Years of eligibility remaining:........... 1 2 3 4 5

4. Which is your dominant shoulder:..... R L

Athletic Experience

1. Circle the number of years you have been playing your current sport at any level:.......................... 1 2 3 4 5 6 7 8 9 10

2. How many days a week do you participate in organized practice (in season)?............................ 1 2 3 4 5 6 7

3. How many hours a day do you spend in organized practice (excluding warm-up)?...................... 1 2 3 4 5 6+

4. How many minutes do you spend warming up for practice?............................................... 0-5 5-10 10-15 15+

5. Do you stretch your shoulder for practice? Yes No

6. What types of stretching do you do?
   Triceps  Biceps/Pects  Posterior Shoulder

7. How many days per week do you play your current sport outside the school setting?.................... 1 2 3 4 5 6 7

8. How many hours are spent playing your current sport per day outside the school setting?........... 1 2 3 4 5 6+

9. How many times have you injured the R shoulder?..... 0 1 2 3 4 5+

10. How many times have you injured the L shoulder.... 0 1 2 3 4 5+

Part II: INJURIES

Have you experienced one or more shoulder injuries related to your current sport which forced you to seek medical attention from either a Doctor or an Athletic Trainer?

Yes- Please continue the questionnaire
No- You need not answer any more questions. Please return the questionnaire to the athletic trainer.

Injury #1
1. What was the date of your injury? _____(Mo) __________(Yr)
2. Did you have to limit your activity due to this injury?  Yes  No
3. How many days did you limit your activity?..........  ___________(days)
4. What position were you playing at the time of injury?

5. Which shoulder was injured?.....................  Dominant  Non-Dominant
6. Did you see an athletic trainer for your injury?........ Yes  No
7. Did you see a doctor for your injury?...................... Yes  No
8. Did you have surgery for your injury?...................... Yes  No
9. If the answer to question 8 was no, have you been advised that you may need surgery in the future?......................... Yes  No
10. If a Doctor or an Athletic Trainer evaluated the Injury, Please circle one of the following:
    
    Rotator cuff tendinitis
    Rotator cuff impingement
    Biceps tendinitis
    Glenoid labrum tear
    Other
    Not Known

Injury #2
1. What was the date of your injury? _____(Mo) __________(Yr)
2. Did you have to limit your activity due to this injury?  Yes  No
3. How many days did you limit your activity?..........  __________(days)
4. What position were you playing at the time of injury?

5. Which shoulder was injured? Dominant Non-Dominant

6. Did you see an athletic trainer for your injury? Yes No

7. Did you see a doctor for your injury? Yes No

8. Did you have surgery for your injury? Yes No

9. If the answer to question 8 was no, have you been advised that you may need surgery in the future? Yes No

10. If a Doctor or an Athletic Trainer evaluated the Injury, Please circle one of the following:

   Rotator cuff tendinitis

   Rotator cuff impingement

   Biceps tendinitis

   Glenoid labrum tear

   Other

   Not Known

Injury #3
1. What was the date of your injury? (Mo) (Yr)

2. Did you have to limit your activity due to this injury? Yes No

3. How many days did you limit your activity? (days)

4. What position were you playing at the time of injury?

5. Which shoulder was injured? Dominant Non-Dominant

6. Did you see an athletic trainer for your injury? Yes No
7. Did you see a doctor for your injury?......................... Yes  No

8. Did you have surgery for your injury?......................... Yes  No

9. If the answer to question 8 was no, have you been advised that you may need surgery in the future?................................. Yes  No

10. If a Doctor or an Athletic Trainer evaluated the Injury, Please circle one of the following:

    Rotator cuff tendinitis
    Rotator cuff impingement
    Biceps tendinitis
    Glenoid labrum tear
    Other
    Not Known
Appendix D

Debriefing

Thank you for your participation in today’s study. Athletic Trainers are interested in understanding the connection between dominant shoulder strength and range of motion and the presence of a shoulder injury. Some studies have indicated that when there is a greater amount of strength, there is a greater range of motion, but in the presence of injury both strength and range of motion can be decreased. A decrease in strength and range of motion could also lead to further injury of the shoulder. The experiment today gathered data on strength and range of motion amounts which will be analyzed along with the presence of injury or absence of injury.

