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Observing Range Of Motion (ROM) In Baseball Athletes During An Off-Season Resistance Training Program And Practice

Jimmy Justin Morin

OBSERVING RANGE OF MOTION (ROM) IN BASEBALL ATHLETES DURING AN OFF-SEASON RESISTANCE TRAINING PROGRAM AND PRACTICE

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Jimmy Justin Morin
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This thesis, submitted by Jimmy Morin in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

John Fitzgerald

Tanis Hastman

Steve Westereng

This thesis is being submitted by the appointed advisory committee as having met all of the requirements of the School of Graduate Studies at the University of North Dakota and is hereby approved.

Wayne Swisher
Dean of the School of Graduate Studies

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ABSTRACT

The purpose of this study was to observe possible changes in ROM of the shoulder and the hip after an off-season resistance training program and practice. The participants engaged in their normal off-season fall ball practice and off-season training regimen. Participants (N=20) were recruited from The University of North Dakota Baseball team. Before the athletes began their off-season training, a pre-test measurement was taken on shoulder Internal Rotation (IR), External Rotation (ER), Horizontal Adduction (HAdd), and hip and knee flexion. Resistance training took place three days a week for twelve weeks, and fall ball practice was four days a week for four weeks within the twelve week period. Following the twelve week off-season post-test measurements were taken to assess any changes. The results indicated that there was no statistical difference in shoulder IR (-.749, p = .463), ER (.067, p = .947), HAdd (1.14, p= .267), and knee flexion (right leg, (.903, p= .378, and left leg, (1.07, p= .300). There was a statistical difference in hip flexion (right, 5.96, p= .000, and left, 4.91, p= .000). There was also a statistical difference between pre- and post-max lifts in the back squat (-6.01, p= .000), deadlift (-7.26, p= .000), and the power clean (-9.37, p= .000). There was, however, no correlation between the strength increases and hip flexion ROM decreases. An off-season strength program does not affect the shoulder, probably due to a decrease in throwing volume. The hip is affected, and flexibility training should be addressed prior to in-season play.

CHAPTER I

THE PROBLEM

Introduction

Shoulder mobility in the overhead athlete has been found to be both excessive (hypermobile) and limited (hypomobile) compared with shoulders not exposed to overhead sports (Borsa, Laudner, & Sauers, 2008). Overhead throwing in baseball requires the coordination of large forces from the lower to the upper extremities generating extreme linear and angular velocities at ball release (Shanley, Thigpen, & Clark, 2012). Throwing athletes are at a high risk for a shoulder joint injury because of the repetitive stress placed on this site during shoulder external rotation, abduction, and horizontal abduction during the throwing motion (Dwelly, Tripp, & Tripp, 2009). These stresses have been postulated to cause chronic degenerative changes in symptomatic and asymptomatic players and cause alterations in passive glenohumeral range of motion (ROM) (Shanley, Thigpen, & Clark, 2012). Studies have shown increased external rotation (ER) and decreased internal rotation (IR) at 90° of abduction in the throwing shoulder, as well as documented decreases in elbow extension and flexion ROM (Reinold, Wilk, & Macrina, 2008). Baseball players will often describe generalized tightness in the musculature of their posterior shoulders and elbow flexors after pitching or increased throwing (Reinold, Wilk, & Macrina, 2008).

Since most baseball players have been playing since they were young children, it is likely that at the collegiate level, most of these athletes will have hyper mobility in there their throwing arm, as well as bony and soft tissue adaptations (Dwelly, Tripp, & Tripp, 2009). Although ROM changes may be adaptive, some changes in ROM are associated with pain, decreased performance, and shoulder disorders (Dwelly, Tripp,

Tripp, 2009). Mechanisms contributing to degenerative injuries observed in the adult baseball athlete are believed to be initiated during the athlete's early playing years (Hurd & Kaufman, 2012). Addressing loss of motion and muscle weakness in an injury prevention program might be an effective strategy for preventing injuries to the throwing extremity in this population (Hurd & Kaufman, 2012).

The sport of baseball is dependent on the physical qualities of power, speed, strength, and local muscular endurance, specifically in the upper extremity (Andrew B. Carter, 2007). Shoulder injuries are frequent due to the required repetitive bouts of high velocity arm movements (Noffal, 2003). The ligamentous restraints about the shoulder complex are moderately sufficient in providing static stabilization; however, dynamic stabilization is required to prevent glenohumeral translation during the overheadthrowing motion (Andrew B. Carter, 2007). In an overhead throw, the internal rotator muscles act concentrically during the acceleration phase, whereas the external rotator muscles act eccentrically during the deceleration phase (Noffal, 2003). Strength and conditioning coaches may implement functional exercises into their training programs (Andrew B. Carter, 2007). It is important to note that in the overhead-throwing motion, the stress is centered on a muscle's capacity to exert its maximal force output in a minimal amount of time (Andrew B. Carter, 2007). The overhead-throwing motion is difficult to reproduce in a gym setting, therefore rehabilitation techniques have been founded in the practice of making the imposed demands during training closely similar to those incurred during athletic competition (Andrew B. Carter, 2007). There are many theories on how to train overhead athletes, such as weight training, chains, medicine ball training, full body workouts, ROM exercises, as well as resistance bands with exercise (McCurdy, Langford, & Ernest, 2009).

An off-season strength and condition program is geared to increase strength and power with heavy resistance training prior to an athletic season (Szymanski, 2001). There are many physiological adaptations that come with heavy resistance training, therefore it is crucial that the resistance-training programs are individualized (e.g., based on individual goals) in order to maximize the outcomes (Kraemer & Ratamess, 2004). The major adaptation that occurs to resistance training is an increase in the crosssectional area of muscle, which is termed hypertrophy (Brooks, Fahey, & Baldwin, 2005). It is the goal of clinicians and coaches to maximize upper extremity strength and power in order to increase performance characteristics while concomitantly decreasing the likelihood of injury (Andrew B. Carter, 2007). Dynamic neuromuscular stabilization of the shoulder is imperative in the prevention of shoulder injury in the overheadthrowing athlete (Andrew B. Carter, 2007). However, it is best to consider the lower extremity as well since research shows that 46.9% of the velocity of the overhand throw could be attributed to the stride and body rotation, whereas 53.1% of the velocity was due to action of the arm (DeRenne, Ho, & Murphy, 2001).

The volume and intensity of the resistance program when coupled with offseason practices, called Fall Ball, can cause extreme stresses to the overhead athletes shoulder joint, as well as the hip joint where most of the power and force with throwing will stem from (Jaffe & Moorman, 2001). Having proper ROM is just as important as strength and power in these athletes (Jaffe & Moorman, 2001). Throwing alone will increase External Rotation (ER) and decrease Internal Rotation (GIRD), whether it is immediately after throwing or over time (Borsa, Laudner, & Sauers, 2008). The flexibility of a joint is affected by its structure, by muscle elasticity and length, and by nervous system activity (Brooks, Fahey, & Baldwin, 2005). Greater fast-twitch muscle fibers in males will make them more susceptible to muscle hypertrophy, which is an adaptation to heavy resistance training (Brooks, Fahey, & Baldwin, 2005). This may decrease ROM in the muscles overtime if flexibility is not improved following exercise gradually and conservatively (Brooks, Fahey, & Baldwin, 2005). Limited evidence exists evaluating the impact of an off-season conditioning program on shoulder and hip ROM. Looking at this is important because it may lead to improving programs for injury prevention in-season. Therefore, the purpose of this study was to examine a collegiate Baseball teams ROM throughout an off-season strength training program, as well as Fall Ball practices.

Variables

Student athletes on the baseball team from the University of North Dakota (UND), a Division IAA National Collegiate Athletic Association, will go through a prescribed resistance training regimen from the strength and conditioning staff at UND for three months, while participating in Fall Ball ran by the coaching staff for the first month. The athletes will log their weight and reps, as well as their lifts on a note card kept in the team weight room. The amount of throws during practice for pitchers, as well as throwing specific drills for position players, will be recorded to help keep track of throwing and running during practice. A standard goniometer was used to measure shoulder and hip ROM.

Hypothesis. Heavy resistance training may increase muscle strength and size, as well as tightness, when tension is at a maximum (Brooks, Fahey, & Baldwin, 2005), and according to Hill and Weldon (2003) when there is increased muscle stiffness due to heavy lifting, the forces transferred to the contractile properties will have a harder time trying to reduce the force. Research also shows that throwing alone will cause ROM deficits throughout daily practice (Reinold, Wilk, & Macrina, 2008). Therefore, we hypothesize that a strength and conditioning program focused on heavy resistance alone, as well as throwing and conditioning in practice, will have detrimental effects on hip and shoulder ROM.

Assumptions. I am assuming that increases in strength and size due to a heavy lifting regimen when coupled with throwing at practice will decrease ROM due to an increase in muscle hypertrophy. I am also assuming that the athletes will not participate in stretching protocols following resistance training and practice, which may not lead to a decrease in hip and shoulder ROM.

Limitations. Because this is an observation study, I am limited in my ability to manipulate any of the independent variables. Injuries may occur which will force me to decrease my participants throughout my study as well. Most of these athletes may have participated in summer leagues, or may have a certain workout regimen or stretching protocol they do for themselves that may alter some data. A pre-participation questionnaire will be given out to record these possible limitations.

Purpose. The purpose of this study was to examine a collegiate Baseball teams ROM throughout an off-season strength training program, as well as Fall Ball practices. This study is significant because it will provide a rare observation into an off-season program and how it will effect performance during the regular season. Decreasing ROM may have detrimental effects on function in sport and this may lead to injury. It is important to observe ROM adaptations in overhead athletes in the off-season, as opposed to in-season and post-season, to further improve the program for in-season injury prevention.

