EFFECT OF A STRENGTH BASED ROTATOR CUFF PROGRAM COMBINED WITH A POSTERIOR GLENO-HUMERAL JOINT CAPSULE STRETCHING PROGRAM ON PITCHING SHOULDER STRENGTH IN COLLEGIATE BASEBALL PLAYERS.

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PROGRAM COMBINED WITH A POSTERIOR

GLENO-HUMERAL JOINT CAPSULE STRETCHING

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COLLEGIATE BASEBALL PLAYERS.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

Pitching is one of the most dynamic and complex activities in sports.[1] It involves an immense amount of stress placed on the throwing shoulder when moving through the range of motion.[1] As a result of these stresses, it is the medical professional and coaching staff's responsibility to condition the athletes in order to reduce the risk of injury.

Two of the major factors that must be considered during throwing are strength and flexibility.[2-5] The extreme range of motion involved in throwing a baseball is necessary to provide an acceleration force. Although this ROM is necessary it has been reported to cause anterior instability leading to shoulder injuries.[1,2,6] In one study it was reported that when compared to the non-throwing shoulder, the pitching shoulder had 9° of greater external rotation and 15° less internal rotation.[7] Decreased internal rotation has been shown to be a major contributing factor to a number of shoulder injuries including labrum tears, rotator cuff tears, and impingement syndrome.[3,5,8,9] This lack of internal rotation must be addressed rather than accepted during the rehabilitation process.

During shoulder rehabilitation the main focus is directed toward the decelerator and dynamic stabilizer muscles of the glenohumeral joint.[2,5,10,11] Recently however, a much broader focus has placed emphasis on the kinetic chain involved in the throwing process, most notably the scapula and its stabilizing muscles.[2,8,9,12-14]

Isokinetic testing of the shoulder internal and external rotators has been reported to be reliable in determining shoulder strength.[15] From this, testing has been incorporated in developing a profile for healthy shoulders and determining possible indicators for injury. The purpose of this study is to examine the effectiveness of a rotator cuff strengthening and posterior capsule stretching program on isokinetic external rotation strength within the throwing shoulder of Division I college baseball pitchers.

Statement of the Problem

Pitching a baseball places a great deal of stress on the shoulder complex.[1] Muscular fatigue along with posterior shoulder tightness has been reported through clinical trials to be a significant factor in the likelihood of a baseball pitcher developing a traumatic injury.[13,16,17] Rotator cuff tears, labrum tears, and impingement syndrome have all been related to a decrease in posterior shoulder strength.[5,18] Researchers have developed an external rotation strength profile for the average baseball pitcher at the high school, college, and professional levels through the use of an isokinetic dynamometer.[19-23] Reduction in these values has been reported in surgical patients,[18] yet this reduction has not been identified as a cause of injuries. Post-surgical rehabilitation programs have been shown to regain strength and flexibility of the shoulder complex, which allows athletes to resume activity at a high level and attempt to prevent injuries from occurring in the future.[4,6,8,13,14]

Prevention of athletic injuries should be a major goal for all athletic trainers, coaches, and athletes. Many times however, this prevention takes place only after an athlete has sustained an injury. Rehabilitation exercises must be examined for their effectiveness in increasing external rotator strength in healthy collegiate baseball pitchers. With this knowledge, athletic trainers are able to implement a preventative shoulder strengthening program in collegiate baseball players.

Purpose of the Study

The purpose of this study is to examine the effectiveness of a rotator cuff strengthening and posterior capsule stretching program on isokinetic external rotation strength within the throwing shoulder of Division I college baseball pitchers.

Hypothesis

The research study was performed in order to determine if a posterior shoulder strengthening and stretching program is effective in improving the isokinetic external rotation strength profile within the throwing shoulder of Division I college baseball pitchers. The study utilized a convenience sampling with a causal-comparative no control design. Isokinetic external rotation strength was determined through the use of a Biodex System 3 Isokinetic Dynamometer (Biodex Medical Systems, Shirley, New York).

Null Hypothesis:

1. There is no difference between the isokinetic external rotation peak torque, external/internal rotation ratio, external rotation/body weight ratio, or average peak torque strength in college baseball pitchers before and after the strengthening/stretching program.
2. There is no difference between the isokinetic external rotation peak torque, external/internal rotation ratio, external rotation/bodyweight ratio, or average peak

torque strength between the freshman/sophomore and junior/senior groups before and after the strengthening/stretching program.

Alternative Hypothesis:

1. There is a difference between the isokinetic external rotation peak torque, external/internal rotation ratio, external rotation/body weight ratio, or average peak torque strength in college baseball pitchers before and after the strengthening/stretching program.
2. There is a difference between the isokinetic external rotation peak torque, external/internal rotation ratio, external rotation/bodyweight ratio, or average peak torque strength between the freshman/sophomore and junior/senior groups before and after the strengthening/stretching program.

Definition of Terms

1. *Average External Rotation Peak Torque* – The greatest average torque produced for a repetition within a set.[24]
2. *External Rotation/Body Weight Ratio* – A ratio displayed as a percentage of the maximum torque production to the subject's body weight.[24]
3. *External Rotation/Internal Rotation Ratio* – A ratio between the agonist and antagonist muscle groups' tested.[24]
4. *External Rotation Peak Torque* – The highest value of torque developed throughout the range of motion.[24]
5. *Fatigue* – Defined by the primary investigator as the point at which the subject felt they could no longer perform the exercise, or the point at which the primary investigator felt the subject was incapable of continuing with proper form.

Limitations

The limitations to this study include the following:

1. Subjects were regularly involved in a lifting program throughout the fall and spring semesters. This however is common for Division I athletes.
2. Biodex testing was not randomized as to which speed the subjects participated in first.

Deliminations

The potential deliminations of this study include the following:

1. The subject population are Division I student athletes and results cannot be generalized to elite or recreational athletes.
2. The subject sample in this research study is from a Division I midwestern university baseball team which does not represent the general population of male athletes among various sports.
3. This research study will utilize a convenience sample with a causal-comparative no control design. Results cannot be generalized to the male athlete population, because there was no random sampling.

Assumptions of the Research Study

The assumptions of this research study include the following:

1. Subjects will answer all questions on the Information and Health History Questionnaire honestly.
2. All subjects will meet the inclusion criteria for this study.
3. Subjects will complete all exercise to the best of their ability.

4. Subjects will be honest with the Certified Athletic Trainer if they experience any discomfort or pain during the course of the strengthening/stretching program.
5. The Biodex System 3 Isokinetic Dynamometer is a valid and reliable instrument for determining external rotation strength.

Summary

The act of pitching a baseball places an immense amount of stress on an athletes' shoulder. Clinical trials have enabled researchers to associate weakness of the external rotator muscles of the shoulder with the occurrence of injuries. Isokinetic profiles have been developed for athletes from the high school to the professional level in order to determine what values should be considered normal. Post surgical rehabilitation uses the idea that with increased strength of the external rotator muscles, individuals can help reduce their chance of sustaining future injuries. Prevention of injuries is a major concern for health professionals. This prevention however, should be stressed before the initial injury. It is the responsibility of athletic trainers, coaches, and athletes themselves to monitor as well as improve the strength of the pitching shoulder, especially the external rotator muscles.

CHAPTER II

LITERATURE REVIEW

REHABILITATION OF THE SHOULDER

Rehabilitation and maintenance of the shoulder can be a difficult and complex process because of the extreme amounts of mobility that exists within the shoulder. Four joints make up the shoulder complex and assist in its function.[25] These joints are the glenohumeral joint, made up by the glenoid of the scapula and head of the humerous, acromioclavicular joint, by the interaction of the acromion and the clavicle, sternoclavicular joint, through the joining of the sternum and the clavicle, and the scapulothoracic joint, by way of the scapula and thoracic vertebrae.[25] Some researchers have identified the importance of these joints working together in a delicate interaction in order for normal shoulder function to occur.[14,26] Through the rehabilitative process it is the goal of the athletic trainer, physical therapist, coaches, and athlete, to develop a proper balance between strength, flexibility, and stability.[3-5] This median between flexibility and stability has been identified as the "throwers' paradox", because of the extreme amount of motion required for pitchers to accelerate their arm, while still maintaining strength and stability.[2] With this in mind, goals have been developed to assist health professionals to obtain optimal flexibility and stability. In one study authors developed 6 basic goals to rehabilitate the injured shoulder: 1.) maintain full motion, 2.) decrease posterior capsule tightness, 3.) increase internal rotation, 4.) lift eccentrically, 5.) gain muscle mass through the deceleration phase of throwing, and 6.) rehabilitate within the functional planes of motion, specifically the scapular plane.[8] Recently, researchers have made additions to these goals which include the treatment of the entire kinetic chain involved in the throwing motion,[14,27] through the use of isolated and combined movement patterns,[14] improving neuromuscular control and proprioception,[3,14] and building stamina within the shoulder to allow for maintained joint position over many repetitions.[4]

