Glenohumeral Internal Rotation Deficit in Division Three Collegiate Football Quarterbacks

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Abstract

The research looked at the internal rotation loss in collegiate football quarterbacks. A goniometer was used to measure the internal and external rotation of the shoulder for each subject. These measurements were then compared to what is considered glenohumeral internal rotation deficit, GIRD, as defined in the literature. A majority of the current literature focused on GIRD and its connection to baseball pitchers. This research focused on GIRD and its possible connection to football quarterbacks because of the repetitive overhead motion. GIRD is often connected to baseball pitchers due to the extensive research done with baseball pitchers. There are several differences between baseball pitchers and football quarterbacks that vary from weight of the ball to average distance per throw. The research will try to identify if these differences between sports have an impact on the amount of GIRD present in each overhead athlete. The hypothesis is that collegiate football quarterbacks will have GIRD but not to the extent that can be seen in baseball pitchers.
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Introduction:

Glenohumeral internal rotation deficit (GIRD) is a condition in which the internal rotation range of motion for the dominant/throwing shoulder is less than that of the non-dominant/non-throwing shoulder. This problem is commonly seen in overhead athletes due to the repetitive motion and the forces needed to decelerate the arm. The problem can be very detrimental to the overhead athletes. The loss in internal range of motion can lead to other injuries in the shoulder and the elbow that can be even more problematic for the athlete. These injuries could require surgery that leads to significant time lost due to injury and rehabilitation. An athlete with more than 25 degrees of GIRD is defined as a shoulder at risk which means the athlete’s shoulder is more at an increased risk for injury. With a growing number of athletes becoming involved in overhead athletics, more athletes could be at risk for having GIRD and being at a higher risk for more severe injuries.

The purpose of this study is to determine if GIRD is present in division three collegiate football quarterbacks. Most of the studies on GIRD have been conducted on collegiate and professional baseball pitchers due to the high number of subjects. There has been little to no research performed on football quarterbacks. The research question is whether or not collegiate football quarterbacks develop GIRD over one football season and, if so, is it to the extent that is seen in baseball pitchers? The implications of this study are that collegiate football quarterbacks could be susceptible to the same injuries that are seen in collegiate/professional baseball pitchers. It is hypothesized that collegiate football quarterbacks will develop GIRD over the course of a season but not to the extent seen in baseball players.

As stated earlier, there is little research that has been conducted on collegiate football quarterbacks. On the other hand, there is a large volume of research that exists supporting the
connection between GIRD and collegiate/professional baseball players. Therefore, the literature review will focus on the research regarding baseball.

**Literature Review:**

Sports are highly functional activities which require a great deal of athletic ability. These athletic abilities can vary depending on each sport. Some sports are more upper extremity dominant such as baseball, softball, and swimming. In these sports the athletes are using a large amount of force to generate large velocities for a fastball or to cut through the water. The repetitive motions of these upper extremity sports can cause additional stresses to the shoulder, arm, and hand of the athletes. The additional stress can lead to injury in the upper extremity.

There was a recent six year study performed by Laudner and Sipes (2009) that looked at the incidence of shoulder injuries in volleyball, softball, baseball, tennis, and swimming at Division 1 Illinois State University. They reviewed the medical records of the teams to identify the number of shoulder injuries. The authors then divided the shoulder injuries into nine specific injury categories. Out of the 371 athletes in the study only 112 were injured players. There were 140 injuries from those 112 injured players. The authors reported that subacromial impingement and rotator cuff (RTC) tendonitis were 27% and 24% of shoulder injuries. The study also found higher incidence rates of subacromial impingement in baseball players, subacromial impingement and RTC tendonitis for softball and tennis players, and subacromial impingement, RTC tendonitis and biceps tendonitis for swimmers. This shows that there are upper extremity injuries that can be associated with overhead sports. The research is limited however, due to a sampling of one institution.
The problem that many throwing athletes face today is the constant overuse of the dominant arm over the non-dominant arm. When cared for improperly this can lead to a decrease in range of motion in the dominant arm. This decrease in internal rotation is known as glenohumeral internal rotation deficit, or GIRD. Studies have found that throwing athletes tend to have high amounts of GIRD (Bigliani et al., 1997; Brown et al., 1988; Crockett et al., 2002; Ellenbecker et al., 2002; Reagan et al., 2002). The high amounts of GIRD can have negative impacts on the performance of the athlete and on the health of the athlete. It has been found that GIRD of 20° or more can make an athlete more susceptible to having injuries at the shoulder and the elbow (Burkhart, Morgan & Kibler, 2003). A recent study by Wilk et al. (2010) determined that the risk for injury was almost doubled when pitchers had GIRD compared to pitchers without GIRD. These findings show that the range of motion of throwing athletes is very important to preventing injury. Deficits in internal rotation need to be treated with rehabilitation to prevent injury.