CHAPTER II

REVIEW OF LITERATURE

Introduction

In order to fully understand the importance of sufficient shoulder and hip range of motion (ROM), it is important to gather previous research and studies that have been done in relation to this study. To understand the key elements in this study there are six major areas of focus. The first will review the biomechanics of an overhead throw. The second will discuss how overhead throwing will cause specific physiological adaptations in the shoulder. The third area will briefly describe typical off-season, or Fall Ball, conditions at practice. The fourth will review the importance of strength and power, and how it relates to this sport. The fifth will focus on some physiological effects of resistance training, and how they may interfere with the stages of throwing. The last will discuss the importance of ROM in baseball athletes to fully understand biomechanical factors that may lead to injury.

Biomechanics of an Overhead Throw

Most baseball athletes at the collegiate level have played since they were very small children. As the athletes get older the biomechanics of the overhead throw become more advanced and eventually are mastered due to repetition. It is important to discuss the different stages of throwing and the muscles used in each phase. The three primary phases are the cocking phase, the acceleration phase, and the follow-through (Starkey, Brown, & Ryan, 2010). Within the cocking phase there is maximal external rotation (ER) that occurs in order to prepare for great force generation (Jaffe & Moorman, 2001). The first part of the cocking phase is the wind-up, which will place the glenohumeral (GH) joint in a neutral position. This neutral position creates less stress on the GH joint and places the elbow in a small amount of flexion (Reinold, Wilk, & Macrina, 2008). The concentric force mostly will come from the lower extremity with no eccentric force production present (Starkey, Brown, & Ryan, 2010).

The wind-up when it reaches its full potential will lead into the cocking part of the cocking phase. The GH joint is now at 90 degrees of abduction (Abd) with the maximal amount of ER possible to create a larger force (Jaffe & Moorman, 2001). The scapula is abducted while the serratus anterior holds it to the chest wall, while the rotator cuff musculature maintains a centralized head within the glenoid fossa of the scapula (Jaffe & Moorman, 2001). Stress is now placed on the anterior and inferior GH joint capsule with 90 degrees of elbow flexion and increased valgus forces placed on it (Starkey, Brown, & Ryan, 2010). The ER muscles are concentrically contracted while the internal rotation (IR) muscles are eccentrically contracted (Starkey, Brown, & Ryan, 2010). Throughout the cocking phase the center of gravity is placed over the pivot foot to allow superior balance and coordination prior to the throw (Starkey, Brown, & Ryan, 2010).

The acceleration phase involves a powerful de-rotation of the shoulder in which the muscles contract eccentrically as the shoulder rotates around a fixed point (Jaffe &

Moorman, 2001). The GH joint is moving from an ER position to an IR position at 90 degrees of Abd, while the elbow begins to move from a flexed position to an extended position (Starkey, Brown, & Ryan, 2010). Many muscles are concentrically contracted at this point, including the IR muscles, serratus anterior, the upper trapezius, and the trunk and legs (Starkey, Brown, & Ryan, 2010). The posterior musculature begins to help decelerate the arm by contracting eccentrically, and these muscles include the middle and lower trapezius, the rhomboids, and the ER muscles (Wilkin & Haddock, Isokinetic Strength of Collegiate Baseball Pitchers During a Season, 2006). The center of gravity is moved between the pivot foot and the plant foot to help generate speed caused by the lower extremity (Starkey, Brown, & Ryan, 2010).

Prior to the follow-through phase, there is a deceleration phase that involves a powerful deceleration of the shoulder and arm after ball release (Jaffe & Moorman, 2001). At this point in the throw, the GH joint is in complete IR but still at 90 degrees of Abd. GH stresses are now placed on the posterior joint capsule, along with the posterior musculature, that even causes slight distraction of the GH joint (Starkey, Brown, & Ryan, 2010). The elbow has now gone from 90 degrees to about 20 degrees of flexion as it makes it way to full extension. The eccentric muscle contraction is crucial in the deceleration phase (Wilkin & Haddock, Isokinetic Strength of Collegiate Baseball Pitchers During a Season, 2006). Research has shown that in the eccentric muscle contraction many micro tears as well as rotator cuff and biceps muscle pathologies will occur (Wilkin & Haddock, Isokinetic Strength of Collegiate Baseball Pitchers During a Season, 2006). The biceps brachii and brachialis, specifically, are eccentrically contracted along with the ER muscles to help decrease arm speed (Starkey, Brown, &

Ryan, 2010). IR muscles and a little bit of the triceps brachii concentrically contract to create force, which brings the center of gravity over the plant foot completely (Starkey, Brown, & Ryan, 2010).

The biomechanical process of an overhead throw ends with the follow through phase. At this point the GH joint is horizontally adducted (Add) and in complete IR, with the elbow in complete extension (Starkey, Brown, & Ryan, 2010). IR muscles are being concentrically contracted and ER muscles are still eccentrically contracted, placing stress on the posterior joint capsule (Jaffe & Moorman, 2001). Understanding the biomechanics of an overhead throw can yield information on what may be causing decreases in ROM, causing pain, and can help fix mechanical errors that can decrease chances of injury (Starkey, Brown, & Ryan, 2010). Because stability is not inherent to the glenohumeral joint itself, but rather results from the soft tissues surrounding the joint, the shoulder has much more mobility than other joints in the body (Jaffe & Moorman, 2001). This great mobility places the shoulder at high risk for injury resulting from trauma or overuse (Borsa, Laudner, & Sauers, 2008).

Physiological Adaptations in the Shoulder. Borsa and Laudner (2008) suggest that structural changes in the GH joint capsule, ligaments, glenoid labrum, rotator cuff musculature, and bony adaptations are a cause of long-term exposure to overhead activity. Researchers continue to speculate whether these adaptations compromise shoulder stability, exposing the overhead athlete to shoulder injury (Borsa, Laudner, & Sauers, 2008). Shoulder hypermobility in the thrower is thought to cause excess arm cocking, therefore allowing greater force to be produced upon release (Wilk & Arrigo, 1993). There is a contradiction here, as Wilk & Arrigo (1993) point out, because the GH joint should be hypermobile and loose enough to perform better, yet still be stable enough to prevent subluxation or tears. Humeral retroversion, glenohumeral internal rotation deficit (GIRD), and a gain in shoulder external rotation (ERG) are additional adaptations shown in research (Borsa, Laudner, & Sauers, 2008).

Early reports indicate the retroversion is a normal adaptive remodeling response of the osseous tissue to throwing, which is not pathological, especially at a young age (Borsa, Laudner, & Sauers, 2008). As mentioned earlier, most of these collegiate athletes have been overhead throwing since approximately age four. Evidence exists that the dominant shoulder in throwing athletes exhibits a unique and paradoxical glenohumeral ROM (Crockett, Gross, Wilk, & Schwartz, 2002). Specifically, there is greater ER and a loss of IR when the dominate shoulder is compared to the non-dominant shoulder (Crockett, Gross, Wilk, & Schwartz, 2002). The implication of this altered arc of motion is that a physiologic adaptation of the dominate shoulder through repetitive micro-trauma leads to selective stretching of the anterior capsule and tightening of the posterior capsule, creating a propensity for instability and secondary impingement (Crockett, Gross, Wilk, & Schwartz, 2002). Although retroversion is not painful prior to adolescents, it can become an extreme source of soreness during adolescents while throwing (Wilk & Arrigo, 1993). Baseball, like most other intercollegiate sports experiences, has become a year-round training endeavor, so the possibility of increase risk from retroversion is higher at this level (Carter, Kaminski, & Douex, 2007).

Glenohumeral Internal Rotation Deficit, or GIRD, is a decrease in IR total motion at 90 degrees of Abd. Most research involved with measuring an overhead athlete's range of motion will discuss GIRD because it is present in most of the athletes. It is important to recognize that the difference in IR between the dominant and non-dominant shoulders for both pitchers and non-pitchers with a history of shoulder injury is less than the 20 degree difference in IR, which is a clear definition of GIRD (Scher, Anderson, Weber, & Bajorek, 2010). Dwelly & Tripp (2009) measured a decrease in IR in the dominant shoulder immediately and 24 hours after throwing, compared with prethrowing measurements. Research has shown that shoulder IR, total motion, and elbow extension ROM are significantly reduced immediately after baseball pitching (Reinold, Wilk, & Macrina, 2008). This decrease in ROM continued to be present 24 hours after pitching (Reinold, Wilk, & Macrina, 2008). According to Hurd & Kaufman (2012) the internal rotators are the primary upper limb accelerators during pitching. Repetitive throwing increases strength and causes muscle growth, which may also be a cause of decreased ROM in IR (Hurd & Kaufman, 2012). This would suggest that as strength of the internal rotators increases, demand on the posterior musculature during pitching also increases to counter limb acceleration (Hurd & Kaufman, 2012).

It is believed that the gains in ER are secondary to the demands of throwing. The late cocking phase of throwing requires maximal ER to achieve optimal internal rotation velocity (Dwelly, Tripp, & Tripp, 2009). GIRD is symmetrical to ERG in the dominant arm of the throwing athlete. Because the arm is forcefully propelled forward from maximal ER to IR, a gain in ROM of the ER musculature, specifically the rotator cuff muscles, is necessary to throw a high velocity ball (Hurd & Kaufman, 2012). Overhead throwers also show decreases in horizontal adduction, which contributes to altered rotational ROM patterns that favor increased ER and limited IR ROM (Borsa, Laudner, & Sauers, 2008).