This study is addressing how strength and/or range of motion could affect the presence of injury in the dominant shoulder in Division I athletes. More specifically, I am investigating if injuries also affect the strength and range of motion variables.

All of the information collected in today’s study will be confidential, and there will be no way of identifying you personally in the data archive. I am not interested in any one individual’s response; I am only looking at the general patterns that appear when data is correlated.

Your participation is appreciated and will help athletic trainers discover more ways of assisting and implementing strength, conditioning, and rehabilitation programs in regards to shoulder injury. I ask that you do not discuss your results with others who are
participating in it, as it could affect their performance and the validity of research conclusions. If you have any questions or concerns, you are welcome to talk with me via email at @carreill2@winthrop.ed, or by phone at (843) 385-2809. If you have any questions about subject’s rights, you may contact the Winthrop University IRB board.

THANK YOU AGAIN FOR YOUR PARTICIPATION
Appendix E

Instrumentation

Figure 1

Biodex System 3 Pro
Appendix F

Figure 2

Standard Goniometer
Appendix G
Winthrop University

Request for Modification of Previously Approved or Exempt Protocol

**Instructions:** Complete this form along with a revised protocol and/or other related documents. Submit an electronic copy to Teresa Justice, Director, Sponsored Programs and Research (justice@winthrop.edu). Your email will serve as your signature.

<table>
<thead>
<tr>
<th>RESEARCHER OF RECORD: Laura Carroll</th>
<th>COLLEGE/DEPARTMENT: PESH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO-RESEARCHERS:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>TITLE OF RESEARCH:</strong> A Correlation Between Strength and Range of Motion of Shoulder Pathology in the Dominant Shoulder of Division I Athletes</td>
<td></td>
</tr>
<tr>
<td><strong>PROTOCOL NUMBER:</strong> IRB14090</td>
<td><strong>DATE OF APPROVAL:</strong></td>
</tr>
<tr>
<td><strong>DATES OF THE RESEARCH PROJECT:</strong> Beginning Date: Fall 2014</td>
<td>Ending Date: Fall 2015</td>
</tr>
</tbody>
</table>

**Type of Modification Request (Check all that apply):**

- [ ] Change in Researcher of Record or Co-Researchers
- [ ] Modification in the data collection surveys, procedures or other methods
- [ ] Modification in subject selection criteria or recruitment methods
- [ ] Modification to the Informed Consent form
- [ ] Modification to the Parental or Guardian Permission for a Minor Child to Participate in a Research Study form
- [ ] Modification to the Assent to Participate in a Research Study form
- [ ] Modification to the scope of the research project
- [ ] Change in the start and/or end dates of the project [You do not need to complete a new protocol if this is your only change.]

Explaination or justification for changes noted above: I am requesting to add a demographic survey to administer to study participants. The survey will be coded and participants will not be able to be individually identified by information. The demographic information I will be obtaining will further my research.

\[Signature of Researcher of Record\]

\[Date\]

**This section to be completed by the IRB Chair**

<table>
<thead>
<tr>
<th>For Expedited and Full Proposals:</th>
<th>For Exempt Proposals:</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Approved]</td>
<td>![Not Approved]</td>
</tr>
<tr>
<td><img src="https://example.com" alt="Validated as continuing to meet the criteria for exempt status." /></td>
<td><img src="https://example.com" alt="Not validated as continuing to meet the criteria for exempt status." /></td>
</tr>
</tbody>
</table>

**Comments/Recommendations:**

\[Comment\]
Note: Do not include personal home address and phone numbers on Informed Consent, Assent, Parental Permission or Debriefing forms. If you are a student, please use your faculty mentor's office address and phone number. As a student, you may show your Winthrop email address as a contact point.
Winthrop University