The throwing motion of baseball pitchers and football quarterbacks consist of similar phases. They consist of an early cocking, late cocking, acceleration, deceleration, and follow through. The acceleration phase is where the majority of the forces are generated for the high velocity throws. At this point in the phase the shoulder is coming from maximum external rotation into internal rotation. Several studies have found that (Dillman, Fleisig, & Andrews, 1993; Pappas, Zawacki & Sullivan, 1985) the velocity generated during the acceleration phase can be between $7000^\circ$ and $9000^\circ$ per second. The large muscles of the back, chest, and shoulder consisting of the pectoralis major, latissimus dorsi, and subscapularis help create the high rotational velocities of the shoulder during internal rotation of the shoulder (Fleisig, Barrentine, Escamillia, & Andrews, 1996). Once the ball is released the shoulder is now slowing down and
is in the deceleration phase. This has been called the most violent phase of the pitching motion (Seroyer et al., 2010).

Unlike the acceleration phase, the deceleration phase does not have a quantity of large muscle groups trying to slow down the arm. The infraspinatus, teres minor and posterior deltoid, located on the back of the shoulder, decelerate the high velocity movement of the arm (Burkhart et al., 2003; DiGiovine, Jobe, Pink, & Perry, 1992). The muscles undergo large amount of strain and eventually tighten due to repetitive deceleration of the shoulder. This tightness leads to the loss of internal rotation commonly seen in throwing athletes (Burkhart et al., 2003).

The impacts of GIRD can be detrimental to a throwing athlete if the GIRD goes untreated. There have been numerous consequences that occur if GIRD is not properly treated. It has been found in previous research that GIRD may contribute to ulnar collateral ligament (UCL) injuries in the throwing side elbow (Burkhart et al., 2003; Dines, Frank, Akerman, & Yocum, 2009). A tear of the UCL could lead to Tommy John surgery which is where the UCL is removed and replaced by a tendon from the body. The tendon used to replace the UCL is not as strong and effective as the original UCL. This can equate to slower speed of pitches and decreased performance. A recent study looked at the effects of medial UCL surgery on performance of pitchers. They found that there was a significant decrease in ERA, WHIP and innings pitched after having a medial UCL reconstruction surgery (Keller, R. A., Steffes, M. J., Zhuo, D., Bey, M. J., & Moutzouros, V., 2014). The amount of time missed due to a UCL reconstruction can almost be an entire season depending on when the injury occurs. Erickson et al. (2017) found that the average return to sport for a professional baseball pitcher after a UCL reconstruction was 15.3± 12.0 months while the average return sport at the same professional level as before the surgery was 17.3± 13.0 months.
GIRD has also been linked to an increased risk of developing a type II SLAP tear, or a superior labrum anterior to posterior tear (Burkhart et al., 2003; Burkhart, Morgan, & Kibler, 2000). The job of the labrum is to deepen the shoulder joint. If this lining is torn it can be painful and restrict motion. A recent study conducted in 2014 revealed that the return to play rate for MLB pitcher following surgery for a SLAP was 69% while the return to prior performance was 15% (Fedoriw, W. W., Ramkumar, P., McCulloch, P. C., & Lintner, D. M). A surgical repair from a labral tear in NFL players resulted in 140.2 days missed and 8.4 games missed (Chambers et al., 2017). The time missed and decreased performance from injuries associated with GIRD highlight the impact on reducing the amount of GIRD in an overhead athlete.