Baseball athletes are exposed to long-term overhead activity; therefore adaptations within the shoulder anatomy are inevitable. As Borsa and Laudner (2008) point out, research needs to continue to investigate whether or not these adaptations lead to injury. The GH joint should be hypermobile and loose enough for overall better performance, yet still be stable enough to prevent any type of injury (Wilk & Arrigo, 1993). Since collegiate Baseball is a year-round sport, the chances of increasing injury from retroversion, GIRD, or ERG become significantly higher (Carter, Kaminski, & Douex, 2007). Whether or not playing year-round is the cause of potential injury is not conclusive in research.

Off-Season Conditions in Practice. The off season typically occurs over the period of 13 weeks, starting in late September and stopping in mid-December for the holidays. The goal of the offseason program is to prepare the players for larger workloads and more baseball-specific training (Szymanski, 2001). General conditioning and speed-endurance training are the types of exercises performed in this phase (Szymanski, 2001). Baseball players may practice throwing more than a hundred times in a single training session and the techniques involved impose multiple constraints on the shoulder joint (Dupuis, Tourny-Chollet, Delarue, & Beuret-Blanquart, 2004). With respect to baseball, this branch of sport requires various techniques of throwing, hitting and catching the ball, all of which depend strongly on shoulder muscles (Dupuis, TournyChollet, Delarue, & Beuret-Blanquart, 2004). The performance demands of a baseball pitching staff differ from those of other team positions in that pitchers play at irregular intervals, from every four days for a starting pitcher to more frequent, short appearances for relief pitchers (Cimino, 1987).

The literature records extensive descriptions of rehabilitation subsequent to specific injuries or to surgical intervention for an athlete's shoulder, but it affords much less information about preventive and off-season conditioning for the throwing athlete (Jaffe & Moorman, 2001). It is important to know what should be applied during offseason training in order to prevent in-season injury. The four essential components of any shoulder rehabilitation program are to 1) restore normal passive and active range of motion, 2) reestablish synchrony of motion, 3) increase strength and endurance in integrated muscle action, and 4) facilitate a progress return to pitching (Jaffe & Moorman, 2001). There may be many differences among professional, collegiate, and high school levels as to how off-season programming should go and what is necessary. However, these four goals, regardless of injury or not, should be maintained during the off-season (Jaffe & Moorman, 2001). I have summarized the essentials to a preventative program that assists in throwing during the off-season.

Restoring and maintaining full ROM is developed during the off-season by synchrony of motion (Jaffe & Moorman, 2001). Emphasis for this goal is on the cocking phase, in which abduction, extension, and external rotation must all occur synchronously (Jaffe & Moorman, 2001). This goal may be accomplished by repetitive motions without ball release. These important drills should focus on achieving the correct motion, which hinges on being in balance and timing movements accurately through execution (Winkin, 2001). Specific drills should also stress pitch location, which according to most coaches is more important than pitch speed (Winkin, 2001). Countless hours and repetitive throws using correct technique is the best way to develop pitch location (Winkin, 2001).

After synchronous motion is established, strength and endurance may be addressed with throwing, coupled with low weight high rep exercises (Jaffe & Moorman, 2001). Velocity is not an important part of the early stage of return to throwing. Proper throwing mechanics as well as accuracy and fluid motion are first achieved with velocity slowly increasing until regular speeds are reached (Jaffe & Moorman, 2001). A longtoss/short-toss program may be implemented at this stage, which will also build shoulder strength and endurance.

Hitting in baseball is often considered the most difficult skill in any sport (Winkin, 2001). Perhaps that is the reason why there are many approaches to teaching this aspect of the game (Winkin, 2001). Whatever the approach, solid hitting is the result of two things, and they should be addressed throughout the of-season program; 1) being quick with the bat and 2) finding a good pitch to hit (Winkin, 2001). Heavy-bat drills, quality contact swings in practice, and at the plate practice will improve both of those results (Winkin, 2001). Defense of drills should also be practiced, such as fielding ground balls, line drives, and fly balls, and then making the correct throw (Winkin, 2001). Drills should include balls being hit directly at the athletes, hit to the glove side, or hit to the throwing arm, all in an attempt to address position-specific skills, relays, and double plays (Winkin, 2001).

The off-season program should involve total-body conditioning and specific shoulder and upper-extremity exercises that accompany throwing biomechanics (Jaffe & Moorman, 2001). Maintaining a good endurance level is also important and may be accomplished with running, swimming, or cycling. Speed training such as accelerations, starts, sprints, and base running drills are introduced to make the speed and endurance training more specific to baseball's movements (Szymanski, 2001). Acceleration drills are completed by jogging, striding, and sprinting for 10-yd intervals over 30 yards. Start drills are performed by players taking their lead-off stance, using the appropriate crossover step, and sprinting for 10 yards. This helps players work on their explosiveness and technique for base stealing or advancing to other bases (Szymanski, 2001). Pitchers typically will run more than position players due to faster intervals of throwing during competition (Cimino, 1987). A lack of emphasis on flexibility is the most common error in most conditioning programs (Jaffe & Moorman, 2001). Performing specific flexibility exercises daily during the off-season may decrease stress placed on it during the season (Jaffe & Moorman, 2001).

In summary, previous research hypothesizes that over the course of an athletic season throwers' dominant shoulders would lose IR and gain ER, leaving the total arc unchanged (Dwelly, Tripp, & Tripp, 2009). One study showed GIRD was less evident during pre-fall than in pre-spring and post-spring seasons (Dwelly, Tripp, & Tripp, 2009). Another study showed that on average, pitchers will display an increase in ER concurrent with a decrease in internal rotation and horizontal adduction in the dominant arm but not in the non-dominant arm between two seasons (Shanley, Thigpen, & Clark, 2012). Pitching, throughout a typical National Collegiate Athletic Association (NCAA) college baseball season, exposes the shoulder muscles to physical stress (Wilkin & Haddock, 2006). This repeated stress on the shoulder muscles may lead to changes in strength over the course of the regular spring season (Wilkin & Haddock, 2006). This may suggest that throwing demands from an off-season program are far less than in-season throwing. In addition, the repeated stresses on the shoulder during the season may produce a subtle loss of flexibility at the end of the season (Jaffe & Moorman, 2001). Thus an off-season program should emphasize regaining the strength and flexibility lost during the regular season while maintaining the overall synchrony of motion needed in the throwing athlete (Jaffe & Moorman, 2001).

Importance of Strength and Power. The sport of baseball is dependent on the physical qualities of power, speed, strength, and local muscular endurance, specifically in the upper extremity (Andrew B. Carter, 2007). Overhead throwing performance requires an intricate balance between the static and dynamic structures of the shoulder in order to maintain functional stability (Dale, Kovaleski, Ogletree, & Heitman, 2007). The throwing motion is a kinetic chain event that involves the neuromuscular coordination and sequencing of body segments that result in the transfer of energy from the lower extremities to the hips, pelvis, trunk, shoulder girdle, arm, hand, and finally, the ball (Anloague, Spees, Smith, & Herbenick, 2012). Muscular Strength is the amount of force that a muscle can produce with a single maximum effort (Brooks, Fahey, & Baldwin, 2005). Power, related to strength, is defined as the ability to perform work rapidly (Work= Force x Distance) (Brooks, Fahey, & Baldwin, 2005). In most activities, such as throwing a baseball, power is much more important than strength (Brooks, Fahey, & Baldwin, 2005).

Research suggests that there are strong relationships between strength and power measures and overhead throwing force production, suggesting that to some extent, strength and power qualities influence performance in an overhead throw (Kraemer & Ratamess, 2004). Most athletes engage in some type of strength training program at their school. Strength training is a way to build lean muscle without fat gain, which can cause a disability in overall strength. Aside from increasing strength and power, strength training is recommended as the intervention of choice for the prevention of injury and treatment of a previous injured body part (Hanson, Srivitsan, Agraual, & Mauan, 2009), which should be the main focus in the off-season program.

Research shows that several of the performance variables related to overhead throwing performance emphasize the anaerobic energy systems (Ebben, Hintz, & Simenz, 2005). Approximately 80% of the energy is supplied by the ATP-PC system, 15% by glycolysis, and 5% from oxidative phosphorylation (aerobically) (Szymanski, 2001). In the past coaches of overhead athletes were skeptic with the recommendation of weight training for fear that it will decrease flexibility and negatively affect the performance of the athletes (Ebben, Hintz, & Simenz, 2005). However, evidence suggests that baseball players who participated in a short-term strength training program had less chances of a shoulder injury than a control group at 24, 48, and 72 hours after a throwing session (McCurdy, Langfird, & Ernest, 2009). Free-weight dynamic constant external resistance is the most common type of strength training used for athletic conditioning (McCurdy, Langfird, & Ernest, 2009). An advantage of free-weight training is the requirement to stabilize the unsupported resistance (McCurdy, Langfird, & Ernest, 2009). The unstable load provides a neuromuscular stimulus for strength improvement that is widely accepted to be most specific to forces required for improved athletic performance (McCurdy, Langfird, & Ernest, 2009).

An overhead throw, especially in pitchers, depends on leg power to help aid in a high velocity thrown ball (Ebben, Hintz, & Simenz, 2005). Several reports indicate that leg power explains a larger portion of the variation within physical function performance than leg strength does (Bean, Leveille, Kiely, & Bandinelli, 2003). Improvements in strength, power, and body composition as a result of strength training will predict improvements in specific tasks related to physical function in the overhead athlete (Ebben, Hintz, & Simenz, 2005). More specifically, anaerobic power in the lower body as well as the upper extremities is a high contributor to pitching performance (Ebben, Hintz, & Simenz, 2005). The ability to have power, as well as strength, allows for the forceful nature of an overhead throw (Ebben, Hintz, & Simenz, 2005).