REQUEST FOR REVIEW OF RESEARCH INVOLVING HUMAN SUBJECTS
Institutional Review Board

| RESEARCHER of RECORD: Laura Carroll |
| PHONE NUMBER: (123) 456-7890 |
| EMAIL: carroll2@winthrop.edu |
| ADDRESS: 123 Main St. |

| CO-RESEARCHERS: |
| FACULTY ADVISOR: McLaine |
| ADDRESS: |

| STATUS: [ ] Faculty or Staff |
| (If a student, complete faculty advisor section) |
| [ ] Graduate Student |
| [ ] Undergraduate Student |

| TITLE OF RESEARCH: A Correlation Between Strength and Range of Motion and Shoulder Pathology in the Dominant Shoulder of Division I Athletes |

| DATES OF THE RESEARCH PROJECT: |
| Approval Requested for Start Date:  |
| [ ] The requested start date should be at least 2 weeks after the next scheduled meeting of the IRB |
| End Date: 12/31/2015 (Maximum of one year; must be renewed annually) |

| IS THIS RESEARCH BEING FUNDED BY RESEARCH GRANT? |
| [ ] YES; Sponsor: |
| [ ] Funding Applied for; Sponsor: |
| [ ] NO |

| [ ] Yes [ ] No In this activity being carried out by student as a classroom assignment to be reviewed by the faculty member. |
| [ ] Yes [ ] No Will the information gathered or developed in this activity be used in a presentation or publication outside of the classroom? |

| IF you checked yes to both questions above, please explain how the information will be used outside of the classroom. The Master's Thesis will be available for the other students to review through the PESH department, presented at a conference, or used in publication. |

| INDICATE THE TYPES OF MEMBERS OF THE RESEARCH TEAM WHO WILL HAVE DIRECT CONTACT WITH HUMAN SUBJECTS: |
| [ ] FACULTY MEMBER |
| [ ] STAFF MEMBER |
| [ ] UNDERGRADUATE STUDENT |
| [ ] GRADUATE STUDENT |
| [ ] OTHER; SPECIFY: |
3. **A. BRIEFLY DESCRIBE THE PURPOSE OF THE RESEARCH IN NON-TECHNICAL LANGUAGE:** Determine if strength and/or range of motion influences shoulder pathologies.

**B. DESCRIBE RESEARCH PROTOCOL OR METHODOLOGY TO BE USED:** Biodex and goniometer testing.

4. **EXPLAIN BRIEFLY BUT COMPLETELY WHAT TASKS OR ACTIVITIES THE SUBJECTS IN THIS RESEARCH WILL BE DOING:** (If a survey/questionnaire is to be used, state how many questions will be asked and the expected time to complete the survey). **Athletes will have dominant shoulder strength tested using the Biodex testing protocol for shoulder. Shoulder flexion, extension, internal rotation, and external rotation strength will be measured.** The Biodex requires the athletes to move through certain motions at a fixed rate of speed, and is a very common assessment in athletic training and physical therapy settings. Goniometer testing will be used to assess range of motion and will be compared to range of motion norms. Athlete will be questioned on shoulder pathologies they are or have experienced while playing at the the collegiate level through a demographic survey that will not reveal their individual identity. The demographic survey will include information that involves gender, age, and injury history.

5. **DESCRIBE SUBJECTS FOR THIS RESEARCH, INCLUDING A STATEMENT OF WHO WILL BE RECRUITED AND THE ANTICIPATED POPULATION SIZE:** Volunteer athletes from a Division I school.

6. **DO YOUR SUBJECTS INCLUDE ANY OF THE FOLLOWING:**
- [ ] Yes [ ] No Infants and children younger than 7 years?
- [ ] Yes [ ] No Institutionalized mentally impaired people?
- [ ] Yes [ ] No Students enrolled in your own classes?
- [ ] Yes [ ] No Students enrolled at Winthrop University?
- [ ] Yes [ ] No Prisoners?
- [ ] Yes [ ] No Other special populations? Specify.

7. **DESCRIBE HOW SUBJECTS WILL BE RECRUITED FOR THIS RESEARCH:** Contact coaches and AD and they contact athletes.