Football quarterbacks can experience the same upper extremity injuries as overhead sports even though there has not been much research involving quarterbacks due to the low number of subjects. A study completed by Kelly, Barnes, Powell, & Warren (2004) looked at the injuries in NFL quarterbacks. This was a 22 year retrospective study that used the National Football League Injury Surveillance System (NFLISS) to help determine the location of the injury. Injuries were categorized by body part and then the shoulder injuries were broken down into specific injuries. The study found that shoulder injuries were the second most common injuries that a quarterback suffered. The two most common shoulder injuries that occurred due to the throwing motion were RTC tendonitis and biceps tendonitis. Other injuries included anterior labral tear, posterior capsule strain, and impingement. All of the above injuries can be caused by a lack of glenohumeral internal rotation.

The article mentioned the differences between football quarterbacks and baseball pitchers. For the purposes of this literature review, data for football players was taken from the National Football League (NFL) due to the availability of data compared to the lack of data from
the National Collegiate Athletic Association (NCAA). It has been found that shoulder internal rotation velocities are 3-4.5 time faster for pitchers than for quarterbacks (Fleisig et al., 1996). This increased rotational velocity would cause the posterior muscles to work harder to slow the arm down because the arm is traveling faster in the same amount of time. It has also been found that the range of motion for a football throw is decreased when compared to a baseball pitcher (Fleisig et al., 1996; Gowan, Jobe, Tibone, Perry, & Moynes, 1987; Kelly et al., 2002). The combination of slower internal rotation velocities and a decreased range of motion while throwing could be why football quarterbacks are not commonly studied for GIRD.

In addition to the difference in internal rotation velocities is the velocity of the throw of the athletes. Baseball players typically throw at a higher velocity than football quarterbacks. According to Major League Baseball (MLB), in 2015 the average pitch was around 90 mph, which is slightly faster than a collegiate player (Pitches Per Start Leader: 2015 MLB Season, 2015). This is well beyond the capable velocities of the average NFL quarterback. The fastest throw on record by a quarterback in the NFL was 60 mph (Chase, 2014). This velocity is slower than the average knuckleball, 66.8 mph, which is the slowest pitch in the MLB (Rhodes, 2017). While the average MLB pitcher tries to throw as fast as they can, the average NFL quarterback adjusts their throw depending on the type of pass they want to achieve. If the quarterback wants to “float” the ball over a defender he will most likely throw a touch pass which is a low velocity throw. This low velocity throw will not have the same amount of force generated like the 90 mph fastball would generate. Therefore, the quarterback does not have a large force to decelerate which means that his muscles will not tighten up as much as a baseball pitcher. This could be one of the reasons why GIRD is typically seen in baseball pitchers.
The difference in the weight of the ball thrown could have some impact on the development of GIRD in football quarterbacks. By rule, the average MLB baseball weighs between 5 oz. and 5\(\frac{1}{4}\) oz. (MLB, 2014). This weight is consistent with a collegiate baseball. On the other hand, the average NFL football is slightly heavier than a baseball. They can be anywhere from 14 to 16 oz (NFL, 2016), which is about 2.8-3.2 times heavier than the average baseball. Though the football quarterbacks are not throwing at the velocities seen in the MLB, they are throwing a ball almost 3 times as heavy which could cause more force needed in order to throw the ball. However, this additional force can cause the velocity of the throw to be decreased. This requires less eccentric force required by the teres minor, infraspinatus, and posterior deltoid.