In an off-season program, strength and power development are targeted 4-5 days per week (Ebben, Hintz, & Simenz, 2005). Research shows that there are five important exercises worked on to increase strength and power (Ebben, Hintz, & Simenz, 2005). These include the back squat, the lunge, the lat-pull down, the dumbbell row, and lastly exercises that target the rotator cuff musculature (Ebben, Hintz, & Simenz, 2005). Increasing strength and power prior to preseason may reduce pain associated with throwing and may reduce in-season injuries with baseball players (Ebben, Hintz, & Simenz, 2005).

Importance of Range of Motion (ROM). Several factors appear to be involved in throwing, including speed of movement, strength, muscular endurance, neuromuscular adaptation, and flexibility of specific body areas to perform a skilled act such as throwing (Logan, McKinney, & Rowe, 1966). A lack of emphasis on flexibility is the most common error in most conditioning programs, and an overhead thrower relies heavily on flexibility, in both their upper extremity and lower extremity (Ebben, Hintz, & Simenz, 2005). The throwing motion is very complex and involves an elaborate transfer of energy throughout the entire body (Scher, Anderson, Weber, & Bajorek, 2010). Thus, large forces are not restricted to the shoulder alone but rather are imparted across all the anatomical joints involved in the throwing motion (Scher, Anderson, Weber, & Bajorek, 2010).

Forces at the shoulder may be greater in an athlete who is compensating for injuries or ROM restrictions at joints some distance from the shoulder (e.g., lower back, hip, ankle) (Scher, Anderson, Weber, & Bajorek, 2010). According to Hurd & Kaufman (2012), addressing loss of motion and muscle weakness in injury prevention programs might be an effective strategy for preventing injuries to the throwing extremity in this population. Kaplan & ElAttrache (2011) discuss peak changes in ROM being seen at ages 11 to 13 years old. It would thus appear that overhead throwing during years of rapid growth has the greatest potential to affect vulnerable tissues, including humeral head orientation and capsular laxity, which both have the potential to contribute to alterations in ROM (Kaplan, ElAttrache, Jobe, & Morrey, 2011). ROM is also affected by the athletes desire to push through certain injuries (Scher, Anderson, Weber, & Bajorek, 2010).

Reinold & Wilk (2008) introduced the concept of total motion in the shoulder. Total motion is the total value of ER plus IR ROM (at 90° of abduction). Significant reduction in the amount of shoulder IR, total motion, and elbow extension ROM was found immediately after pitching (Reinold, Wilk, & Macrina, 2008). Although ROM was beginning to show a trend toward returning to baseline values, this significantly altered motion was still present 24 hours after pitching (Reinold, Wilk, & Macrina, 2008). Although an acute decrease in ROM may be a normal physiological response, due to the inflammatory response, baseball pitchers may be more susceptible to shoulder injury if they continue to pitch with decreased IR and total motion (Reinold, Wilk, & Macrina, 2008). Many research studies show that overhead throwers increase ER and decrease IR throughout a season (Reinold, Wilk, & Macrina, 2008).

Lower extremity ROM is also crucial to prevent injury in the upper extremity and to deliver a forceful throw (Scher, Anderson, Weber, & Bajorek, 2010). Upper extremity injuries were responsible for 75% of the total time lost because of injury in a collegiate baseball population, with rotator cuff tendinitis cited as the most frequent injury (Scher, Anderson, Weber, & Bajorek, 2010). Scher & Anderson (2010) did a study that found a lack of IR in the non-dominant hip may transfer some of the demands of decelerating the body from the hip to the shoulder, thereby dissipating less force through the trunk and increasing forces at the shoulder. As an individual pitcher throws faster the pelvis and upper torso angular velocities increase, as well as the Trunk Forward Tilt, or TFT (Anloague, Spees, Smith, & Herbenick, 2012). Functionally, the ability to bend forward at the trunk can be related to hamstring flexibility and trunk mobility (Anloague, Spees, Smith, & Herbenick, 2012). Anloague & Spees (2012) found a direct relationship between dominant arm rotational range of motion and the sit-and-reach test.
This test may identify an overhead thrower’s potential for TFT to maximize the lag effect necessary to achieve maximum ER of the dominant arm and increased ball velocity (Anloague, Spees, Smith, & Herbenick, 2012).

Hamstring and hip flexibility can possibly maximize the shoulders ability to reach complete ER through a longer stride length, or dominant leg extension, causing a rapid ER to IR transition in a pitchers throwing motion (Anloague, Spees, Smith, & Herbenick, 2012). In contrast, a decrease in hip ROM will cause the thrower to increase their shoulder ER to compensate (Anloague, Spees, Smith, & Herbenick, 2012). This increased ER at the shoulder may increase soft-tissue forces and predispose the overhead thrower to shoulder injury (Anloague, Spees, Smith, & Herbenick, 2012).

Shanley and Thigpin (2012) found that the differences in rotational ROM measures found between studies done may be due to the differences in competition level, presence of a formal stretching program, timing of exposure, positions played, skeletal maturity, cohort demographics, measurement and stabilization methods, timing of data collection (preseason vs. preseason to postseason) and relatively small samples in each study. The nature of baseball causes for the repeated stresses on the shoulder during the season, producing a subtle loss of flexibility at the end of the season (Jaffe & Moorman, 2001).

Summary. The ability of throwing the ball faster is not only important for baseball pitchers, but is also important for position players to execute successful defense (DeRenne, Ho, & Murphy, 2001). The glenohumeral joint itself is inherently unstable, losing stability at the expense of mobility (Carter, Kaminski, & Douex, 2007). Decreased stability, in turn, can lead to subluxation, secondary impingement, and rotator cuff and labral tears (Carter, Kaminski, & Douex, 2007). Pitchers with increased retroversion would likely reach greater ER during late cocking, allowing for greater ROM in the acceleration phase and greater ball velocity; however, this would place greater eccentric stress on the posterior shoulder (Shanley, Thigpen, & Clark, 2012). Overhead throwers who presented with GIRD tended to present with decreased humeral abduction (HAbd) and greater dominant shoulder humeral retrotorsion compared with those who did not present with GIRD (Shanley, Thigpen, & Clark, 2012). Although ROM increases in ER and decreases in IR are an adaptive response to repetitive throwing, some changes in ROM are associated with pain, decreased performance, and shoulder disorders (Dwelly, Tripp, & Tripp, 2009).

Overhead throwing athletes who participated in a short-term strength training program had less shoulder pain than an athletes who did not at 24, 48, and 72 hours after a throwing session (McCurdy, Langfird, & Ernest, 2009). Specifically exercising the lower extremity with the upper extremity allows for overall better performance (DeRenne, Ho, & Murphy, 2001). Therefore, resistance-training programs for overhead throwing athletes to improve throwing velocity, particularly for pitchers, should be designed to include arm, trunk, and lower body exercises (DeRenne, Ho, & Murphy, 2001). Flexibility should be primarily focused on hip mobility and the dynamic flexibility (Rotator cuff) of the shoulder for overhead athletes (Ebben, Hintz, & Simenz, 2005). Longer durations of dynamic stretching and activity seem to provide a positive response to the neuromuscular system enhancing performance (Ebben, Hintz, & Simenz, 2005). It appears that all individuals should include static stretching in their overall fitness and wellness activities for the health and functional benefits associated with increased ROM and musculotendinous compliance (Ebben, Hintz, & Simenz, 2005). Areas requiring improved flexibility are the shoulder, particularly the posterior capsule and rotator cuff, the dominant hip flexors, the non-dominant hip internal and external rotators, and the dominant latissimus dorsi (for its connection directly from the pelvis to the arm) (Scher, Anderson, Weber, & Bajorek, 2010).

Our study was used to show possible outcomes with ROM if stretching is ignored when heavy resistance training and throwing are done. It is evident that ROM will decrease with normal throwing as a normal adaptation to the repetitiveness of the sport (Reinold, Wilk, & Macrina, 2008). Increasing strength and power causes physiological adaptations that may also decrease ROM (Brooks, Fahey, & Baldwin, 2005). Literature has not specifically looked at an off-season strength program and practice, and how that alone may affect ROM prior to in-season play. It is important to address ROM losses and implement exercises and preventative programs that are specifically aimed at decreasing injury. Baseball athletes cannot allow their ROM to become problematic, especially if they are hoping to have long and healthy careers.

CHAPTER III

METHODS

Experimental Approach to the Problem

An observational study design was utilized to evaluate an off-season strength and conditioning program, as well as off-season practice, and its effects on range of motion in overhead athletes. An off-season program is primarily for strength and power gains. Heavy workloads in the gym coupled with overhead throwing may be detrimental to shoulder and hip range of motion. Range of Motion (ROM), or the degree in which a joint can be moved to the endpoints in range of motion, is being measured using a standard goniometer. The Goniometer is a device that measures "passive" ROM, or static flexibility. Passive ROM goniometry assessment has been shown to be the gold standard and reliable when performed by the same tester (Scher, Anderson, Weber, & Bajorek, 2010). Therefore, the participants will be passively moved with no muscle contraction to assess ROM. With a single examiner using this method, a rotational measurement error of +/- 3 degrees has been reported (Scher, Anderson, Weber, & Bajorek, 2010).

Participants

Thirty-five college-aged men who attend the University of North Dakota and play on the Baseball team were recruited for this study. Four participants quit the team, four were excluded due to injury prior to testing, and seven did not want to participate, leaving a total of twenty participants. Twelve are pitchers and eight are position players. The participants have been a part of an organized athletic experience for an average of twelve years. The participants have been engaged in a strength and conditioning program for an average of four years. Informed written consent was obtained after the procedures and any possible risks associated with this study were explained in detail. The team consists of players ranging from ages 18 to 23, with the average age being 20.7. All participants were in good health with no signs of musculoskeletal injuries. Exclusion criteria consisted of any previous medical condition that may hinder participation in practice and the lifting program as well as exclusion from the team. The descriptive characteristics for the participants are presented in Table 1.