Given this, emphasis is placed on the importance of the entire kinetic chain working together during overhead activities. As a result the shoulder has become the focus of many rehabilitative programs. Another component in the kinetic chain is scapular motion. Kibler[12] identified 5 functions of the scapula: 1.) maintenance of the glenohumeral joint, 2.) retraction and protraction, 3.) elevation of the acromion, 4.) serves as a base for muscular attachment, and 5.) acts as a link in the kinetic chain. Through these functions the athlete is allowed to actively throw a baseball. Braun et al.[2] also reported that the scapula is important for its ability to provide a stable platform for the humeral head during rotation and elevation. In line with this concept, it is reported that most scapular dysfunction occurs in the periscapular muscles, most notably the serratus anterior and the lower trapezius.[27] Kibler and Sciascia[13] also reported weakness of the scapular stabilizers to be a contributing factor in shoulder injuries, but identified the levator scapulae and lower trapezius as the major muscles, and that increased scapular protraction plays an important role in external impingement injuries. With this in mind, it is important to strengthen these muscles in order to improve scapular position and obtain a stable scapular platform.[1,8] Exercises identified for improving scapular stability and function include: inferior glides, low rows, hip/trunk control, scapular retraction and depression,[13] protraction,[6] and the “six pack”.[4] The “six pack” includes exercises that target the rotator cuff and scapular musculature, strengthening the muscles involved while utilizing an exercise ball. These strengthening exercises require core and scapular stability while moving the shoulder through each plane of motion.[4]

ISOKINETIC TESTING

Strength characteristics of the throwing shoulder in both baseball pitchers and position players has been examined by numerous researchers, with an isokinetic dynamometer.[7,15,19-23,28-33] Isokinetic dynamometers enable researchers to test strength characteristics for specific motions at specific speeds. Both the Cybex and Biodex brands have been used, and have been shown to be reliable when looking at test-retest results for shoulder internal and external rotation.[15] The bulk of testing has been used to determine bilateral comparisons between non-throwing and throwing shoulder in baseball pitchers.[7,15,19-23,28,31-33] Others have looked at the strength differences between position players and pitchers.[30] External and internal rotator peak torque, external/internal rotator peak torque ratios, and peak torque/body weight ratios have been the major focus of these studies. Although there are discrepancies within the data, results have played a major role in the development of a pitching shoulder profile. Bilateral comparisons of external peak torque have shown no differences between the throwing and non throwing shoulder.[19,20,23,32] Exceptions to these results however were reported by Brown et al.[7] who observed a greater peak torque in the external rotators in the non throwing shoulder.

This difference may be explained by the fact that Brown used the modified neutral position while other researchers tested in a 90°/90° position of shoulder abduction and elbow flexion. Internal rotation has been shown through clinical evidence to be greater on the throwing arm than on the non-throwing arm.[7,20,31] Wilk et al.[23] and Alderink and Kuck[19] however reported these torques to be equal bilaterally. Newsham et al.[32] showed no difference in the external/internal ratios between the throwing arm and the non throwing arm, yet others reported that the ratio was less on the throwing arm.[18,21,23,30,31] Quantitatively the ratio of external rotation to internal rotation has been determined to be between 61% and 70%,[7,23,30,32] and peak torque to body weight ratios have shown to be between 12% and 15%.[19,23] When comparing pitcher to position player the main difference was that pitcher internal rotation peak torque was greater than that of the position players.[7] Lastly, Wilk et al.[23] and Walmsley and Szybbo[22] identified that peak torque and rotational speed of the machine share a negative relationship. This is important when testing isokinetically, to determine if the subject is giving their maximal effort. As evidence by these mixed results it is easy to determine why there are still a number of questions about the strength characteristics of a healthy shoulder. Comparisons between testing is difficult because of the difference in machines, testing speeds, and testing positions.

STRETCHING

Increasing internal rotation and stretching the posterior capsule of the shoulder has been identified as one of the main goals of a shoulder rehabilitation program.[11] Researchers have historically focused on posterior shoulder capsule tightness as one of the main causes or contributing factors to shoulder injuries.[13,16,18,34] In addition, posterior/inferior joint capsule tightness, which is seen commonly with individuals lacking internal rotation, has been a contributing factor for labral tears.[1,35-37] Harryman et al.[16] along with Kibler and Sciascia[13] reported that a tight posterior shoulder results in an anterior/superior translation of the humeral head. This translation has been reported to be a contributing factor to labral tears. Andrews et al.[38] introduced the concept of the "grinding factor", stating that as the humeral head translates during the throwing motion, it can potentially cause labral damage in the stable shoulder. A study examining the range of motion characteristics in the throwing and non-throwing shoulders in pitchers, as well as between pitchers and position players resulted in common characteristics in the throwing shoulder of pitchers. Brown et al.[7] reported bilaterally for pitchers to have: 9° greater external rotation, 5° less flexion, 15° less internal rotation, and 11° less horizontal flexion. Also, when looking at the profiles of pitchers compared to position players they reported that the pitchers had 9° greater external rotation.[7] Magnusson et al.[39] supported these finding showing that pitchers presented with greater external range of motion when compared to age matched controls. With these characteristics in mind internal rotation stretches have been studied for their effectiveness for both acute and long term results in baseball pitchers, most notably the cross-body and sleeper stretch. McClure et al.[40] described the chronic effects of both the sleeper stretch and cross-body stretch on internal rotation when compared to a control. Results of this study showed a significant increase as a result of the cross-body stretch when compared to the control, and an increase with the use of the sleeper stretch, but these results were shown to be insignificant. Laudner[41] also looked at the acute effects of sleeper stretch on internal rotation range of motion, and reported significant increases. From these investigations one can suggest that stretching of the posterior capsule is important, and stretching should be incorporated into a strengthening program in order to obtain maximal results.

BIOMECHANICS AND KINETICS OF THROWING

In order to examine the shoulder and develop a proper evaluation, clinicians must understand the mechanics of throwing a baseball and the stresses being placed on the shoulder. Also, they need to understand at which points in the throwing process most injuries occur. This will allow clinicians a better understanding of the muscle groups they need to focus on for rehabilitation.

Researchers have identified 6 phases that make up the overhand baseball throwing process. These phases include the wind-up, early cocking/stride, late cocking, acceleration, deceleration, and follow through.[1,10,41] The most important of these phases include the late cocking and deceleration phases.[10] During overhand throwing the shoulder is placed under an immense amount of stress, both because of the extreme range of motion involved and also because of the amount of angular velocity that is produced.[10,21,42-46] In order for the acceleration phase to begin the overhand throwing shoulder requires an increased external rotation during the cocking phase.[10] Dillman et al.[42] reported that during the cocking phase, external rotation can reach angles of up to 170°. The angular velocity of internal rotation has been well documented to range from anywhere from 6,000°/sec to 6,940°/second.[10,21,43-46] With speeds this great, it is easy to see why shoulder injuries are common in baseball pitchers. In order to reduce this velocity, the rotator cuff and posterior shoulder muscles must work to slow the shoulder down during the deceleration phase of a pitch. Fleisig et al.[3] reported through electromyography that the rotator cuff produces a compression force of 400N during the deceleration phase, while the shoulder is placed under a total compression force of 1090N. Although these pressures are placed on the rotator cuff and posterior shoulder muscles, Escamilla et al.[47] reported continued mechanics throughout a simulated game involving 105 and 135 pitchers. Instead it was suggested that pitchers compensate with a decrease in forward trunk tilt, velocity, and knee extension when athletes reached the point of fatigue. This confirms the ideas about the open kinetic chain and how important it is to rehabilitate the entire body, rather than focusing solely on the rotator cuff and other muscles involved in scapular rhythm.