Another difference between pitchers and quarterbacks that could lead to an increase in GIRD is the distance of the throw. Based on the MLB rules, all pitchers throw from a mound that is 60 ft. 6 in. from home plate (MLB.com, 2014). Regardless of the professional status of the pitcher, they are still throwing at 60’6”. This differs greatly when compared to the average NFL quarterback. The average distance found in the NFL was around 7.36 yards which equates to 22.2 ft (NFL, 2015). It is hard to accurately compare the distance of the throws between the two sports for several reasons, the first being the fact that only completed passes are recorded. This means that a quarterback could throw five 30 yard passes that are dropped, roughly 150 feet combined, and they would not be recorded. Quarterbacks could have thousands of unrecorded yards thrown due to dropped passes.

Another reason the 7.36 yards is an inaccurate representation is that only yards passed the line of scrimmage are recorded. A quarterback can be standing on the right hash and throw the ball all the way to the opposite sideline for a distance of 89.3 feet, but he only gets credit for the yards
beyond the line of scrimmage (*NFL Field Dimensions, 2017*). This type of throw happens a lot during football games. The quarterback will stand on one side of the field and throw the ball to the opposite side of the field but will never get credit for the yardage. Once again, this could lead to thousands of yards that are unrecorded.

A third reason that adds to the difficulty of accurately comparing the yards thrown between sports is that the quarterback gets credits for the yard that the wide receiver gets after he catches a ball. A quarterback could throw the ball 5 yards downfield and the wide receiver runs for another 10 yards. This leads to the quarterback getting credit for 15 yards despite only throwing the ball for 5 yards. There rarely is a game where a wide receiver stops immediately after catching a pass. This leads to an overestimation of the yards that are actually being thrown by the quarterback.

Another difference between the two athletes is the amount of throws per game. In 2015, pitchers averaged 87 pitches per start (*Pitches per Start Leader: 2015 MLB Season, 2015*). The average NFL quarterback attempted 36 passes a game in 2015. (*TeamRanking, 2015*). The average pitcher will throw roughly 2.4 times more throws per game that the average quarterback. The number of throws for a quarterback is going to be lower than a baseball pitcher because the quarterback can hand the ball off to his running back and does not have to throw every play. The pitcher does not have this option. He has to throw a pitch every time he is on the field. The number of throws per game for a quarterback does not accurately represent the college quarterbacks because most NFL teams are balanced, meaning they have an equal number of passing and running plays. This differs from college teams because each college team has their own offensive system they follow. Some teams prefer to run the triple option, a running style of offense that tries to use deception and misdirection to confuse the defense. The quarterbacks that
play in a triple option style of offense may only throw the ball 5-10 times a game. This greatly reduces the quarterbacks’ chances of developing GIRD. On the other hand, a quarterback in the West Coast style offense, which focuses more on passing than running, could throw more than 36 times a game. This could put the quarterback at an increased risk of GIRD.

One last difference between the two sports is the typical week for each athlete. The typical week varies from team to team as each coach has a different system that works for them. For the purposes of this study the typical week for baseball players was taken from the pitching coach at Otterbein University due to the fact that it was easily available to the tester while a typical week for a MLB pitcher was not easily available. A full breakdown of the day by day activities for a pitcher can be seen in Appendix A. A typical week for a starting pitcher has them throwing live in the game on Saturday. The pitcher would have Sunday as their day to recover, noted as Day 1 in Appendix A. Monday would be Day 2 for the pitcher which consists of drill work. On Tuesday, the pitcher will throw a bullpen session and Wednesday will focus on recovery or sock drill work. On Thursday, the pitcher will focus on command and secondary pitches. This leaves Friday to a side day for the pitcher to prepare for the game on Saturday. Each pitcher will go through these regardless of whether they are the number one pitcher or the number three pitcher. They also will get equal repetitions throughout the week.

The typical schedule for a football quarterback differs greatly than that of a pitcher. This weekly breakdown of a quarterback’s practice schedule is from Otterbein University. Typically, only the starting quarterback plays in the game on Saturday. The quarterback has Sunday and Monday off to recover from the previous game. Practice from Tuesday to Thursday usually consists of the same things. The quarterbacks will practicing their timing with the receivers and running backs, they will throw in a 7v7, no linemen involved, and then they will throw when the
whole team is practicing. On Friday, the quarterback will get limited repetitions in order to prepare him for the game on Saturday. Appendix B gives a breakdown of the daily practice of a quarterback with the throwing parts of practice highlighted in yellow. Quarterbacks differ from baseball pitchers in that usually only the top two quarterbacks get the majority of the repetitions with the starting quarterback getting over half of the repetitions.