Table 1. Descriptive characteristics (n=20)

	Mean+/- SD	Min-Max
Age (years)	20.7 +/- 1.38	18-23
Height (in.)	73.35 =+/- 2.73	69-78
Weight (lbs.)	205.35 +/- 22.06	185-255
AEx. (years)	12 +/- 1.78	10-13

Note. AEx indicates athletic experience in Baseball.

General Protocol Design. Each participant attended two data collection sessions, the pre-test and the post-test. Each person completed all of the lifting sessions, practice sessions, and the two test days. About one week was taken to familiarize each participant with the type of lifts that took place in the gym and to cover overall practice conditions and drills that would be performed. The off-season lifting program is a total of twelve weeks, with lifting sessions three days a week. Fall Ball practice is a total of four weeks with practices four days per week within the twelve weeks of the off-season. The athletes were told to not train outside of the UND strength program other than any necessary rehabilitation for maintenance. The workouts provided were designed to add strength and power to their full body. The pre-test was taken the week prior to the first session of lifting and practice. The post-test followed the conclusion of the twelve week strength and conditioning program. All of the workouts were done in the strength and conditioning training facility. Practice sessions were done at a local baseball field where the team plays their home games. All of the ROM tests were taken place in the Division of Sports Medicine Athletic Training Room.

Procedure: Tests. Participant's height, weight, age, position in baseball, years of experience, and previous medical history will be recorded. A questionnaire was also be given to assess summer participation in baseball related activity or strength and conditioning activity. The pre-test of ROM measurements were done early in the morning to exclude any possible blood flow allowing more degrees of motion. A measurement of the shoulder joint, called the glenoid-humeral joint, was taken in three different motions: internal rotation, external rotation, and humeral horizontal adduction, all done at 90 degrees of abduction in the coronal plane and 90 degrees of elbow flexion with the elbow slightly off the table's edge (Scher, Anderson, Weber, & Bajorek, 2010). Hip flexion measurements were taken using the same goniometer with the axis on the joint line of the lateral knee, the stable arm in line with the lateral thigh, and the movable arm along the midline of the fibula (Scher, Anderson, Weber, & Bajorek, 2010).

Measurements were taken only when the back remained on the table (Scher, Anderson, Weber, & Bajorek, 2010). Finally, knee flexion was measured to assess quadriceps ROM. ER and IR are widely assessed for ROM in overhead athletes (Anloague, Spees, Smith, & Herbenick, 2012), as well as horizontal Adduction (HAdd) due to posterior muscle tightening from repetitive throwing (Carter, Kaminski, & Douex, 2007).

Goniometry is the widely used to measure joint ROM and can be done either actively or passively, however for this study it is done passively. By passively moving the joint, it makes it easier for the tester to take measurements without any help, and allows the tester to look for compensation of the muscles surrounding the joint. When taking measurements, the Goniometer is generally placed along the lateral surface of the extremity (lateral thigh for the lower extremities, lateral forearm for the upper extremities). The 0 indicates the starting position and is identical to the standard anatomical position. The Goniometer ranges from 0-180 degrees of motion and has two arms. The stationary arm is placed parallel with the longitudinal axis of the fixed reference part, while the movable arm is placed on the longitudinal axis of the movable segment. Figure 1. in appendix A. shows a Goniometer. Table 2 shows the normal available range of motion for the motions measured in this study.

Table 2: Normal Range of Motion measurements. (Prentice, 2011)

Joint	**Action**	**Degrees of Motion**
Shoulder	Internal Rotation	90
	External Rotation	90
	Horizontal Adduction	40
Hip	Flexion	125
Knee	Flexion	140

Procedures: Strength Program. Tracking cards were used to assess strength gains in the strength and conditioning program, with every four weeks consisting of different phases of training. The team met early evenings following practice for the first four weeks on Monday, Wednesday, and Friday for strength training, with Tuesday and Thursdays used for condition and speed work. The conditioning and speed work varied week to week. An example of the card for each phase is shown in Appendix A, figure 3. The sessions lasted between sixty and ninety minutes. Both pitchers and position players performed the same workouts each week.

There were three phases that followed a high volume training session that lasted two weeks. These two weeks were used to introduce training into individuals who may have been out of shape from the summer. Weeks one through four (Phase I) consisted of a power cleaning program, back squat, and deadlift as core lifts every Monday. The lifts were supplemented with 1 arm rows, front squats with a reverse lunge, and abdominal work. Wednesday lifts consisted of a dumbbell neutral grip bench press with plyometric pushups, weighted chin ups, and Bulgarian split squats paired with a row. Abdominal work followed after these core lifts. Friday workouts consisted of a power clean progression, front squat, chest supinated row, and a barbell overhead press as the core lifts. Romanian deadlift was paired with the overhead presses and abdominal work concluded the lift.

Weeks five through eight (Phase II) had Monday workouts consisting of power cleans, back squats paired with plyometric jumps, and Bulgarian split squats paired with a row and overhead press. Wednesday workouts consisted of lateral medicine ball toss, plyometric pushups, deadlifts, and bench press paired with supinated rows. Friday workouts consisted of power cleans, front squats paired with bench jumps, and pull-ups paired with single legged Romanian deadlifts.

Weeks nine through twelve (Phase III) Monday workouts consisted of power cleans, back squats, and push presses paired with rows and side planks. Wednesday lifts consisted of medicine ball shot puts, deadlifts, dumbbell incline press paired with plyometric pushups, and supinated bent rows. Friday workouts were power cleans, front squats, box jumps, and pistol squats paired with pull-ups.

Procedures: Field Practice. Practice consisted of a dynamic warm-up and light throwing, with a maximal distance of 120 feet. Pitchers and position players were then split up for specific drills. Batting practice took up the bulk of fall ball sessions, in which four groups of four to five hitters were grouped to practice swings. Pitchers who were not participating in throwing for the day helped shag balls that were hit into the outfield.

Pitchers typically threw four days a week, with one day consisting of long toss (maximum 180 feet) and another day for a bull pen. Bull pen throwing is used to mimic game time preparation, in which the pitcher uses a mound and throws fast pitches to get the arm in shape. Throws ranged from 20-40 pitches on those days at maximum velocity possible.

Position drills, such as base running and ball fielding were short drills that were either done before batting practice as an additional warm-up, or after depending on time constraints due to weight training scheduled times. Practice plans changed daily, however these three components remained consistent throughout the four weeks of fall ball.

Statistical Design. SPSS version 22 was used to analyze the data and the results. A paired samples t-test was used to assess the differences between the participants' pretest and post-test ROM measurements. The alpha was set at 0.05 and two-sided p values were used for all calculations. It was also used to assess the differences between pre- and post-max lifts. T-tests are often used to compare the means from two different groups of data. They can help you find out if means are significantly different from one another or if they are relatively the same. A Pearson's r correlation was used to assess whether two variables were related to one another. The goal was to see if there was a direct relationship between strength changes in the deadlift, back squat, and the power clean with changes in hip flexion ROM. Pearson's r is a statistic that helps you understand the strength of the linear relationship between two variables.

CHAPTER IV

RESULTS

Introduction

The differences of measurements from the pre- test to the post-test were used to calculate means to get a raw score to assess changes in ROM. The upper body measurements, which included IR, ER, and HAdd, were unaffected by the off-season training. However, hip flexion was statistically different from baseline indicating that the group lost ROM. Knee flexion was also unaffected from the off-season training. Pearson's correlation was used to see whether strength gains in the back squat, deadlift, and power clean had any effect on the hip flexion ROM.

Analysis

A paired samples t-test was conducted to compare pre-test ROM measurements to post-test ROM measurements. The goal was to see if there was a significant difference in ROM from pre-test to post-test. There was a statistical significant difference in right and left hip flexion ($M= 16.30$, $SD=12.23$, $M= 12.20$, $SD= 11.12$) between pre- and post-test measurements; right leg, $t(19) = 5.96$, $p= 0.000$, and left leg, $t(19) = 4.91$, $p= 0.000$. There was not a significant difference in shoulder IR ROM ($M= -2.00$, $SD= 11.95$) between the pre- and post-test measurements; $t(19) = -0.749$, $p = 0.463$. There was not a significant difference in shoulder ER ROM (M= .067, SD= 16.75) between pre- and posttest measurements; t(19) = 0.067, p = 0.947. There was not a significant difference in shoulder HAdd ROM (M= 3.35, SD= 13.09) between pre- and post-test measurements; t(19) = 1.14, p= 0.267. There was not a significant difference in right or left Knee Flexion (M=1.00, SD= 4.95; M=1.25, SD 5.25) between pre- and post-test measurements; right leg, t(19) = 0.903, p= 0.378, and left leg, t(19) = 1.07, p= 0.300. These statistics are shown in Table 3.

Table 3: Paired Samples Test between Pre-Test and Post-Test ROM measurements.

Pairs	Mean	Std. Deviation +/- Std. Error Mean	t	df	Sig. (2-tailed) p-value
Shoulder IR	-2.00	11.95 +/- 2.67	-.749	19	.463
Shoulder ER	0.25	16.75 +/- 3.74	.067	19	.947
Shoulder HAdd	3.35	13.09 +/- 2.93	1.144	19	.267
Hip Flexion (right leg)	16.30	12.23 +/- 2.74	5.96	19	.000
Hip Flexion (left leg)	12.20	11.12 +/- 5.00	4.91	19	.000
Knee Flexion (right leg)	1.00	4.95 +/- 1.11	.903	19	.378
Knee Flexion (left leg)	1.25	5.25 +/- 1.17	1.07	19	.300

A paired samples t-test was also conducted to compare pre-test max lifts and posttest max lifts of the back squat, deadlift, and the power clean. There was a statistical significant difference in the back squat lift (M= -27.10, SD= 20.18) between pre- and post- max testing; t(19) = -6.01, p= 0.000. There was a statistical significant difference in the deadlift exercise (M= -52.55, SD= 32.38) between pre- and post- max testing; t(19) =

-7.26, p= 0.000. There was a statistical significant difference in the power clean lift (M= -30.90, SD= 14.75) between pre- and post- max testing; t(19) = -9.37, p= 0.000. These statistics are shown in Table 4.