SHOULDER INJURIES

In order to function normally the shoulder requires the delicate interaction of the sternoclavicular, acromioclavicular, glenohumeral, and scapulothroacic joints.[26,34] Injuries occur mainly because of one or both of the following: 1.) weakness in the posterior shoulder muscles including the scapular stabilizers, or 2.) tightness of the posterior capsule of the shoulder.[13,16] The rotator cuff of the shoulder provides dynamic stability to the glenohumeral joint during the overhead pitching motion, so injuries to this muscle group is common in baseball players, especially pitchers.[11,14] The rotator cuff as discussed earlier is responsible for decelerating the arm comfortably and safely, dissipating the excess kinetic injury.[42,46] As a result of this action, injuries usually occur through these these muscles contracting eccentrically during the deceleration phase.[10] As muscles fatigue they lose their ability to absorb energy and as a result, injury may occur.[46] These injuries can either be acute or chronic. Most of these injuries are the cause of chronic microtrauma due to muscular fatigue,[17] while acute injuries can occur by overstretching the anterior shoulder.[6] Robinson[17] reported that most trauma involved with the shoulder occurs as a result of fatigue of the supraspinatus muscle, while others concluded that many injuries to the shoulder occur from scapular problems.[8,12]

A common complaint of many pitchers is the feeling of their arm being "dead". Rowe and Zairns[48] examined this complaint and found this "dead arm" feeling to be the result of the pitchers inability to throw with their previous velocity and control because of pain and unease.[48] Many injuries occur due to lack of function within the muscles of the shoulder or muscles within the kinetic chain.

CHAPTER III

METHODOLOGY

SELECTION OF PARTICIPANTS

Participants were recruited from a Division I midwestern university baseball team. The criteria for the subjects to be included in this study were: (1) must be a current NCAA Division I Student Athlete for the Oklahoma State University baseball team; (2) must be actively participating in practice as a pitcher or 2-way player (pitcher and fielder); (3) must not have sustained an injury to the shoulder, elbow, or hand on their throwing arm within the last 12 months which has caused a loss of playing time greater than 1 week, including practices or games; (4) must have undergone a complete physical by the team physician and be cleared to fully participate in all baseball related activities.

RESEARCH DESIGN

The research study utilized a convenience sampling with a causal-comparative no control design. Those individuals who met the inclusion criteria were approached individually, before and after practice, to ask their participation in the study. Individuals were given an informed consent form outlining how the study would be conducted. Subjects were instructed that by signing the informed consent they were agreeing to participate, and that previous information pertaining to their strength training program and isokinetic testing would be made available. Subjects were then given an ID number which they used throughout the remainder of the study. Subjects were asked to honestly fill out an information and health history questionnaire (IHHQ). The questionnaire provided the investigators with information pertaining to the athletes' current health condition and disqualified certain individuals from participating in the study. Subjects who qualified for the study were then given instruction on what would be expected of them throughout the remainder of the study. Qualifying participants were asked to participate in a shoulder strengthening program, 3 days a week, for the remaining 5 weeks of the fall semester, and 2 days a week for 12 weeks during the spring semester. Subjects were also asked to participate in isokinetic testing prior to their departure for winter break, and during the first week of March 2010. Participants were encouraged to fully comply with the instructions of the primary investigator, where failure to comply did not result in punishment.

SUBJECTS

Twelve collegiate baseball pitchers [age = 19.67 ± 1.07 yrs, height = 186.06 ± 5.85 cm, mass = 84.28 ± 8.22 kg] participated in this study. Informed consent along with an information and health history questionnaire was obtained prior to the beginning of the study. There were 6 right-handed pitchers and 6 left-handed pitchers. Two of the participants were 2-way players, 1 right-handed pitcher who also hit right-handed and 1 left-handed pitcher who also hit left-handed. Subjects were assigned an ID at the beginning of the study, which they used when signing in for their strength training program, and also when reporting for isokinetic testing. Demographic information pertaining to the participants in the study was used from the previous Biodex testing administered in September 2009.

INSTRUMENTS

The Biodex System 3 Isokinetic Dynamometer (Biodex Medical Systems, Shirley, New York), was utilized to assess the external rotation peak torque (PT), external rotation peak torque to internal rotation peak torque ratio (ER/IR), external rotation peak torque to body weight ratio (PT/BW), and external rotation average peak torque (AVG), of each participant at speeds of 180°/sec and 300°/sec. This device provides an accurate reading of the subjects' strength characteristics throughout a full range of motion at a specific speed, set by the examiner.[49] Testing with this system was administered in a position with the subject standing next to the machine with his arm in a position of modified neutral.

ISOKINETIC TESTING

Subjects reported to the main athletic training room for isokinetic testing on 2 occasions during the course of this study. Participants were instructed not to lift weight during the day prior to their testing, and to arrive wearing athletic clothing. A 5 minute warm-up period on an upper body ergometer at a pace between 70 and 80 rpm began the testing session. Immediately following the warm-up period, subjects were asked to stand next to the Biodex with their pitching arm in the machine in a modified neutral shoulder position and their elbow flexed to 90°. Although many researchers have used the 90°/90° position because of its similarity to the pitching motion,[19-21,23,28,30-33] Davies[49] reported that the modified neutral was the best and safest position for testing of the shoulder because of the reduced stress on the shoulder. Malerba et al.[15] also used a similar position when determining test-retest reliability, where the subjects' shoulder was in a position of 45° of abduction and 30° of horizontal flexion. Subjects were instructed to stand with the foot pertaining to their throwing arm in a slightly forward position (right foot forward for a right handed pitcher). Data from previous testing were utilized for appropriate isokinetic set-up. Information such as hand and elbow positioning, machine height, and range of motion arch taken from the previous testing, was used in order to maintain similarity between tests. The subjects then received instructions on how testing would be conducted. Once subjects were informed on how testing would take place and what was expected of them, testing began. Each individual began at an angular velocity of 180°/sec and performed 5 sub-maximal repetitions. Testing at 180°/sec consisted of 10 maximal repetitions, followed by a 2 minute rest period. Following the 2 minute rest period, subjects performed 5 sub-maximal repetitions at an angular velocity of 300°/sec, followed immediately by 30 maximal repetitions.

STRENGTHENING/STRETCHING PROGRAM

Throughout the fall each participant underwent a strengthening/stretching program, 3 days a week, developed with the intent to help increase rotator cuff strength, improve scapular stabilization, and maintain core strength. Subjects report to either the main athletic training room or baseball athletic training room for each session. Upon arrival each subject was instructed to write the date next to their identification number, in order to maintain confidentiality. Weight requirements were assigned for each exercise by the primary investigator, and weight increases, throughout the 12 week program, were assigned, based on perceived difficulty of the exercise according to the participant.

Exercises were based on the principle of the scapula being the kinetic chain from the spine to the shoulder. The first day of exercises consisted of 5 exercises which aimed to strengthen the shoulder in the sagittal, coronal, and scapular planes of motion. Also, exercises were intended to help the athlete build core strength through the use of an exercise ball. Day 2 of the exercise program consisted of 7 exercises requiring the athlete to place their scapula in a medial position while moving the shoulder through all 3 planes of motion. The final day consisted of 6 exercises designed to increase proprioceptive abilities within the shoulder of the subjects. Exercises for each day were as follows:

DAY ONE

All exercises for day one were performed on an exercise ball in a position with their legs fully extended and their chest and head in an upright position. Subjects were instructed to maintain this position throughout the entire course of the repetitions. Each exercise for day one was performed for 3 sets of 30 repetitions. Weight was increased according to the perceived ease of the total workout following the session. If the subject was unable to perform 30 repetitions, they were instructed to go to fatigue. Documentation was made of this change. Illustrations of each exercise are depicted in Figures 1, 2, 3, 4a, 4b, and 5.

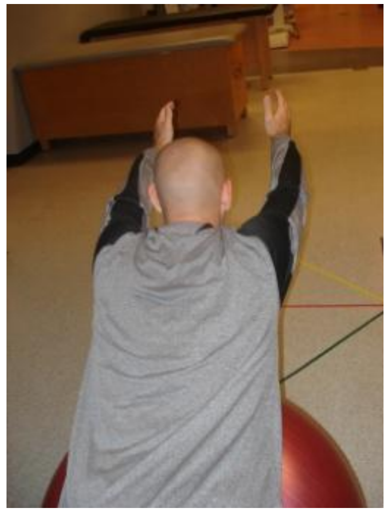

Figure 1: Swiss Ball Exercise “I”

I: Subjects were asked to place their forearm in a neutral position, so that their hands were in a “thumbs-up” position. Subjects then initiated a forward flexion of their shoulder through approximately 180° of motion. When full flexion of the shoulder was performed, a representation of an “I” was noticed.

Figure 2: Swiss Ball Exercise “Y”

Y: The subjects were asked to place their forearm in a neutral position. Subjects then initiated a forward flexion motion in the scapular plane, through approximately 180° of motion. This process gave the representation of a “Y” when the shoulders were in full flexion in the scapular plane, when done correctly.