In conclusion, the differences between the baseball pitcher and football quarterback can help explain why baseball pitchers are most likely to have GIRD. Based on the data for 2015, the average pitcher threw for a combined 5,272 feet (60.6X87) over the course of a game whereas a quarterback, on average, only threw for 799 feet (22.2X36). The average pitcher threw 6.6 times as many feet as the quarterback. This data reveals a known fact that baseball pitchers are at a high risk for GIRD. Nevertheless, football quarterbacks still have the potential to develop GIRD despite not having as strenuous force put on their shoulder during the deceleration phase of the throw.

**Materials and Method**

**Participants:**

The participants consisted of Division three collegiate football quarterbacks from Otterbein University and Ohio Wesleyan University. Twelve subjects were targeted via email (6-Otterbein. 6-Ohio Wesleyan). The subjects included did not have any recent injuries, within the last year, to either shoulder. At the initial testing, eight subjects showed up and four were no shows. During the five weeks between testing two more subjects were injured that prevented them from practicing thus reducing the number of subjects remaining to six. Upon the final testing, one athlete did not show up leaving five subjects. Those five subjects were all right
handed, had played football for an average of 10 years and played quarterback for an average of 8 years.

<table>
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<tr>
<td>Years at QB</td>
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<tr>
<td>Handedness</td>
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</table>

**Procedure:**

The internal and external rotation measurements were taken with the athlete lying in a supine position with their shoulder perpendicular to the table. A researcher stabilized the athlete’s shoulder to prevent excess movement which could skew the results. Another researcher passively moved the athlete’s arm into internal and external rotation for both the dominant and non-dominant shoulder (Appendix C). A standard goniometer was used to measure the athlete’s range of motion. The subjects were asked to complete a warmup consisting of arm circles, cross-body abduction stretch, and a doorway stretch for one set of thirty seconds on each arm. A diagram of the pictures can be seen in Appendix D. This prevented any harm from occurring to the test subjects. The measurements were recorded during the fifth week of the season and then again during the tenth week of the season. This allowed for a five week duration between measurements. These measurements were used to determine if the athlete had glenohumeral internal rotation deficit by comparing the internal and external rotation of the dominant shoulder to that of the non-dominant shoulder. The results of GIRD in quarterbacks were then compared to GIRD in baseball pitchers that was found in the literature. An IRB was approved by Otterbein
University and Ohio Wesleyan University. All subjects were informed of the potential risks of the testing procedure and signed an informed consent form (Appendix E).

**Results:** A paired t-test was used on the Minitab 17 software to perform the statistical analysis. A summary of the results can be seen in Appendix F. The GIRD for the athletes increased from pre-test (4.20°±9.68°) to post-test (12.00°±7.45°). Although the data shows that there was an increase GIRD after the 5 weeks, there was insignificant evidence to show a statistical increase in GIRD (p= 0.177). The internal rotation of the right shoulder increased from pre-test to post-test (64.68°±6.98° to 66.80°±14.02°). This slight increase was not statistically significant (p= 0.679). There was a statistically significant increase in internal rotation of the left shoulder from pre-test to post-test (69.00°±9.43° to 80.80°±6.06°; p= 0.030). External rotation of the right shoulder did reveal a statistically significant increase from pre-test to post-test (99.00°±11.55° to 118.40°±13.52°; p= 0.000). There was not a statistically significant decrease in left shoulder external rotation from pre-test to post-test (100.40°±14.38° to 98.80°±12.87°; p= 0.753).
Discussion:

Several studies have looked at glenohumeral internal rotation deficit and its connection with overhead athletics. The main focus of those research studies has primarily been on baseball pitchers. From those studies it was hypothesized that football quarterbacks would develop GIRD but not to the extent that is commonly seen in baseball pitchers. This is one of a few studies to look at the connection between GIRD and collegiate football quarterbacks. The collected data supported that the five subjects did develop GIRD, however, it was not a statistical increase during the five weeks of this study.