Table 4: Paired Samples Test between Pre-Max and Post-Max Strength Tests.

Pairs	Mean	Std. Deviation +/- Std. Error Mean	t	df	Sig. (2-tailed) p-value
Back Squat	-27.10	20.18 +/- 4.51	-6.01	19	.000
Deadlift	-52.55	32.39 +/- 7.24	-7.26	19	.000
Power Clean	-30.90	14.75 +/- 3.30	-9.37	19	.000

A Pearson product-moment correlation coefficient was computed to assess the possible relationship between the hip flexion ROM differences and the strength differences that occurred. Hip flexion was chosen for this correlation test because the hamstrings are largely involved in these core lifts. There was no correlation between the right hip flexion ROM and back squat [r= -.250, n= 20, p= .289], the deadlift [r= -.206, n= 20, p= .383], or the power clean [r= -.018, n= 20, p= .938].   There was no correlation between the left hip flexion ROM and the back squat [r=.213, n= 20, p= .368], the deadlift [r= .267, n= 20, p= .255], or the power clean [r= .223, n=20, p= .344]. These statistics are shown in Table 5.

Table 5: Correlations for potential predictor variables of Strength gains and ROM loss.

	r	p-value
Right Hip and Back Squat	-.250	.289
Left Hip and Back Squat	.213	.368
Right Hip and Deadlift	-.206	.383
Left Hip and Deadlift	.267	.255
Right Hip and Power Clean	-.018	.938
Left Hip and Power Clean	.223	.344

Summary. The only ROM measurement that was greatly affected was the hip flexion ROM. There were strength increases in the deadlift, squat, and power clean throughout the off-season. There was, however, no correlation between strength increases and hip flexion ROM decreases.

CHAPTER V

CONCLUSION

Summary

Resistance-training programs for overhead throwing athletes should be designed to improve throwing velocity by including arm, trunk, and lower body exercises (DeRenne, Ho, & Murphy, 2001). Literature has not specifically looked at an off-season strength program and practice, and how that alone may affect ROM prior to in-season play. Increasing strength and power, the primary goals in the off-season, can cause physiological adaptations that may also decrease ROM (Brooks, Fahey, & Baldwin, 2005). Flexibility must also be addressed, and should be primarily focused on hip mobility and dynamic stabilizer flexibility (Rotator cuff) of the shoulder for overhead athletes (Ebben, Hintz, & Simenz, 2005). Our study was used to evaluate ROM during the off-season that consisted of heavy resistance training and throwing are done.

When we looked at the hip, we saw ROM decreases. Knee flexion, which is a measure of quadriceps length, was unaffected. However, hip flexion showed significant losses in hamstring length. The losses may be detrimental because tensile forces in the shoulder musculature are now increased due to the lower extremity's decreased ability to absorb or dissipate the energy generated during the acceleration phase (Scher, Anderson, Weber, & Bajorek, 2010). In turn, this may place greater demands on the rotator cuff to act as a brake to decelerate the arm during follow-through and thus lead to posterior shoulder dysfunction and rotator cuff injury (Scher, Anderson, Weber, & Bajorek, 2010).

It is hard to determine why the hamstring length decreased. One possible explanation could be hip extension ROM changes. This measurement was not done due to the difficulty of having a single tester. It is possible that the off-season conditioning program resulted in tight hip flexor muscles, which may result in an increased lordotic curvature of the spine (Starkey, Brown, & Ryan, 2010). This condition may lead to increased anterior hip tilt, predisposing the hamstrings to a stretch, which may reduce hamstring length measurements. The amount of degrees lost in hamstring length was significant because an athlete with 150 degrees of hamstring flexibility compared with an athletes with 134 degrees of hamstring flexibility will have less of a stretch placed on the muscle when trunk forward tilt occurs, decreasing stresses and allowing for more movement. It is important to have hamstring flexibility because forces generated at the shoulder may be greater due to compensation for ROM restrictions at this specific joint, or at joints some distance from the shoulder (eg, lower back, hip, ankle), which is inferior to the shoulder (Scher, Anderson, Weber, & Bajorek, 2010).

Because of the complex nature of the throwing motion, upper extremity function may be intimately related to lower extremity mechanics (Anloague, Spees, Smith, & Herbenick, 2012). One important movement involved in the kinetic chain of throwing is trunk forward tilt (TFT) (Anloague, Spees, Smith, & Herbenick, 2012). As an individual throws faster, pelvis and upper torso angular velocities increase, and so does TFT (Anloague, Spees, Smith, & Herbenick, 2012). There is a lag effect between HAdd and

ER of the shoulder in relation to the trunk, which is induced by this combination of movements (Anloague, Spees, Smith, & Herbenick, 2012). A gradual decrease in TFT may decrease the transfer of momentum from the trunk segment to upper arm, diminishing the forward acceleration of the arm and resulting in a lower ball velocity (R.F. Escamilla, 2007). A greater forward trunk tilt not only helps transfer energy to the arm and enhances ball velocity, it may also help dissipate forces during the arm deceleration phase (R.F. Escamilla, 2007). The results from this study suggest that trunk forward tilt may be decreased due to the decrease of hamstring length.

This study found that hamstring length was negatively affected and this may suggest that increased forces in the shoulder may be present come in-season play. Functionally, the ability to bend forward at the trunk can be related to hamstring flexibility and trunk mobility (Anloague, Spees, Smith, & Herbenick, 2012). Examining the influence of lower extremity mechanics on the upper extremity in baseball players is important to assess reduced kinetic stresses on the shoulder. This may prevent injury, leading to greater durability and health of the throwing shoulder come in-season competition. It is possible that using the arm more and the trunk and legs less may increase shoulder and elbow forces and torques and increase injury risk (R.F. Escamilla, 2007). Likewise, the ability to forward bend can help the arm slow down gradually during the deceleration phase of throwing, which is the most damaging phase to the shoulder (S.T. Seroyer, 2010). Reduced kinetic stresses on the shoulder may prevent injury, leading to greater durability and health of the throwing shoulder (S.T. Seroyer, 2010).

It is evident that shoulder ROM decreases with normal throwing as a normal adaptation to the repetitiveness of the sport (Reinold, Wilk, & Macrina, 2008). Reinold, et. Al. (2008) showed that immediately after throwing and 24 hours post, there is loss of IR (-9.5, p= 0.001). Another study that had simulated the last two innings of a pitched game found that the throwing arm versus the non-throwing arms IR was significantly less (47.98 +/- 9.88 versus 60.69 +/- 8.27, p= 0.001) as well as a significant increase in ER (98.92 +/- 17.7 versus 84.94 +/- 10.74, p= 0.001) (Anloague, Spees, Smith, & Herbenick, 2012). The results of this study showed that shoulder ROM was unaffected, even throughout the resistance training program. Our hypothesis was not supported. This may have resulted because Fall Ball practice consisted of only four weeks of throwing throughout the twelve week off-season. It appears that the off-season strength program has no detrimental effects on the shoulder. Therefore, shoulder specific flexibility training is not needed in an off-season program. This may be why most studies that report shoulder ROM deficits are conducted during the in-season, because of the high volume of throwing being done.

Our study displayed no significant difference in shoulder IR ROM between the pre- and post-test measurements; t(19) = -0.749, p = 0.463, no significant difference in shoulder ER ROM between pre- and post-test measurements; t(19) = 0.067, p = 0.947, and displayed no significant difference in shoulder HAdd ROM between pre- and posttest measurements; t(19) = 1.14, p= 0.267. These findings are inconsistent with the findings of previous studies. One study done during two spring training seasons in professional baseball displayed increases in ER (11.5 +/- 0.1, p= 0.02), decreases in IR (8.4 +/- 11.0, p= 0.03), and HAdd (-17.6 +/- 13.8, p=0.01) (Shanley, Thigpen, & Clark, 2012). Another study compared dominant arms between throwers and non-throwers, which displayed throwers having an increase in ER (128 +/- 9.2, p=0.001) compared to non-throwers (113 +/- 14.6, p= 0.001) (Crockett, Gross, Wilk, & Schwartz, 2002). Our study might have had significant differences in shoulder ROM if the throwing volume was extended for the total twelve week off-season.

In conclusion, it is important to address hip flexion throughout the off-season to decrease possible injury during in-season play. The loss of hamstring length in the both legs indicates that joint stresses may be increased in the shoulder with a throw. Exercises that include hamstring lengthening would be beneficial to decrease these stresses. Specifically, it is recommended that training of the throwing shoulder be accompanied by improved hip flexibility, with specific focus on hamstring flexibility, dominant hip extension, and non-dominant hip internal rotation (Scher, Anderson, Weber, & Bajorek, 2010). Strengthening of these muscles are important to throwing athletes also. After workouts and any type of running, static stretching may be beneficial to improve hamstring lengthening. This can be done as a cool down to decrease muscle tightness and improve hip ROM.

Implications

Baseball athletes cannot allow their ROM to become problematic, especially if they are hoping to have long and healthy careers. It is important to address ROM losses and implement exercises and preventative programs that are specifically aimed at decreasing injury and increasing performance. It appears that the off-season program used in this study resulted in strength and power increases, which is important in baseball athletes in order to improve performance and decrease injury risk in sport. There needs to be a proper balance between strength increases and flexibility for overall health and stability of the muscles required for the forceful nature of the overhead throw.