Figure 3: Swiss Ball Exercise “T”

T: Subjects were instructed to maintain their forearms in a neutral position and move into horizontal extension through the sagittal plane. This motion involves approximately 180° of total shoulder movement, moving from neutral to 90° of horizontal extension and then back to neutral.

Figure 4a: Swiss Ball Exercise “W” Starting Position

Figure 4b: Swiss Ball Exercise “W” End Position

W: The “W” required subjects to maintain their position on the exercise ball while going through 2 separate motions. Subjects pronated their forearms so that the palm of their hands pointed toward their feet. Next, subjects horizontally extended their shoulder with their elbows in 90° of flexion. Once horizontally extended to the end point of range of motion, subjects externally rotated their shoulder, causing the back of their hand to move toward the ceiling. Subjects were then instructed to maintain their horizontally extended position and internally rotate their shoulder to their previous position. Lastly, subjects lowered their shoulders to the beginning position.

Figure 5: Swiss Ball Exercises “M”

M: The forearm was placed in a supinated position. Subjects were instructed to extend their shoulder, toward the ceiling, through the full range of motion. When performed correctly, this exercise gave the representation of the letter “M”.

DAY TWO

Exercises for day 2 were similar to that of day 1. The major difference between day 1 and 2 is that subjects were placed in a position not requiring core strength (i.e. in a prone position on a table). Thera-band® external rotation was performed during day 2 at a rate of 3 sets of fatigue. Fatigue was described as the point when subjects felt that they could no longer actively perform the exercise, or the point where the primary investigator felt that the subjects could no longer externally rotate their shoulder with proper form. Prone “Y”, “T”, and “M” (Figures7,8,9), along with prone row (Figure 10), and side-lying external rotation (Figure 11), were all performed at 3 sets of 30 repetitions. Lastly, protraction of the shoulder began at 3 sets of 10, moving to 3 sets of 30, and then increasing weight as needed.

Figure 6: Thera-band® External Rotation with Bolster

Thera-band® External Rotation: With the subject standing, a bolster was held between the subjects' body and elbow to position the patient in slight shoulder abduction. The subject was then asked to externally rotate the shoulder approximately 115°. This exercise was performed for 3 sets of fatigue.

Figure 7: Prone "Y"

Prone Y: The prone "Y" is an exercise similar to the "Y" on the exercise ball. This exercise was performed with the subjects lying face-down on a table with their throwing arm resting slightly off the table. Subjects then were asked to move their scapula in a medial direction (setting the scapula). While holding this position, subjects were instructed to move their shoulder through forward flexion within the scapular plane, with their forearm in a neutral position. Each repetition required the athlete to set the scapula and maintain this position through forward flexion and to the resting position.

Once the shoulder was back to the resting position subjects released the scapula to a fully resting position.

Figure 8: Prone “T”

Prone T: Maintaining the same process of setting the scapula for each repetition required for the prone “Y”. Prone “T” was performed in the same plane of motion, and shoulder and forearm position, as the exercise ball “T”.

Figure 9: Prone “M”

Prone M: Setting the scapula with each repetition subjects were instructed to move their shoulder through the same motion as that of the exercise ball “M”. Subjects shoulder was moved through extension with the shoulder externally rotated so that the subjects’ palms were pointed downward.

Figure 10: Prone Row

Prone Row: Subjects were prone on the table making sure to “set” the scapula prior to each repetition. Subjects extended their elbow moving towards 90° of flexion. Following this motion the subjects returned their elbow to the original position and released the scapula.

Figure 11: Side-lying External Rotation

Side-lying External Rotation: Subjects were instructed to lie on their non-throwing shoulder with a bolster between their body and elbow of the throwing arm. Starting in this side-lying position, subjects externally rotated their shoulder approximately 115°, making sure to return to their body after each repetition.

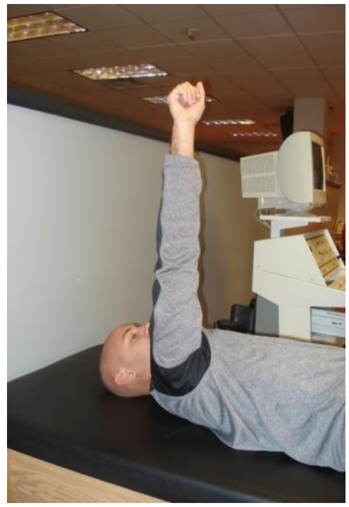

Figure 12: Protraction

Protraction: A supine position was utilized for this exercise. Lying supine on the table subjects were instructed to simulate a punch with their throwing shoulder. Throughout this exercise subjects were instructed to maintain their scapula on the table.

DAY THREE

Day 3 consisted of proprioceptive exercises for the throwing shoulder. Throwing a baseball is a complex motion which requires the athlete transfer energy from their core to the tips of their fingers.[1-3,47] The final session for the strengthening program involved a Body Blade® (Mad Dog Athletics Inc., Venice, CA). According to the manufacturer, the Body Blade® it is a tool designed to enhance strength, balance, coordination, proprioception, power, and core stabilization by working through 3 planes of motion. The Body Blade® works by using inertia, and is a tool commonly used in athletic training rooms. Each exercise with the Body Blade® began with 3 sets of 30 seconds, progressing to 3 sets of 45 seconds, and finally 3 sets of 1 minute. Exercises using the Body Blade® included positions of: 90° shoulder abduction and external rotation/90°

elbow flexion (Figure 13), shoulder neutral/90° elbow flexion (Figure 14), 90° shoulder flexion (Figure 15), 90° shoulder abduction (Figure 16), and a simulated throw (Figure 17a and 17b). Also, on day 3 the subjects participated in an exercise referred to as ABC’s (Figure 18). This exercise was performed 3 times following the Body Blade® workout.

Figure 13: Body Blade®, 90°/90°

90°/90°: This position is one of 90° of shoulder abduction and 90° of elbow flexion, with 90° of shoulder external rotation. In this position, subjects attempted to move the blade in a coronal plane motion (i.e. forward-and-backward).

Figure 14: Body Blade®, Neutral/90°

Neutral/90°: A position with the shoulder next to the subjects' side and elbow flexed to 90°. In this position the subjects attempted to move the blade in a sagittal plane motion (i.e. side-to-side).

Figure 15: Body Blade®, 90° Flexion

90° Flexion: With the shoulder in 90° of flexion and elbow straight, the subjects moved the Body Blade® in the transverse plane (i.e. up-and-down).

Figure 16: Body Blade®, 90° Abduction

90° Abduction: The throwing shoulder of the subjects was placed in 90° of abduction. Subjects were then instructed to move the Body Blade® in a transverse plane (up-and-down).

Figure 17a: Body Blade®, Simulated Throw Starting Position

Figure 17b: Body Blade®, Simulated Throw Ending Position

Simulated Throw: The most difficult of all Body Blade® exercises, the simulated throw required subjects to maintain movement of the Body Blade® while enacting the pitching motion. Many of the subjects struggled to maintain this motion of the Body Blade® while moving their arm in a pitching motion.

Figure 18: ABC's

ABC's: Subjects were instructed to spell out, in capital letters, the entire alphabet from A-Z, on the wall with the use of a ball. Instructions were given for the subjects to maintain a locked, extended elbow and to maintain a position where the hand was in direct line with the shoulder.

Stretching: Following each strengthening session subjects underwent a posterior capsule stretching program for their shoulder. Stretches such as the sleeper stretch (Figure 19), cross-body stretch (Figure 20), Hawkins-Kennedy stretch, and internal and external rotation at 90° of shoulder abduction were utilized to help increase the athletes' internal rotation range of motion. Each subject was stretched by the primary investigator or a student athletic trainer trained in stretching and proper techniques for each stretch. During the first week of the strengthening/stretching program the primary investigator monitored the student athletic trainer's technique.

Figure 19: Sleeper Stretch for Internal Rotation

Figure 20: Cross-body Stretch for Internal Rotation

Conclusion: During winter intersession break no data were collected on any subjects. Subjects in the study were instructed to maintain their strength with similar exercises at home. Subjects were also instructed to perform the sleeper stretch on their own following each exercise session. Once subjects returned to school, following the break, they began their strengthening/stretching program under the supervision of the primary investigator, 2 days a week. Days 1 and 3 were used throughout the second semester until the conclusion of the study at the end of February. Following the study, subjects underwent Biodex testing of their external rotation peak torque, average peak torque, peak torque/body weight ratio, and external/internal rotation ratio at 180°/sec and 300°/sec, following the same protocol. Analysis of the data occurred at the conclusion of all isokinetic testing.