8. **HOW WILL YOU ASSURE THAT PARTICIPATION OF THE SUBJECTS IS VOLUNTARY?** Signed consent form informs them they can drop out of the study at any time.

8a. **CAN THE HUMAN SUBJECT BE DIRECTLY IDENTIFIED BY:** (For any responses of "yes" indicate in the space provided how the subject’s privacy will be protected.)
- [ ] Yes [ ] No Name on Response form;
- [ ] Yes [ ] No Photograph;
- [ ] Yes [ ] No Television/VCR/DVD tapes;
- [ ] Yes [ ] No Audiotape;
- [ ] Yes [ ] No Coded Research Forms;
- [ ] Yes [ ] No Detailed Biographical Data;
- [ ] Yes [ ] No Informed Consent, Assent or Parental Permission forms;
- [ ] Yes [ ] No Other:

8b. **If you checked yes to any item in 8a; then:**
- [ ] Yes [ ] No Will personally identifiable data be shared with others outside of this research team? If you checked yes, please explain.
9. **The Researcher Shall Make Every Possible Attempt to Maintain Confidentiality of the Research and the Human Subjects. If for Some Reason, the Responses, Information, or Observations of the Subject Became Known to Persons Other Than the Researchers, Could This Information Potentially Place the Subject at Risk Of:**

- [ ] Yes  [ ] No  **Damage to His/Her Financial Standing?**
- [ ] Yes  [ ] No  **Damage to His/Her Present or Future Employability?**
- [ ] Yes  [ ] No  **Criminal or Civil Liability?**
- [ ] Yes  [ ] No  **Psychological/Emotional Problems?**

**Explain any “Yes” answers and steps that have been taken to minimize risk:**

---

10. **Are Any of the Techniques Listed Below Involved in the Research?**

- [ ] Yes  [ ] No  **Invasive Medical Procedures?**
- [ ] Yes  [ ] No  **Non-Invasive Medical Procedures?**
- [ ] Yes  [ ] No  **Strenuous Exercise?**
- [ ] Yes  [ ] No  **Other Physical Testing**

**Explain any “Yes” answers and steps that have been taken to minimize risk:** The biodex is a machine that requires the athlete to move through certain motions at a fixed rate to assess strength. A demonstration will be presented prior to testing and if at any time the athlete feels uncomfortable, parameters will be modified or the test can be dropped out of the study. I will be supervised by another certified athletic trainer with prior experience in using the biodex to ensure proper protocol is conducted. I will also be supervised by another certified athletic trainer during goniometer testing to assure measurements are taken accurately.

---

11a. **Describe How Legally Effective Informed Consent Will Be Obtained and Attach a Copy of the Consent Form. If Minors Are to Be Used as Research Subjects, Describe Procedures Used to Gain Consent of Their Parent(s), Guardian(s), or Legal Representative(s).** All athletes are 18 or older and are capable of giving consent.

---

11b. **Waiver of Signed Informed Consent Requirement**

To request a waiver of a signed informed consent, complete the following:

- [ ] The only record linking the subject and the research would be the consent document, and the principal risk will be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject’s wishes will govern. Section 46.117(c)(1)

- [ ] The research presents no more than minimal risk of harm to the subjects, and involves no procedures, for which written consent is normally required outside of the research context. Section 46.117(c)(2)

- [ ] The research or demonstration project is to be conducted by or subject to the approval of state or local government officials and is designed to study, evaluate, or otherwise examine (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under these programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs; and the research could not practically be carried out without the waiver or alteration. Section 46.116(c)

- [ ] The research involves no more than minimal risk to the subjects, the waiver will not adversely affect the rights and welfare of the subjects, the research could not
In cases where the documentation requirement is waived, the IRB may require the investigator to provide subjects with a written statement regarding the research.