Strengths. We found that hip flexion decreased following the off-season training program. Trunk forward tilt is a very important movement in the overhead throws kinetic chain, therefore our findings may lead to prevention of limited hamstring flexibility. Our study also helped to show that unless there is a high volume of throwing being done, the shoulder ROM may be unaffected, regardless of a heavy resistance training program.

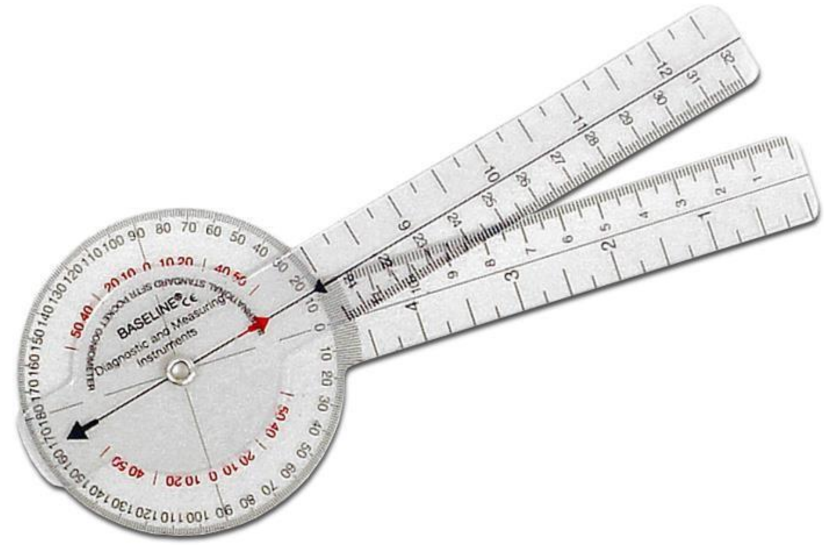
Weaknesses. Our study sample was small, which reduced statistical power to detect differences that may be clinically relevant. It would have been beneficial to employ a different approach for measuring ROM instead of the goniometer. Use of a digital goniometer, a computerized ROM system (Q-ROM, very expensive), or a bubble inclinometer may provide increased accuracy f measurement. Utilizing two people to do the passive measurement scan would also be beneficial to further look for any compensation and to assist with measurement.

Recommendations. For future research the recruitment of more athletes would be preferred. Specific hip ROM measurements used in research, such as hip extension and hip internal rotation, should be included. The addition of these specific joint movements can further help evaluate performance effects, as well as injury rates. Hip extension may also be used to address increased lordotic curvature of the spine, which may predispose the hamstrings to a stretch and influence hamstring length measurements. This study should be done in a warm-weather environment, which would allow an increase in throwing volume during the off-season. It may be possible that shoulder ROM would be significantly affected if the participants are allowed to be outside and practice. Future research may also show that strength increases in the squat, deadlift, and the power clean may be correlated with hip extension ROM changes as well.

This study was used to show the possible ROM outcomes after an off-season resistance training program and fall ball practice. The shoulder ROM was unaffected due to the lack of performing throws for the entire program. Hip flexion was affected and may have resulted in the heavy resistance training of the lower body. With these results it may be necessary to pay more attention to lower body flexibility instead of the upper extremities. This may decrease shoulder injury in-season by allowing the lower body to perform without any restriction, taking any stress off the shoulder which may be present due to lack of trunk forward tilt and larger leg drives.

Appendix A

Figure 1. Standard Goniometer



Appendix B

Workout Cards Phase

I.

PHASE 1 **NORTH DAKOTA BASEBALL** **PHASE 1**

WEEKS 1-4

Name	D.B. BENCH	BACK SQ.	FRONT SQ.	OH PRESS
MONDAY				
Warm-Up	Warm-Up A			
Power Clean	OH SQUAT X10			
	PLANK (F/L/R/) x 45 sec			
	X3	X3	X3	X3
	X3	X3	X3	X3
	X3	X3	X3	X3
Back Squat	X5 done at 75 percent			
	X5 0	X5	X5 0	X5 0
	X5	X5	X5	X5
	X5	X5	X5	X5
	X5	X5	X5	X5
Deadlift 60%-70%	5X 0	X5 0	X5 0	X5 0
	5X	X5	X5	X5
	5X	X5	X5	X5
Triple Pair w/	5X	X5	X5	X5
1 Arm Row	6X	6X	6X	6X
	6X	6X	6X	6X
	6X	6X	6X	6X
Front Squat Reverse Lunge	8X	8X	8X	8X
	8X	8X	8X	8X
	8X	8X	8X	8X
CORE/Prehab	POT STIRS, TOM HOUSE PROGRAM			

WEDNESDAY				
Warm-Up	Warm-Up B			
MED BALL LATERAL TOSS	1-2 Warm Up sets			
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
Weighted Chinups	X5 done at 75 percent			
	X5 0	X5 0	X5 0	X5 0
	X5	X5	X5	X5
	X5	X5	X5	X5
	X5	X5	X5	X5
	X5	X5	X5	X5
D.B. BENCH PRESS	X3	X3	X3	X3
	X3	X3	X3	X3
	X3	X3	X3	X3
Pair with	X3	X3	X3	X3
PLATE PUSH	15X	15X	15X	15X
	15X	15X	15X	15X
	15X	15X	15X	15X
	15X	15X	15X	15X
Blast Strap Row	6X	6X	6X	6X
	6X	6X	6X	6X
	6X	6X	6X	6X
Core/ Prehab	STABILITY BALL KNEE UPS X 10, TOM HOUSE PROGRAM			

POWER CLEAN				
FRIDAY				
Warm-Up	Warm-Up C			
Power Clean Prog.	OH SQUAT X10			
	PLANK (F/L/R) x 45 sec			
	3X	3x	2x	2x
	3X	3x	2x	2x
	3X	3x	2x	2x
	3x	3x	2x	2x
FRONT SQUAT	X5 done at 75 percent			
	3X 0	3X 0	3X	3X 0
	3X	3X	3X	3X
	3X	3X	3X	3X
	3X	3X	3X	3X
PAIR	3X	X5	3X	3X
CHREST. SUPP. ROW	8x	8x	8x	8x
	8x	8x	8x	8x
	8x	8x	8x	8x
	8x	8x	8x	8x
BARBELL OH PRESS	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
PAIR				
RDL	8x	8x	8x	8x
	8x	8x	8x	8x
	8x	8x	8x	8x
CORE	SUITCASE CARRIES X2 EACH ARM, TOM HOUSE PROGRAM			

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Phase II.

PHASE 2 — **NORTH DAKOTA BASEBALL** — **PHASE 2**

WEEKS 5-8

Name	D.B. BENCH	BACK SQ.	FRONT SQ.	OH PRESS
MONDAY				
Warm-Up	Warm-Up A			
Power Clean	OH SQUAT X10			
	PLANK (F/L/R/) x 45 sec			
	X2	X2	X2	X2
	X2	X2	X2	X2
	X2	X2	X2	X2
	X5 done at 75 percent			
Back Squat	X5 0	X5	X5 0	X5 0
	X5	X5	X5	X5
Pair With Reactive Jumps X 5	X5	X5	X5	X5
	X5	X5	X5	X5
	5X 0	X5 0	X5 0	X5 0
Bulgarian Split	5X	X5	X5	X5
	5X	X5	X5	X5
Triple Pair w/	5X	X5	X5	X5
	6X	6X	6X	6X
1 Arm Row	6X	6X	6X	6X
	6X	6X	6X	6X
	5X	5X	5X	5X
OH PRESS	5X	5X	5X	5X
	5X	5X	5X	5X
CORE/Prehab	POT STIRS, TOM HOUSE PROGRAM			

WEDNESDAY				
Warm-Up	Warm-Up B			
MED BALL LATERAL TOSS	1-2 Warm Up sets			
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
DEADLIFT	X5 done at 75 percent			
	3X 0	3X 0	3X 0	3X 0
	3X	3X	3X	3X
	3X	3X	3X	3X
	3X	3X	3X	3X
	3X	3X	3X	3X
D.B. BENCH PRESS	X3	X3	X3	X3
	X3	X3	X3	X3
	X3	X3	X3	X3
Pair with	X3	X3	X3	X3
PLYO PUSHUPS	8X	8X	8X	8X
	8X	8X	8X	8X
	8X	8X	8X	8X
	8X	8X	8X	8X
SUPINATED ROW	8X	8X	8X	8X
	8X	8X	8X	8X
	8X	8X	8X	8X
Core/ Prehab	STABILITY BALL KNEE UPS X 10, TOM HOUSE PROGRAM			

POWER CLEAN				
FRIDAY				
Warm-Up	Warm-Up C			
Power Clean Prog.	OH SQUAT X10			
	PLANK (F/L/R) x 45 sec			
	x2	x2	x2	x2
	x2	x2	x2	2x
	x2	x2	x2	2x
	X2	x2	x2	2x
FRONT SQUAT	X5 done at 75 percent			
	2X 0	2X 0	2X	2X 0
	2X	2X	2X	2X
	2X	2X	2X	2X
	2X	2X	2X	2X
PAIR	2X	2X	2X	2X
BENCH JUMPS	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
PULL UPS	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
PAIR				
SINGLE LEG RDL	8x	8x	8x	8x
	8x	8x	8x	8x
	8x	8x	8x	8x
CORE	SUITCASE CARRIES X2 EACH ARM, TOM HOUSE PROGRAM			

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Phase III.