CHAPTER IV

RESULTS

Introduction

The purpose of this study is to examine the effectiveness of a rotator cuff strengthening and posterior capsule stretching program on isokinetic external rotation strength within the throwing shoulder of Division I college baseball pitchers. The null hypothesis was 1.) there is no difference between the isokinetic strength in college baseball pitchers before and after the strengthening/stretching program, and 2.) there is no difference between the isokinetic strength in college baseball pitchers between freshman/sophomore and junior/seniors before and after the strengthening/stretching program. The alternative hypothesis was 1.) there is a difference between the isokinetic strength in college baseball pitchers before and after the strengthening/stretching program, and 2.) there is a difference between the isokinetic strength in college baseball pitchers between freshman/sophomore and junior/seniors before and after the strengthening/stretching program.

Subjects who met the inclusion criteria were asked to sign a consent form and truthfully completed the IHHQ. Isokinetic testing for the shoulder internal and external rotators was performed at 3 different time periods during the course of the study. Between testing sessions participants reported to the training room for rehabilitation 3 times a week during the first 12 weeks and 2 times a week for the second 12 weeks of the study.

Subject Profile and Demographics

Sixteen pitchers and two-way players completed the consent form and the IHHQ. Four subjects were excluded from the study due to sustaining an injury within 12 months prior to the beginning of the study. The remaining 12 participants included 6 right handed pitchers and 6 left handed pitchers [age 19.67 ± 1.07 yrs, height = 186.06 ± 5.85 cm, mass = 84.28 ± 8.22 kg]. Two subjects participated as a pitcher and fielder, while the remaining 10 were pitchers only. Internal rotation range of motion (37.17 ± 8.05°), external rotation range of motion (103.58 ± 9.59°), and total shoulder range of motion (mean = 140.75 ± 10.65°) were also reported. Subject age, height, weight, internal rotation, external rotation, and total range of motion are reported in Table 1.

Table 1. Subject Demographics

Age	Height (cm)	Mass (kg)	IR(°)	ER(°)	Total ROM(°)
19	190.5	92.73	26	114	140
18	177.8	75.00	31	98	129
21	187.96	87.27	45	88	133
18	187.96	69.55	31	100	131
21	177.8	81.36	22	109	131
19	195.58	101.36	40	100	140
20	177.8	80.91	41	119	160
20	190.5	82.27	47	106	153
20	182.88	83.18	46	95	141
21	187.96	82.73	36	102	138
19	190.5	94.09	40	95	135
20	185.42	80.91	41	117	158
19.67	186.06	84.28	37.17	103.58	140.75
1.07	5.85	8.22	8.05	9.59	10.65

Groups Comparisons

Isokinetic testing was performed on 3 separate occasions. The first testing session was completed prior to the beginning of fall baseball practice during the second week of the semester. Second and third sessions were completed 12 and 25 weeks following the first testing session. Data were analyzed with subjects separated into 2 groups based on class rank (freshman/sophomore and junior/senior). Peak torque external rotation, peak torque to body weight ratio, average peak torque, and external to internal rotation ratio were analyzed for differences between speed (180°/sec and 300°/sec) and time (pre-, mid-, and post-season). Mean and standard deviation scores for groups separated by class rank are reported for 180°/sec in Table 2 and 300°/sec in Table 3.

Table 2. Class Rank Comparison 180°/sec

180°/sec	Fresh/Soph		Junior/Senior	
PT ER	Mean (Nm)	S.D.	Mean (Nm)	S.D
pre	23.38	3.93	20.4	4.17
mid	24.72	6.79	26.56	5.6
post	24.48	2.99	24.27	4.26
PT/BW				
pre	12.54	2.82	11.23	2.3
mid	12.76	2.54	14.56	2.74
post	12.98	1.62	13.33	2.08
Avg PT				
pre	20.4	2.72	17.54	3.24
mid	22.26	5.47	23.2	4.57
post	21.76	3.47	21.17	3.31
ER/IR				
pre	50.78	9.94	51.36	12.52
mid	49.18	12.63	55.03	12.09
post	52.46	10.7	55.59	12.16

Table 3. Class Rank Comparison 300°/sec

300°/sec	Fresh/Soph		Junior/Senior	
PT ER	Mean (Nm)	S.D.	Mean (Nm)	S.D
pre	19.84	4.38	16.36	5.73
mid	20.02	6.36	21.30	5.44
post	19.46	4.03	18.44	2.84
PT/BW				
pre	10.54	2.49	8.97	3.11
mid	10.26	3.08	11.69	2.79
post	10.20	1.36	10.13	1.63
Avg PT				
pre	15.90	3.47	12.93	3.96
mid	15.66	4.95	16.90	5.30
post	14.98	2.78	14.77	2.78
ER/IR				
pre	49.10	12.69	44.22	10.00
mid	47.80	18.27	49.53	12.43
post	49.98	12.43	45.90	8.48

Main effect differences between groups (fresh/soph, junior/senior) and speed and time were not significant ($P > .05$). Subsequent tests were performed for groups and strength characteristics between all subjects. Analysis combined groups to speed (180°/sec and 300°/sec) and time (pre-, mid-, post-season). Group comparison means and standard deviations are reported in Table 4.

Table 4. Whole Group Comparison

	180°/sec		300°/sec	
PT ER	Mean (Nm)	SD	Mean (Nm)	SD
Pre	21.64	4.17	17.81	5.30
Mid	25.79	5.90	20.77	5.71
post	24.36	3.63	18.87	3.25
PT/BW				
Pre	11.78	2.50	9.63	2.86
Mid	13.81	2.70	11.09	2.87
post	13.18	1.83	10.16	1.46
Avg PT				
Pre	18.73	3.25	14.17	3.91
Mid	22.81	4.74	16.38	4.96
post	21.42	3.23	14.86	2.65
ER/IR				
Pre	51.12	11.02	46.25	10.93
Mid	52.59	12.12	48.81	14.37
post	54.28	11.17	47.60	9.99

A 2 x 2 x 3 x 4 repeated measures ANOVA was performed for ER PT, PT/BW ratio, avg. PT, and ER/IR ratio to test for significance between speed and time. Significance was set at a level of ($P < .05$).

ER/IR ratio

Significant main effects differences for speed with ER/IR ratio were observed ($P < .02$). Data were collapsed across group and time, and a dependent t-test was performed. Means for 180°/sec (55.66 Nm ± 11.19) and 300°/sec (47.55 Nm ± 11.62) were used for the dependent t-test. ER/IR ratio did not differ within group and time ($t_{35} = .61$, $P < .05$) between the two speeds (180°/sec and 300°/sec). Analysis for the main effects of ER/IR ratio is noted in Table 5. Means and standard deviations for the dependent t-test are reported in Table 6.

Table 5. ER/IR Ratio Main Effects

Speed	F	Sig.
Sphericity Assumed	8.391	.016
Greenhouse-Geisser	8.391	.016
Huynh-Feldt	8.391	.016
Lower-bound	8.391	.016

Table 6. ER/IR Ratio for Dependent T-Test

ER/IR	Mean (Nm)	S.D.
180°/sec	52.66	11.19
300°/sec	47.55	11.62

PT/BW ratio

Significant main effects for speed were found for peak torque to body weight ratio ($P < .001$). Data were collapsed across group and time and a dependent t-test was performed for differences between the 2 testing speeds (180°/sec and 300°/sec). Means for 180°/sec (12.92 Nm ± 2.46) and 300°/sec (10.29 Nm ± 2.49) were used in the t-test. Significant differences were found between the 2 testing speeds ($t_{35} = 305.48$, $P < .05$), with increases in strength values for the slower speed of 180°/sec. Main effect analysis for PT/BW ratio is reported in Table 7. Means and standard deviations for the dependent t-test for PT/BW ratio are reported in Table 8.

Table 7. PT/BW Ratio Main Effects

Speed	F	Sig.
Sphericity Assumed	48.857	< .001
Greenhouse-Geisser	48.857	< .001
Huynh-Feldt	48.857	< .001
Lower-bound	48.857	< .001

Table 8. PT/BW Ratio for Dependent T-Test

PT/BW	Mean (Nm)	S.D.
180°/sec	12.92	2.46
300°/sec	10.29	2.49

Average PT

Average peak torque was shown to have significant main effects for both speed ($P < .001$) and time ($P < .04$). Both group and time were combined and a dependent t-test was performed to test for significance between the 2 testing speeds. Analysis of the 2 speeds ($t_{35} = 12.45$, $P < .05$) resulted in significantly higher values for 180°/sec (20.99 Nm ± 4.08) when compared to 300°/sec (15.14 Nm ± 3.95). A one-way ANOVA was performed to test for significance between the 3 testing times (pre-, mid-, post-season) with the speeds combined into 1 group and the speeds separated into 2 groups (180°/sec and 300°/sec). Results indicated no significant difference between the 3 testing times with groups collapsed for speed ($F_{2,69} = .29$). Analysis of the main effects for speed and time are noted in Table 9 and Table 10 respectively. Means and standard deviation for the dependent t-test are noted in Table 11. One-way ANOVA values are reported in Tables 12, 13, and 14.