The average amount of GIRD in this study was determined to be 12.00° ± 7.45° upon the post-test measurement. The measurement falls outside of the range typically defined as clinical GIRD, which is greater or equal to 20°. The literature has shown that a typical range for athletes without shoulder injury is between 10°-15° (Brown et al., 1988; Crockett, Gross, & Wilk, 2002; Reagan et al., 2002; Tyler, Roy, Nicholas & Gleim, 1999). Other studies have looked at GIRD in athletes with injured shoulders. It has been found that baseball players with throwing injuries had an average 19.7° of GIRD (Myers, Laudner, Pasquale, Bradley, & Lephart, 2006). The athletes in this study did not have a current shoulder injury, within one year, but they could have had a shoulder injury more than a year ago. The results of this study are comparable to those reported in the literature and they fall into the 10°-15° range and also the 19.7° found in players with throwing problems.

The increased external rotation on the dominant arm was expected to be found in the study. There has been a reported increase in dominant arm external rotation due to the changes in the shoulder (Chant CB, Litchfield R, Griffin S, & Thain LM, 2007). A factor that could have increased the amount of external rotation gain on the dominant arm is the increased repetitions
the quarterbacks had as the season went on. This could have led to the 19.4° increase (99.0° to 118.4°) in dominant arm external rotation.

It is hard to say what exactly caused an increase in nondominant arm internal rotation. The increase in internal rotation of the nondominant arm could be accounted for by extra stretching of the subjects. Many of the subjects asked for stretches that could help increase their internal rotation, thus decreasing their GIRD. The sleeper stretch and cross-body adduction stretch were demonstrated for the subjects. Some of the subjects could have completed them throughout the day while others could not have completed them at all. This could explain the 11.8° increase (69.0° to 80.80°). The increases could also be caused due to the small sample size where a dramatic increase by one athlete could skew the results. Error on behalf of the tester could also be a factor. Various studies used testers that were experienced with goniometer. In this study the tester was not as experienced and could have made an error or two that skewed the data and led to the increases seen in nondominant arm internal rotation.

The presence of GIRD in athletes has been connected to posterior capsular tightness in the shoulder and this causes an anterosuperior migration of the humeral head (Harryman et al., 1990). This migration can alter the mechanics of a throwing athlete causing the athlete to be unable to externally rotate as far as they should be able to (Meister, 2000). This posterior tightness can cause shoulder impingement and possibly ulnar collateral ligament insufficiency in the elbow. This creates further problems for the athlete and needs to be treated as well.

Several studies have been conducted and suggested that posterior capsule stretching is an effective way to increase internal rotation subsequently decreasing GIRD (Jazwari, McCluskey, & Andrews, 2002; Kibler & Chandler, 2003; Wilk, Meister & Andrews, 2002). The most common stretches used to decrease posterior shoulder tightness are the sleeper stretch and cross-
body adduction stretch. McClure et al. found that the horizontal cross-arm stretch was more effective than the sleeper stretch for the posterior shoulder. In a study by Manske, Meschke, Porter, Smith, & Reiman (2001), 46 college subjects had their shoulder range of motion measured at a baseline test, 4 weeks after the baseline and 8 weeks after the baseline. The study revealed that both sleeper stretch and the cross-arm stretch increased internal rotation from the baseline to four weeks after baseline. Manske et al. hypothesized that a combination of the horizontal cross-arm stretch and a joint mobilization may be a more effective treatment for posterior shoulder tightness. Regardless of whether or not it is the cross-arm stretch, sleeper stretch, joint mobilization, or a combination of them, it is highly recommended that athletes with GIRD complete posterior capsule stretching in order to reduce GIRD and prevent risks of injuries.