PHASE 3 **NORTH DAKOTA BASEBALL** PHASE 3

WEEKS 12-16

Name	D.B. BENCH	BACK SQ.	FRONT SQ.	OH PRESS
MONDAY				
Warm-Up	Warm-Up A			
Power Clean	OH SQUAT X10			
	PLANK (F/L/R/) x 45 sec			
	X2	X2	X2	X2
	X1	X1	X1	X1
	X1	X1	X1	X1
Back Squat	X5 done at 75 percent			
	X2 0	X2	X2 0	X2 0
	X1	X1	X1	X1
	X1	X1	X1	X1
	X1	X1	X1	X1
SIDE LAYING PLANK ADD.	5X 0	X5 0	X5 0	X5 0
	5X	X5	X5	X5
	5X	X5	X5	X5
Triple Pair w/	5X	X5	X5	X5
1 ARM BLAST STRAP ROW	6X	6X	6X	6X
	6X	6X	6X	6X
	6X	6X	6X	6X
D.B. OH ALT EXT. PRESS	6X	6X	6X	6X
	6X	6X	6X	6X
	6X	6X	6X	6X
CORE/Prehab	POT STIRS, TOM HOUSE PROGRAM			

WEDNESDAY				
Warm-Up	Warm-Up B			
LATERAL TOSS	1-2 Warm Up sets			
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
DEADLIFT	X5 done at 75 percent			
	2X 0	2X 0	2X 0	2X 0
	2X	2X	2X	2X
	2X	2X	2X	2X
	2X	2X	2X	2X
	2X	2X	2X	2X
BARBELL BENCH PRESS	X3	X3	X3	X3
	X3	X3	X3	X3
	X3	X3	X3	X3
Pair with	X3	X3	X3	X3
PLYO PUSHUPS	8X	8X	8X	8X
	8X	8X	8X	8X
	8X	8X	8X	8X
	8X	8X	8X	8X
CHEST SUPPORTED ROW	8X	8X	8X	8X
	8X	8X	8X	8X
	8X	8X	8X	8X
Core/ Prehab	STABILITY BALL KNEE UPS X 10, TOM HOUSE PROGRAM			

POWER CLEAN				
FRIDAY				
Warm-Up	Warm-Up C			
Power Clean Prog.	OH SQUAT X10			
	PLANK (F/L/R) x 45 sec			
	x2	x2	x2	x2
	x2	x2	x2	2x
	X1	X1	X1	X1
	X1	X1	X1	X1
FRONT SQUAT	X5 done at 75 percent			
	2X 0	2X 0	2X	2X 0
	2X	2X	2X	2X
	X1	X1	X1	X1
	X1	X1	X1	X1
PAIR	X1	X1	X1	X1
Depth Jumps	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
SINGLE LEG RDL TO REV. LUNGE	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
	5x	5x	5x	5x
PAIR				
CHINUP	8x	8x	8x	8x
	8x	8x	8x	8x
	8x	8x	8x	8x
CORE	SUITCASE CARRIES X2 EACH ARM, TOM HOUSE PROGRAM			

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Appendix C

Consent Form

THE UNIVERSITY OF NORTH DAKOTA
CONSENT TO PARTICIPATE IN RESEARCH

TITLE: **Observing Range of Motion (ROM) in Baseball Athletes during an Off-Season Resistance Program and Practice**

PROJECT DIRECTOR: *Jimmy Morin, ATC, LAT*

PHONE # *909-296-2953*

DEPARTMENT: *Kinesiology*

STATEMENT OF RESEARCH

A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only subjects who choose to take part. Please take your time in making your decision as to whether to participate. If you have questions at any time, please ask.

WHAT IS THE PURPOSE OF THIS STUDY?

You are invited to participate in a research study assessing shoulder and hip range of motion. The principal investigator (person in charge) of this study is Jimmy Morin, ATC, LAT. The advisor for this study is John Fitzgerald, Ph.D. The researcher works in the Sports Medicine Department at the University of North Dakota and is a graduate student in the Department of Kinesiology. You were selected as a possible participant because you are an NCAA Division I baseball player. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The purpose of the study is to evaluate range of motion in overhead athletes during the off-season resistance training program and fall ball practice. Our goal is to determine if there will be any changes throughout the off-season with heavy weight training and practice conditions.

HOW MANY PEOPLE WILL PARTICIPATE?

Approximately 35 people will take part in this study at the University of North Dakota.

HOW LONG WILL I BE IN THIS STUDY?

Your participation in the study will last 8 weeks, the total time of the off-season program. You will need to visit the Athletic Training Room located in the Hyslop Sports Center 3 times. Each visit will take about 10-20 minutes.

WHAT WILL HAPPEN DURING THIS STUDY?

If you agree to participate in this study, we would ask you to participate in three data collection visits to the University of North Dakota. All three visits will be in the Hyslop Athletic Training Room on the campus of the University of North Dakota. Total testing time for the first session will be approximately 20 minutes or less. The next two sessions will be about 10 minutes or less. The testing sessions will include the following:

First data collection sessions, (approximately 20 minutes):

- Standard measurements of height and weight will be taken.
- You will be asked to fill out a brief questionnaire for your previous medical history as well as previous summer activity you participated in.
- Range of motion will be assessed. You will be asked to lie down on a treatment table wearing loose fitting clothing. The researcher will passively move your upper and lower extremity using a goniometer for measurements.

Second and third data collection sessions (approximately 7 minutes):

- Range of motion will be assessed. You will be asked to lie down on a treatment table wearing loose fitting clothing. The researcher will passively move your upper and lower extremity using a goniometer for measurements.

Participants are free to skip any questions on questionnaires that he/she would prefer not to answer.

WHAT ARE THE RISKS OF THE STUDY?

This study is an observational study. The range of motion testing in this study requires zero effort from the participant. The researcher will be passively moving you to get measurements using a goniometer, which is the standard form of measuring range of motion. The researcher is trained and available to deal with any injuries that may arise. All personal information will be kept confidential. Participant data will be stored according to an unidentifiable participant number.

You may experience frustration that is often experienced when completing surveys. Some questions may be of a sensitive nature, and you may therefore become upset as a result. However, such risks are not viewed as being in excess of “minimal risk.” If, however, you become upset by questions, you may stop at any time or choose not to answer a question.

WHAT ARE THE BENEFITS OF THIS STUDY?

You may not benefit personally from being in this study. However, we hope that, in the future, other people might benefit from this study because the data may help develop the ability to screen for range of motion changes that may increase the risk for injury, and may reduce performance in the sport of Baseball.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

You will not have any costs for being in this research study.

WILL I BE PAID FOR PARTICIPATING?

You will not be compensated for your participation in this study.

WHO IS FUNDING THE STUDY?

The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

CONFIDENTIALITY

The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you will not be identified. Your study record may be reviewed by Government agencies, the UND Research Development and Compliance office, and the University of North Dakota Institutional Review Board. No individual information will be shared with either coaches or staff.

Any information that is obtained in this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. You should know, however, that there are some circumstances in which we may have to show your information to other people. For example the law may require us to show your information to a court or to tell authorities if we believe you have abused a child, or you pose a danger to yourself or someone else. Confidentiality will be maintained by means of data encryption according to current University policy. The data will be destroyed after a three year time period.

If we write a report or article about this study, we will describe the study results in a summarized manner so that you cannot be identified. Your name will not be used as each participant will be identified with a number.

COMPENSATION FOR INJURY

The risk of injury with passive range of motion testing is minimal to none. If an injury does occur, as a direct result of this study, immediate and appropriate medical treatment will be made available.   However, you or your insurance carrier will be responsible for all medical costs associated with any injury while taking part in this study. No compensation is available.

IS THIS STUDY VOLUNTARY?

Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota. If you decide to participate, you are free to withdraw at any time without affecting those relationships.

CONTACTS AND QUESTIONS?

The researcher conducting this study is Jimmy Morin, ATC, LAT. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact the researcher at:

The researcher conducting this study is Jimmy Morin. You may ask any questions you have now, or if you have questions later, you are encouraged to contact him at:

Division of Sports Medicine
University of North Dakota
2751 2nd Ave. N. Stop 9013
Grand Forks, ND 58202
Cell Phone: (909) 296-2953
Email: jimmy.morin@my.und.edu

If you have questions regarding your rights as a research subject, you may contact The University of North Dakota Institutional Review Board at **(701) 777-4279**.

- You may also call this number about any problems, complaints, or concerns you have about this research study.
- You may also call this number if you cannot reach research staff, or you wish to talk with someone who is independent of the research team.
- General information about being a research subject can be found by clicking "Information for Research Participants" on the web site: http://und.edu/research/resources/human-subjects/research-participants.cfm Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subjects Name: ____

__________________________________ ___________________
Signature of Subject Date

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative.

__________________________________ ___________________
Signature of Person Who Obtained Consent Date

Appendix D

Pretest Questionnaire

PRETEST QUESTIONNAIRE

Personal

Name: ____ Test Date:_________________

Age: ______________________ Height:_____________ Weight:______________

Activity Level

1. Evaluate your activity level over the summer. ☐ Poor ☐ OK ☐ Good ☐Excellent
2. How many days did you participate in Baseball related activity? ______________
3. How often did you participate in other activity, not related to Baseball?______________

Environment

1. Have you been training in a gym (weight room) over the past summer? ☐ No ☐ Yes

If yes, please provide details:

____

____

____

Injury

1. Do you currently have any injuries? ☐ No ☐ Yes

If yes, please provide details (type, severity):

____

____

____

2. Have you had any injuries over the past summer? ☐ No ☐ Yes If yes, please provide details (type, severity):

____

____

____

1. Evaluate your last week of training. ☐ Easy ☐ Moderate ☐ Hard ☐ Very Hard physical
2. How fatigued are you today? 1 2 3 4 5

(0 = not at all; 5 = extremely)

3 How many hours ago did you last exercise? __________________

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