12. STORAGE AND DISPOSAL OF DATA AND OTHER RESEARCH MATERIALS:
A. How and where will the data and other research material be stored until no longer needed? **Locked filing cabinet**

B. When will the disposal of data and research materials take place? **5 years**

At a minimum, investigators must maintain research records for at least three (3) years after completion of the research. All records must be accessible for inspection and copying by authorized representatives of the IRB, any federal department or agency supporting the research, and sponsor, if any. (Source: 45 CFR 46.113) If the Principal Investigator is a student, then the faculty advisor will be responsible for the record retention. If you are a member of a professional association or society, you may be required by their practices to keep records longer than 3 years.

C. How will data and research materials be disposed? **Paper shredder**

13. INDICATE ON THE CHECK LIST BELOW, ANY DOCUMENTS THAT APPLY TO YOUR RESEARCH AND ATTACH TO THIS PROTOCOL A COPY OF THE APPLICABLE DOCUMENT.

- [ ] SURVEY INSTRUMENT AND/OR INTERVIEW QUESTIONNAIRE
- [ ] INFORMED CONSENT AGREEMENT
- [ ] PARENTAL OR GUARDIAN PERMISSION FOR A MINOR CHILD TO PARTICIPATE IN A RESEARCH STUDY
- [ ] ASSENT TO PARTICIPATE IN A RESEARCH STUDY (AGES 7-14 YEARS)
- [ ] ASSENT TO PARTICIPATE IN A RESEARCH STUDY (AGES 15 - 17 YEARS)
- [ ] COPIES OF ANY OTHER MAIL TO BE DELIVERED TO RESPONDENTS OR SUBJECTS (E.G. COVER LETTERS,
- [ ] SCRIPTS OF VERBAL INSTRUCTIONS, ETC.

14. □ Yes □ No **DO YOU CONSIDER THIS RESEARCH EXEMPT FROM REVIEW BY THE HUMAN SUBJECTS COMMITTEE? IF YES, PLEASE CHECK THE REASON FOR EXEMPTION FROM THE LIST BELOW.**

a. [ ] Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (a) research on regular and special education instructional strategies; or (b) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods (45 CFR 46.101[a])

b. [ ] Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement) survey procedures, interview procedures or observation of public behavior, unless (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subject at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability or reputation (45 CFR 46.102[a])

Research involving children (subjects that have not attained the age of 18 years) is not exempt under this category unless the research involves only the observation of public behavior and the researchers do not participate or impact the activities being observed (45 CFR 46.101[b])

c. [ ] Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior if (a) the human subjects are educated or appointed public officials or candidates for public office; or (b) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter (45 CFR 46.103)

d. [ ] Research involving the collection study of existing data, documents, records, pathological specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects (45 CFR 46.104)

e. [ ] Research and demonstration projects which are conducted by or subject to the approval of a federal department or agency heads, and which are designed to study, evaluate, or otherwise examine (a) public benefit or service programs
Certifications

By my signature below, I certify that each of the named co-researchers has accepted his/her role in this study. I agree to not begin any research activity on this study until written approval by the IRB has been received. I agree to a continuing exchange of information with the Institutional Review Board (IRB). I agree to obtain IRB approval before making any changes or additions to the project. I will provide progress reports at least annually, or as requested. I agree to report promptly to the IRB all unanticipated problems or serious adverse events involving risk to human subjects. A copy of the informed consent will be given to each subject and the signed original will be retained in my files, unless a waiver of a signed informed consent has been granted.

I further certify that I have successfully completed the following Human Subjects Training Course:
- [ ] CTTI – Biomedical Research Investigator
- [ ] CTTI – Social and Behavioral Research Investigator
- [ ] CTTI – Undergraduate Researcher
- [ ] CTTI – IRB Member

_______________________________
Signature of Researcher

_______________________________
Date

By my signature below, I certify that I have reviewed this research study and agree to counsel the student researcher in all aspects of the research study.

I further certify that I have successfully completed the following Human Subjects Training Course:
- [ ] CTTI – Biomedical Research Investigator
- [ ] CTTI – Social and Behavioral Research Investigator
- [ ] CTTI – IRB Member

_______________________________
Signature (If Student Researcher: Signature of Faculty Advisor)

_______________________________
Date

Approval by Department Chair of Researcher of Record

I have reviewed this research study. I believe the research is sound, that the study design and methods are adequate to achieve the study goals, and that there are appropriate resources (financial and otherwise) available to the researcher. I support the study, and hereby submit it for further review by the IRB.

_______________________________
Signature of Department Head or Dean

_______________________________
Date

Note: Do not use personal home addresses and phone numbers on Informed Consent, Assent, Parental Permission or Debriefing statements.
Winthrop University
Informed Consent Agreement

Researcher: Laura Carroll  ☒Graduate Student ☐Undergraduate Student

Faculty Advisor: Dr. Alice McLaine  Faculty Advisor's Position: Athletic Training Education Program Director

Title of Study: The Correlation Between Dominant Shoulder Strength and Range of Motion and Shoulder Pathologies in Division I Athletes

You are invited to take part in a research study. Before you decide to be a part of this study, you need to understand the risks and benefits. This consent form provides information about the research study. I will be available to answer your questions and provide further explanations. If you take part in this research study, you will be asked to sign this consent form. Your decision to take part in this study is voluntary. You are free to choose whether or not you will take part in the study. If you should decide to participate, you may withdraw from the study at any time.

Purpose of the research study:
To find a relationship between dominant shoulder strength and range of motion (flexibility) and injuries to the shoulder.

Procedures or methods to be used in the study:
Athlete will be asked to sign informed consent form before participation, if they choose to do so. Before participation, athletes will be informed that all information gathered will be voluntary and confidentiality will be assured verbally and in writing. Any data provided to coaches will be in aggregate so that each participant's anonymity will be preserved. They will be told testing will take about 30 minutes and will use injury history and current status as well as Biodex testing for strength and goniometer measurements for range of motion. Biodex testing involves a machine that will put the shoulder through shoulder flexion, extension, internal rotation, and external rotation at fixed speeds that are less than or equal to force used in daily activities or in the athlete's sport. Speeds conducted at 180 degrees/second and 300 degrees/second will be collected for data. The goniometer measurements will be taken in active range of motion in shoulder flexion, extension, internal rotation, and external rotation, and will not exceed normal limits and no additional pressure will be added to the shoulder to increase range of motion during measurements. The participants will also be issued a demographic survey, entailing questions regarding their gender, history playing their specific sport, and injury history. Survey information will be coded and protected during data collection and analysis, and destroyed after thesis study is complete.

Possible Risks/Benefits Associated with Participating in Study:
Athletes can gain insight to repetitive motions and movements that may be causing injury. The Biodex will require athletes to move through speeds that are less than or equal to speed and force used in daily activity or sport. Speeds used are well-documented in current literature and will be conducted at 180 degrees/second and 300 degrees/second. There are no goniometer risks beyond normal daily activity risks. Patient range of motion will be measured on what they can do actively, and no abnormal positioning or external pressure will be applied.
Possible Costs/Compensation Associated with Participating in Study:
No foreseeable costs

Number of questions in the survey/questionnaire and anticipated time to complete the survey/questionnaire: 45 Questions. Time to complete survey is 10-15 minutes, or as needed.

Right to withdraw from the study:
You may withdraw from the study at any time without consequence.

Privacy of records or other data collected in the study:
Any data collected in the study and provided to coaches will be aggregated as to preserve the anonymity of the athlete.

Questions – contact information:
If you have any questions about this study, you may contact me using my Winthrop email account: carrell12@winthrop.edu

Or through my faculty advisor:
Address: mchainea@winthrop.edu
Work Phone: (843) 385-2809  Email: carrell12@winthrop.edu

You may also contact:
Teresa Justice, Director 803-323-2460  justicet@winthrop.edu
Sponsored Programs and Research
Winthrop University
Rock Hill, SC 29733

Signatures:
By signing this consent agreement, you agree that you have read this informed consent agreement, you understand what is involved, and you agree to take part in this study. You will receive a copy of this consent form.

Signature of Participant                         Date

Signature of Researcher                        Date
References