There were several limitations to this study beginning with the subject size of the study. Two area Division three colleges were targeted which resulted in a maximum of 13 potential subjects. However, due to injury and no shows the final subject number dropped to 5. In his study looking at baseball players with UCL insufficiency, Dines et al. (2009) had 29 subjects which allowed him to more accurately get his results. The small number of subjects in this study means that one athlete could have had a rather large increase in GIRD and it would have possibly skewed the data. This could have been the case for the present study where a subject experienced a 20° increase in GIRD in five weeks.

Another limitation to this study was the use of more than one experimenter to help stabilize the shoulder during measurements. Since the testing took place at two separate universities the examiner that stabilized the shoulder changed depending on who was available. Several studies including one done by Wilk et al (2010) utilized the idea of one examiner who
was designated as the stabilizer. This prevented any error from occurring. Having multiple examiners stabilize the shoulder could have led to either an increase or decrease in GIRD depending on the amount of pressure applied upon stabilization.

A third limitation to this study was the time of day that the measurements were gathered. Over half of the subjects had their measurements taken prior to practice. Their warmup consisted of the stretching they did before the pre-test. The two remaining subjects had their measurements taken after practice due to time constraints of the tester. This allowed the other two subjects to have warmed up before practice, thrown during practice and then warmed up again before completing the stretching. This could have made an impact on their measurements allowing them to have an increased GIRD or decreased GIRD depending on how much they threw that day.

One last limitation was that the athletes were not on any stretching restrictions during the five week duration between tests. Most of the subjects asked and were instructed on posterior capsule stretching. They could have completed them multiple times a day or not at all. Manske et al. (2001) instructed their subjects to perform the stretches for 5 repetitions of at least 30 seconds and for at least 3-4 times a week in four weeks. This resulted in an increase in internal rotation for the throwing shoulder. A similar program by the subjects of this study could have led to an increase in internal rotation and a subsequent decrease in GIRD.

Future Research:

Future research is needed on the topic of GIRD and its connection to collegiate football quarterbacks. One way that future research could yield more significant results is if the study increases the number of teams involved in the study. The typical college football team had around four and sometimes five quarterbacks on its roster. Increasing the number of teams to
four or more would result in upwards of twenty subjects. This could lead to more significant results.

The future research could also expand the number of weeks involved and do a season long study. The current study only looked at five weeks of throwing which is just a glimpse of the season. A study starting off at the beginning of the season and carrying on until the end of the season would allow the examiner to see how the subjects are doing on a week to week basis. The examiner could then determine if more GIRD was developed at the beginning or the end of the season.

Another thing that improve future research is communication skills. This study had difficulty trying to communicate with other schools which lead to one school being removed from the study because they never responded back to multiple emails. There was a challenging time trying to coordinate times to measure one of the schools. A future study with good communication skills can prevent this and allow for a smoothly run study.

One last idea for further research is to have the research completed by two examiners instead of one. Using one examiner meant that a different person was stabilizing the subject’s shoulder each time which led to inconsistency. A two-examiner study would allow one examiner to measure and the other to stabilize the shoulder. This could lead to a better reliability and validity of the results.
### Glenohumeral Internal Rotation Deficit in Division Three Collegiate Football Quarterbacks

#### Appendix A

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<td>Reverse Throws</td>
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<td>Reverse Throws</td>
<td>Reverse Throws: Submax</td>
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<td>Reverse Throws</td>
<td>Mobility Circuit</td>
<td>Arm Care: Day 2</td>
<td>Tramp Throws</td>
<td>Lift: Day 2</td>
<td>Arm Care: Day 4</td>
<td>Stretch/Mobility</td>
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<td>Sprint Work</td>
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<td>Sprint Work</td>
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**Warm-Up #1:** All Warm-up #2:
- Training Sock: None
- Wt. Ball WU: See Sheet
- Gamers: FFP’s
- Rev. Throws: 3 x 15
- Arm Care
  - Day 1: Sidelying ER 3 x 15-20”Y’s, T’s, Goal Post, Sky Divers 2 x .5 ea. (Thumbs up & down, Palms down)
  - Day 2: SL Ball Drops 3 x .15/Supine Lying Rhythmic Stabs 3 x .15
  - Day 3: Triple Band Raises 2 x 6 ea./ Manual Res. ER 2 x 6
  - Day 4: Tripods 2 x .15/Release Point Rhythmic Stabs 2 x .20
  - Trampoline Throws: 3 x .15 Rapid/ 3 x .15 Stabilize (partner throws)