Table 9. Average PT Main Effects for Speed

Speed	F	Sig.
Sphericity Assumed	115.217	< .001
Greenhouse-Geisser	115.217	< .001
Huynh-Feldt	115.217	< .001
Lower-bound	115.217	< .001

Table 10. Average PT Main Effects for Time

Time	F	Sig.
Sphericity Assumed	4.476	.025
Greenhouse-Geisser	4.476	.036
Huynh-Feldt	4.476	.025
Lower-bound	4.476	.060

Table 11. Average PT for Dependent T-Test

Avg PT	Mean (Nm)	S.D.
180°/sec	20.99	4.08
300°/sec	15.14	3.95

Table 12. Average PT for One-Way ANOVA

Avg PT	Mean (Nm)	S.D.
Pre	16.45	4.22
Mid	19.60	5.77
Post	18.14	4.43

Table 13. Average PT for One-Way ANOVA at 180°/sec

Avg PT 180°/sec	Mean (Nm)	S.D.
Pre	18.73	3.25
Mid	22.81	4.74
Post	21.42	3.23

Table 14. Average PT for One-Way ANOVA at 300°/sec

Avg PT 300°/sec	Mean (Nm)	S.D.
Pre	14.17	3.91
Mid	16.38	4.96
Post	14.86	2.65

External Rotation PT

Significant main effects were observed when analyzing external rotation peak torque for both speed ($P < .001$) and time ($P < .04$). Both group and time were combined and a dependent t-test was performed to test for significance between the 2 testing speeds. Analysis of the 2 speeds ($t_{35} = 8.54$, $P < .05$) resulted in significantly higher values for 180°/sec (23.93 Nm ± 4.86) when compared to 300°/sec (19.15 Nm ± 4.89). A one-way ANOVA was performed to test for significance between the 3 testing times (pre-, mid-, post-season). Results indicated no significant difference between the 3 testing times with groups collapsed for speed ($F_{2,69} = .34$, $P > .05$). Differences for time were also found to be not significant for groups separated by speed ($P > .05$). Analysis of the main effects for speed and time are reported in Table 15 and Table 16, respectively. Means and standard deviation for the dependent t-test are reported in Table 17. One-way ANOVA means and standard deviations are reported in Tables 18, 19, and 20.

Table 15. External Rotation PT Main Effects for Speed

Speed	F	Sig.
Sphericity Assumed	57.027	< .001
Greenhouse-Geisser	57.027	< .001
Huynh-Feldt	57.027	< .001
Lower-bound	57.027	< .001

Table 16. External Rotation PT Main Effects for Time

Time	F	Sig.
Sphericity Assumed	4.028	.034
Greenhouse-Geisser	4.028	.040
Huynh-Feldt	4.028	.034
Lower-bound	4.028	.073

Table 17. External Rotation PT for Dependent T-Test

ER PT	Mean (Nm)	S.D.
180°/sec	23.93	4.86
300°/sec	19.15	4.89

Table 18. External Rotation PT for One-Way ANOVA

ER PT	Mean (Nm)	S.D.
Pre	19.73	5.06
Mid	23.28	6.23
Post	21.61	4.39

Table 19. External Rotation PT for One-Way ANOVA at 180°/sec

ER PT 180°/sec	Mean (Nm)	S.D.
Pre	21.64	4.17
Mid	25.79	5.9
Post	24.36	3.63

Table 20. External Rotation PT for One-Way ANOVA at 300°/sec

ER PT 300°/sec	Mean (Nm)	S.D.
Pre	17.81	5.3
Mid	20.77	5.71
Post	18.87	3.25

Statistical Conclusion

Both speed and time were analyzed for main effect differences. Groups separated by class rank in 2 groups (fresh/soph and junior/senior) for initial comparisons between speed and time, where non-significance for either variable was observed. The second analysis assessed the entire group for main effect differences for all variables. Significant differences were found for speed at all 4 variables (ER/IR ratio, PT/BW ratio, Avg. PT, and ER PT), while main effect differences for time were found for average peak torque and external rotation peak torque.

Dependent t-tests were performed for each variable to determine differences between testing speeds. Significantly higher strength values were observed at the 180°/sec testing speed when compared to 300°/sec for all variables except ER/IR ratio. One-way ANOVA's were performed for average peak torque and external rotation peak torque, in order to determine if differences between the testing times (pre-, mid-, post-season) occurred. No significant differences were observed between testing sessions for time.

There was a significant difference for both speed and time within the strength characteristics ($P < .05$). Further analysis was performed for speed using dependent t-tests for all strength characteristics. One-way ANOVA's were performed to test for significance between the 3 testing sessions. Significant differences were noted between the 2 testing speeds for all isokinetic strength values except ER/IR ratio. No significant differences were noted between the 3 testing sessions at either speed, or with the speeds combined.

CHAPTER V

CONCLUSION

The focus of this study was to determine if strength gains could be accomplished through a 24 week rotator cuff program in college age pitching shoulders. Through this study it was the goal of the researcher to assist in the development of a preventative rehabilitative program. The alternative hypothesis was that strength gains would be seen after the conclusion of the study. With the information obtained through this study the null hypothesis would be accepted.

DISCUSSION OF FINDINGS

Isokinetic Testing

Mean values for all variables were found to be much lower than previously reported by researches for isokinetic testing.[7,19,22,23,30,32,49] Values from previous research are reported in Table 21.

Table 21. Isokinetic Strength Values from Previous Research

180°/sec	Davies[49]	Wilk et al.[23]	Cook et al.[30]	Alderink and Kuck[19]	Newsham et al.[32]	Brown et al.[7]
ER/IR ratio	66%	65%	70%		67%	67%
PT/BW ratio		15%		12%	18.70%	
Avg. PT						26.25%
ER PT					35%	28.15%
300°/sec						
ER/IR ratio		61%	70%		64%	65%
PT/BW ratio					16.30%	
Avg. PT						21.17%
ER PT					30.4%	22.75%

ER/IR ratio has been reported to be between 65%-70% at 180°/sec and 61%-70% at 300°/sec. These values have been reported for both the Cybex II and Biodex Multi-Joint dynamometers. Ratio's reported at 180°/sec and 300°/sec are 19% and 22% less than previously reported values, respectively, using the lowest percentage reported.

PT/BW ratios have been reported between 12%-18.7%[19,23,32] at the testing speed of 180°/sec and 16.3%[32] at 300°/sec. Although it was reported that PT/BW ratio for 180°/sec (12.92 Nm ± 2.46) falls within the previous range, the 12% value previously reported was seen with the use of the Cybex II isokinetic dynamometer. All values obtained from the Biodex system, also used in this study, were between 15% and 18%. The PT/BW ratio for the faster speed in our study is 37% lower than previously reported.

Average PT values have not been well documented in clinical research. Values that have been reported show average PT to be at 26.25 Nm for 180°/sec and 21.17 Nm for 300°/sec.[7] Values of 20.99 Nm ± 4.08 and 15.14 Nm ± 3.95 were recorded in this study, resulting in 20% and 28% less average PT respectively for the subjects in this study compared to previously reported. Although there are differences previous data was found using the Cybex II dynamometer.[7]

ER PT values of 28.15 Nm[7] and 35.0 Nm[32] at 180°/sec and 22.75 Nm[7] and 30.4 Nm[32] at 300°/sec have previously been reported in clinical studies. The subjects in this study recorded a mean ER PT of 23.93 Nm ± 4.86 and 19.15 Nm ± 4.89 at 180°/sec and 300°/sec respectively. These values are 15% and 16% less than the reported "normal" values for ER PT at 180°/sec and 300°/sec respectively. Higher values in previous research were recorded using the Biodex Multi-Joint dynamometer, while the lower values were recorded on a Cybex II dynamometer.[7,19,23,30,32,49]

The extreme difference between this study and previous research lead to an examination of the methods. Many results are difficult to compare between studies because of differences in testing arm position and the machines used during study. The majority of studies that examine isokinetic shoulder strength place the shoulder in 90° of abduction and 90° of elbow flexion (90°/90°). Although most studies use this position because of its similarity to the position of the arm during an overhead throw, this study used the modified neutral position because this position places less pressure on the superior and inferior aspect of the supraspinatus tendon.[49] Both the Cybex II and the Biodex Multi-Joint dynamometer have been regularly used in research with a trend towards the Biodex resulting in slightly higher values. Neither of these factors seems to be the cause of the discrepancies between studies isokinetic strength values and that of previous research, so other factors must be examined. The isokinetic dynamometer was not calibrated before each testing session. Because of this, care was taken when comparing this study to previous research. Also, the testing speed of 180°/sec was used first for each subject during each testing session. Testing speeds should have been randomized to decrease the chance of a Type II error occurring. Lastly, timing of each session could have resulted in lower values. The subjects in this study are Division I athletes. Although the first testing session took place before the subjects had begun their lifting and throwing programs for fall practice, many of the subjects play baseball during the summer. Depending on the number of innings thrown during the summer and length of time between their last performance and the first testing session, subjects could have developed a degree of fatigue. Previous research has either not stated at what point in the season testing took place, or has taken place early in the pre-season.

Speed and Time

Analysis of the data showed significantly higher strength values for the 180°/sec testing speed when compared to 300°/sec for all variables except ER/IR ratio. These results support previous findings by researchers who have found that as velocity increases, mean peak torque decreases.[19,22,23,32] The majority of these studies have only studied external rotation peak torque. Wilk et al.[23] however determined that PT/BW ratio is also less at higher testing speeds. For this reason, it is difficult to determine whether the findings of this study that ER/IR ratio did not significantly decrease with the increase in testing speed.

Randomization between testing speeds and calibration of the dynamometer was not performed for this study. Because of this, it is difficult to determine the accuracy of the strength values obtain through this study. Also, strength values obtained for this study have been shown to be much less than previous research. Whether this is a determining factor in ER/IR ratio being the only value to not decrease with the increase in speed is difficult to determine. Thirty repetitions were used for the 300°/sec testing speed. Previous studies have tested 10 repetitions.[23] Thirty repetitions were used for this study to mimic the strengthening program. Subjects performed each exercise for 3 sets of 30 repetitions throughout their program. This increased number of repetitions however could have led to this lack of a significant difference.

Class Rank Comparisons

No significant difference was seen between subjects when comparing fresh/soph and junior/senior groups. This finding is in support of previous studies which have shown similar strength values between subjects in high school, college, and professional baseball.[19,20,23] Results indicate that age and class rank are not factors which determine isokinetic strength characteristics.

Testing Sessions

Although there were slight increases in strength between the first, second, and third testing sessions, these values were not significant. These results indicate that the strengthening and stretching program was unsuccessful in increasing the strength of the participants during the course of the study. A number of factors could contribute to these findings. Subjects within the study were involved in a regular lifting program throughout the course of the study. As Division I athletes' subjects were required by the coaching staff to lift on a regular basis with a strength coach. It is unrealistic to expect the subjects to discontinue their routine for the purpose of this study. Testing sessions were scheduled on non-lifting days or before lifting sessions to avoid fatigue, but it is possible that the athletes' strength was decreased during each testing session.

Throughout the strengthening program subjects were somewhat reluctant to participate due to their busy schedules. It was difficult to keep the subjects motivated throughout the entire length of the study. Because of this lack of motivation many subjects did not put forth full effort throughout their rehabilitation sessions and did not progress their lifting weight to the best of their ability. This lack of progression could have contributed to the "leveling off" of their strength. Additionally, it was difficult to monitor every repetition of every set for all of the exercises. Many subjects underwent their program in the training room at times when other athletes were receiving treatment. Because of this, subjects were trusted at times to do every repetition to the best of their ability. With that said, subjects did report for testing session 93% of the time during the first 12 weeks and 96% for the second 12 weeks, excluding the winter break (4 weeks).

Future Research

Most injuries which occur in baseball are a result of repetitive overuse rather than one single incident. This overuse leads to a decrease in strength of the external rotator muscles and eventually failure of the muscle or another structure.[11,14,17,27] Few, if any studies have shown changes that occur in external rotation strength throughout the course of a season. This study did not show an increase or a decrease in isokinetic strength over a 26 week period. It is difficult to state that the strengthening program was not successful due to the lack of knowledge of what is a normal response of the external rotators. It may be that this program actually helped to prevent fatigue which normally occurs. Future studies should identify changes which may occur in isokinetic strength during the course of a season.

This study utilized a different program for each day of rehabilitation throughout the week. Three programs were used in order to give the subjects a variety of exercises and hopefully keep them motivated. Also, this technique mimiced a normal rehabilitation program which would consist of different exercises for each day. Although this program was clinically practical, it is difficult to determine which exercises were effective in increasing shoulder strength. Future research should attention on one set of exercises to determine their effectiveness.

The subjects participated in the strengthening program 3 times a week during the fall and 2 times a week during the spring. With time constraints and the fact that these were healthy subjects, this frequency was deemed to be the best option. Normal rehabilitation program however have been performed 5 days a week historically. In order to make the study clinically applicable, researchers should have subjects participate in the strengthening program 5 days a week.

Concluding Comments

The results of this study indicate that the strengthening program utilized within the study was ineffective in increasing pitching shoulder strength for Division I collegiate pitchers. Although there were no differences for isokinetic strength, the results support previous research which has shown a decrease in isokinetic strength as the testing speed is increased. Differences in strength values were not observed. Future research should determine changes in shoulder strength which occur throughout a season. With this information it can be better determined whether this program was ineffective for increasing strength, or whether it was effective in maintaining strength which may be lost due to overhead throwing. It is important for clinicians to develop preventative rehabilitation program in order to help athletes perform the best of their ability. Through studies such as this one, clinicians can develop programs which may help prevent overuse injuries.

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APPPENDICES

Appendix A

Institutional Review Board Approval

Oklahoma State University Institutional Review Board

Date:	Friday, October 16, 2009
IRB Application No	ED09136
Proposal Title:	Effect of Strength Based Rotator Cuff Program Combined with a Posterior Gleno-Humeral Joint Capsule Stretching Program on Pitching Shoulder Strength in Collegiate Baseball Players
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved   Protocol Expires: 10/15/2010

Principal Investigator(s):

Adam Koch	Douglas Smith
3602 N. Washington, Apt. H6	197 Colvin Center
Stillwater, OK 74075	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Appendix B

Script

Script

Each potential participant will be given a consent form and by the Certified Athletic Trainer for Oklahoma State Baseball prior to the beginning of the test. Each individual athlete as long as the head coach will be asked if they would like to volunteer for this experiment and be informed of the following information:

Exclusionary/inclusionary criteria: All pitchers for the Oklahoma State Baseball Team are eligible to participate in the study as long as they have not had an arm injury in the last 12 months that has caused them to miss playing time.

Time Frame: Subjects will be informed that this is a 24 week study running from October to the end of March. Subjects will be under the primary investigators watch during the time that school is in session, and will be on their own during breaks.

Description of the Study: Subjects will also be informed that this is a study directed at finding how effective a rotator cuff strengthening program combined with a back of the shoulder stretching program is for gaining strength. Subjects will undergo shoulder muscle testing at the beginning of the study to determine their strength. Each testing session should last approximately 15 minutes. Muscle testing will also undergo this test using the same protocol at the 12 week and 24 week marks. The strengthening program will consist of 3 sessions each week during the fall and 2 sessions per week during the spring. Each session will involved a different series of exercises which focus on strengthening the back of the shoulder and rotator cuff, and will end with a back of the shoulder stretch by the primary investigator. Most subjects are expected to struggle with the exercises at the beginning of the study, but are asked to stick with the program because it should get easier. Progression of weight for each exercise will be at the discretion of the primary investigator.

Volunteering: Subjects will be informed that this study is completely on a volunteer basis. No pitchers will undergo any form of punishment or penalty for not participating in the study.

The head coach for the Oklahoma State Baseball Team will be asked to sign a consent form for the use of the information obtained by the Certified Athletic Trainer before the beginning of this study. Initial Biodex testing along with a portion of the strength and stretching program will be taken from the archives of the Certified Athletic Trainer for Oklahoma State Baseball following the signature and authorization from the head coach Frank Anderson.

Okla. State Univ.
IRB
Approved 10/16/09
Expires 10/15/10
IRB# ED0913G

Appendix C

Informed Consent

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
OKLAHOMA STATE UNIVERSITY

Project Title: Effect of a Strength Based Rotator Cuff Program combined with a Posterior Gleno-Humeral Joint Capsule Stretching Program on Pitching Shoulders in Collegiate Baseball Players.

Investigators: Adam Koch, ATC, Graduate Assistant Athletic Trainer
Dr. Doug Smith, PhD, Associate Professor

Purpose:
This study is being conducted through Oklahoma State University. The purpose of this study is to determine if a complete rotator cuff strengthening program combined with a posterior capsule stretching program can increase strength in collegiate baseball pitchers throwing arms.

Procedures:
You will report to the main athletic training room in Gallagher Iba Arena for muscle strength testing during the first week of December and toward the end of February. This will entail standing next to the machine with your arm at your side, in a position which is comfortable. The purpose of this machine is to allow you to move your arm through a full ROM at specific speeds. Before testing begins, a 5 minute warm-up session will be performed on an upper body bike at a speed of 70 to 80 revolutions per minute. After the warm-up session you will go directly to the muscle testing machine for evaluation. Testing will be done at 2 different speeds (180 deg/sec and 300 deg/sec). Prior to each test speed, you will be allowed a practice period which will allow you to adjust to the machine and the speed. Each practice period will consist of (5) repetitions at submaximal effort. The practice protocol will be conducted before each testing speed with a 2 minute rest period between the official test and the next set of practice repetitions. You will then undergo the test which consists of 10 maximal effort repetitions at 180 deg/sec and 30 maximal effort repetitions at 300 deg/sec to determine your strength. Each test will take approximately 30 minutes. During the 12 week strength training program you will undergo a program developed to focus on the rotator cuff and core strengthening. Along with the strengthening programs you will be placed through a stretching program which focuses on the back of the shoulder. At 12 weeks you will undergo another strength testing in order to determine strength. Following this 12 week program you will be on your own for Christmas break when no activities will be recorded. Once you return from Christmas break, you will begin the strengthening and stretching program, but only twice a week. At 24 weeks, you will undergo strength testing for post testing assessment.

Participation in the study will also include the use of historical data relating to the Biodex testing, which you participated in during the first week of September, and the strength/stretching program, which you have been participating in throughout the semester. The strength testing results will be used as a baseline for the testing in December and February. The strength/stretching program which you will undergo will simply be an extension of the program already in place.

Okla. State Univ.
IRB
Approved 10/16/09
Expires 10/15/10
IRB# ED09136

Risks of Participation:
I understand that no exercise is without inherent risks regardless of the care taken. I realize that when participating in muscle strength testing there is a slight risk of injury. The risks associated with this testing may include muscle soreness, muscle strains, and/or sprains. Risks associated with testing will be minimized by proper instruction from the researchers. Personnel administering tests are health care professionals who are medical experts in treating various orthopedic injuries. In case of injury or illness resulting from this study, emergency medical treatment will be available through the Certified Athletic Trainer on site, or through OSU's medical staff located in Gallagher Iba Arena. No funds have been set aside by Oklahoma State University to compensate you in the event of illness or injury.

Benefits:
Identification of whether this strength program along with a posterior capsule stretching program can increase pitching arm strength in collegiate athletes ranging in class rank from freshman to senior. Data taken from this study could potentially be beneficial in preventing orthopedic shoulder injuries in collegiate pitchers. Knowledge of the information obtain through this study could help athletic trainers, coaches, and players to develop strength training programs during the off-season and throughout the regular season.

Confidentiality:
The records of this study will be kept private. Any written results will be discussed as group findings and will not include information that will identify you personally. Subject ID numbers will be assigned to each individual subject, so that records may be kept confidential. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. Records will be maintained in a locked file cabinet in the office of the thesis advisor for up to one year following the conclusion of the study (CRC 197). It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Compensation:
No monetary compensation for your involvement will be provided. Study subjects will receive information regarding the strength and flexibility of their shoulder rotators.

Contacts:
I understand that I may contact the lead investigator or thesis advisor at the following addresses and phone numbers, should I desire to discuss my participation in the study and/or request information about the results of the study:

Adam Koch, ATC
Athletic Complex
Stillwater, OK 74078
(405)334-3971
koc@okstate.edu

Dr. Doug Smith, PhD
CRC 197
Stillwater, OK 74075
(405)744-5500
doug.smith@okstate.edu

If you have questions about the research and your rights as a research volunteer, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

Participant Rights:
I understand that my participation in this research is voluntary, and that there is no penalty for refusal to participate. I also understand that I am free to withdraw and revoke my consent and participation in this research in writing at any time, without penalty.

Signatures:
I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of this form has been given to me.

____________________ _______________

Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

____________________ _______________

Signature of Researcher Date

Appendix D

Information and Health History Questionnaire

Subject Information and Health History Questionnaire

Please answer the following questions to the best of your knowledge. Please place a check in the appropriate box. All information from this questionnaire will be kept confidential.

Subject ID number: _______________

Please indicate the most appropriate answer to the following questions	Yes	No
1. Have you had any injury to your pitching arm which caused you to lose playing time in the last 12 months?		
2. Are you currently on any over the counter medications?		
3. Are you currently taking any supplements on a regular basis?		
4. Do you have any loss of sensation in either arm?		
5. Do you know of or have any medical conditions that might aggravate you during the study?		

Should you become ill and/or incapable of finishing the study, alert the investigator(s) immediately.

VITA

Adam Quinn Koch

Candidate for the Degree of

Master of Science

Thesis: EFFECT OF A STRENGTH BASED ROTATOR CUFF PROGRAM COMBINED WITH A POSTERIOR GLENO-HUMERAL JOINT CAPSULE STRETCHING PROGRAM ON PITCHING SHOULDER STRENGTH IN COLLEGIATE BASEBALL PLAYERS.

Major Field: Health and Human Performance Emphasis in Applied Exercise Science

Biographical:

Personal Data: Mother – Catherine Koch, Father – Jerry Koch, Sister – Jessica Bates.

Education:

Completed the requirements for the Master of Science in Health and Human Performance at Oklahoma State University, Stillwater, Oklahoma in May, 2010.

Completed the requirements for the Bachelor of Science in Athletic Training at Kansas State University, Manhattan, Kansas in 2007.

Completed the requirements for the Associate of Science in Athletic Training at Cloud County Community College, Concordia, Kansas in 2005.

Experience: Graduate Assistant Athletic Trainer for Oklahoma State University's Baseball team, 2 years

Professional Memberships: National Athletic Trainers' Association, Oklahoma Athletic Trainers' Association

Name: Adam Quinn Koch Date of Degree: May, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECT OF A STRENGTH BASED ROTATOR CUFF PROGRAM COMBINED WITH A POSTERIOR GLENO-HUMERAL JOINT CAPSULE STRETCHING PROGRAM ON PITCHING SHOULDER STRENGTH IN COLLEGIATE BASEBALL PLAYERS.

Pages in Study: 58 Candidate for the Degree of Master of Science

Major Field: Health and Human Performance Emphasis in Applied Exercise Science

Scope and Method of Study: The purpose of the study was to determine if a strength based rotator cuff and posterior capsule stretching program influences isokinetic strength in the pitching shoulder of college baseball players. Twelve subjects from a Division I midwestern university baseball team participated in the study. Subjects signed consent forms and completed an IHHQ before participating in the study. Isokinetic testing was completed on a Biodex System 3 dynamometer. Testing included a 5 minute warm-up on an upper body ergometer followed by 10 repetitions at 180°/sec, a 2 minute rest period, and 30 repetitions at 300°/sec. Subjects reported for isokinetic testing at 3 time periods throughout the study (pre-, mid-, post-season). Subjects participated in a strengthening program 3 times per week between the 1st and 2nd testing session, and 2 times per week between the 2nd and 3rd testing session. Exercises included in the strengthening program were intended to improve strength of the rotator cuff, scapular stabilizers, and core stabilizers. Each exercise session was followed by a posterior shoulder capsule stretch.

Findings and Conclusions: Main effect differences were observed for both speed and time. Dependent t-tests revealed significantly higher values for the 180°/sec testing speed compared to 300°/sec for all variables except ER/IR ratio. One-way ANOVA’s for differences in time revealed no significant difference between the 3 testing times. Results of the study indicate that the strengthening and stretching program was unsuccessful in increasing the isokinetic strength in the pitching shoulder. Analysis of data was performed using the statistical program for the social sciences (SPSS) for ER/IR ratio, PT/BW ratio, average PT, and ER PT.

ADVISER’S APPROVAL: Dr. Doug Smith