**Check weighted ball sheet for warm-up**
- Post Throwing Stretching/Mobility
  - Foam Roll
  - Hamstring
  - Quad
  - Hip Flexor
  - Adductors (Butterfly)
  - Forearm
  - Piriformis
  - 90-90
  - Sleeper
  - Forearm
Appendix B

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<tr>
<th>Muskie Practice #1</th>
<th>Tuesday October 4, 2016</th>
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<td>4:10</td>
<td>PR</td>
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<tr>
<td>4:20</td>
<td>Indy</td>
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<tr>
<td>4:25</td>
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<tr>
<td>4:40</td>
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<tr>
<td>4:55</td>
<td>Team D</td>
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<tr>
<td>5:05</td>
<td>Punt</td>
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<td>3-4</td>
<td>Stretch</td>
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<tr>
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<td>KOR</td>
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<tr>
<td>6</td>
<td>Punt</td>
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<td>7-8</td>
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<tr>
<td>9</td>
<td>PR</td>
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<tr>
<td>10</td>
<td>KO</td>
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<th>TE</th>
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<th>QB</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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<td>KOR</td>
<td>Kickoff Return (Hands)</td>
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<td>9</td>
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<td>Punt Return</td>
<td>Barrel Drill</td>
<td>PR</td>
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<td>10-12</td>
<td>Team</td>
<td>Team- Opening Script/Base</td>
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Muskie Practice #3

Thursday October 6, 2016

Muskie Practice #4

Friday October 7, 2016
Appendix C

Figure a) demonstrates the procedure for external rotation while Figure b) shows the procedure for internal rotation. Both measurements were recorded on the right arm as well.
Appendix D

The picture on the left is a demonstration of the sleeper stretch while the picture on the right a demonstration of the doorway stretch
Appendix E

Informed Consent

The Department of Health and Sport Sciences at Otterbein University supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You should be aware that even if you agree to participate, you are free to withdraw at any time without penalty.

We are interested in studying the effects of being a collegiate football quarterback on shoulder range of motion. You will be participating in two sessions that will involve lying on your back while the investigator measures your shoulder range of motion. It is estimated that this will take no more than ten minutes of your time. Although it is not likely, there is a chance you might feel slightly uncomfortable during the measuring of the shoulder motion. We believe that the information will be useful in making a connection between glenohumeral internal rotation deficit and collegiate football quarterbacks.

Your participation is solicited although strictly voluntary. We assure you that your name will not be associated in any way with the research findings. The information will be identified only by a subject number.

If you would like additional information concerning this study before or after it is complete, please feel free to contact me by phone or mail.

Sincerely,
Anthony Wene, Principal Investigator
96 W. Home St, Westerville, OH, 43081
513-262-6493

__________________________
Signature of subject agreeing to participate
With my signature I affirm that I am at least 18 years of age.
Appendix F

<table>
<thead>
<tr>
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<th>Pre-test</th>
<th>Post-test</th>
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<tr>
<td><strong>Right IR</strong></td>
<td>64.68±6.98</td>
<td>66.80±14.02</td>
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<tr>
<td><strong>Left IR</strong></td>
<td>69.00±9.43</td>
<td>80.80±6.06</td>
<td>0.030</td>
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<tr>
<td><strong>Right ER</strong></td>
<td>99.00±11.55</td>
<td>118.40±13.52</td>
<td>0.000</td>
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<tr>
<td><strong>Left ER</strong></td>
<td>100.40±14.38</td>
<td>98.80±12.87</td>
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<tr>
<td><strong>GIRD</strong></td>
<td>4.20±9.68</td>
<td>12.00±7.45</td>
<td>0.177</td>
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Bibliography:


