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ORIGINAL RESEARCH

BASEBALL PLAYERS DIAGNOSED WITH ULNAR COLLATERAL LIGAMENT TEARS DEMONSTRATE GREATER SIDE TO SIDE DIFFERENCES IN PASSIVE GLENOHUMERAL ABDUCTION RANGE OF MOTION COMPARED TO HEALTHY CONTROLS

Sarah Whitt, PT, DPT, ATC/L, OCS, CSCS[1]
J. Craig Garrison, PhD, PT, SCS, ATC[1]
Kalyssa Creed, MS, CCRP[1]
Laura Giesler, MPH, ATC, LAT[1]
John E. Conway, MD[1]

ABSTRACT

Background: Numerous studies have shown that baseball players develop range of motion adaptations in their throwing arm. While some of these shoulder range of motion adaptations can lead to greater throwing velocity, excessive changes in shoulder range of motion can increase the risk of injury to the ulnar collateral ligament (UCL).

Purpose/Hypotheses: The purpose of this study was to compare the passive GH-ABD ROM measures of baseball players with a diagnosed UCL tear (UCL group) to a group of age, activity, and position matched healthy controls (CONT group). The primary hypothesis was that baseball players with an UCL tear would have a greater loss of passive glenohumeral abduction range of motion in their throwing shoulder than healthy controls. A secondary hypothesis was that baseball players with an UCL tear would demonstrate similar glenohumeral abduction range of motion in their non-throwing arm and increased side-to-side glenohumeral abduction differences compared to the healthy cohort.

Study Design: Retrospective prospective case-control study.

Results: The UCL group had significantly greater glenohumeral abduction range of motion on their throwing shoulder (132.5° ± 8.3°) than the CONT group (120.19° ± 11.2°, p = 0.000). Similarly, the UCL group had increased glenohumeral abduction range of motion on their non-throwing shoulder (141.2° ± 9.5°) compared to the CONT group (124.1° ± 11.4°, p = 0.000). Additionally, the UCL group had a greater glenohumeral abduction difference (-8.7° ± 8.4°) than the CONT group (-3.8° ± 7.7°, p = 0.001).

Conclusion: In contrast to the original hypotheses, high school and collegiate baseball players that sustained an UCL injury presented with greater glenohumeral abduction range of motion in both their throwing and non-throwing shoulders compared to healthy controls. However, the finding of greater side-to-side glenohumeral abduction range of motion deficits in the UCL group when compared to the matched healthy controls confirms the secondary hypothesis.

Level of Evidence: Level 3.

Key Terms: baseball players, glenohumeral abduction, ulnar collateral ligament tear

[1] Texas Health Sports Medicine, Fort Worth, TX, USA

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CORRESPONDING AUTHOR
Sarah Whitt
800 5th Ave. Suite 150
Fort Worth, TX 76104
E-mail: sarahwhitt@texashealth.org
Phone: 817-250-7514

INTRODUCTION

Numerous studies have shown that baseball players develop range of motion (ROM) adaptations in their throwing arm.[1-8] Researchers have typically studied changes associated with external rotation (ER) gain, glenohumeral internal rotation deficit (GIRD), humeral torsion (HT), horizontal adduction (HA) loss, and total range of motion (TRM) loss in the throwing athlete.[4,8-11] While shoulder ER has been positively correlated with increased throwing velocity,[12] excessive changes in shoulder ROM can increase the risk of injury,[5,13,14] including injury to the ulnar collateral ligament (UCL) of the elbow.[9]

In recent years the rate of elbow injuries in the throwing athlete, including UCL injuries, is on the rise.[15] Petty et al.[16] noted an increase in ulnar collateral ligament reconstruction (UCLR) rate in high school baseball players with 85 performed from 1988 to 1994 rising to 609 performed from 1995 to 2003. Cain et al.[17] also reported an increase in UCLR procedures performed with 500 being completed in 1999 to 2002 and almost 800 completed during 2003 to 2006. This increase in UCLR incidence places a demand on the sports medicine professional to determine risk factors for these throwing athletes and allow for better assessment and screening.

Much of the literature published in recent years has focused on the changes seen in the shoulder ROM of throwing athletes that have sustained a shoulder injury. When looking at GIRD in throwers with UCL injuries, Dines et al.[14] found they were shown to have 28.5° loss of IR versus 12.7° in healthy controls. Myers et al.[11] found that participants with a history of elbow injury demonstrated a significantly greater difference in humeral retrotorsion between their throwing and non-throwing sides than participants with no history of upper extremity injury. Garrison et al.[9] found that those individuals diagnosed with a UCL tear showed significantly greater deficits in TRM with a trend toward significantly greater deficits in dominant shoulder ER. A loss of TRM in the UCL deficient thrower was also supported by Dines et al.[14] Similarly, Shanley et al.[6] found that softball and baseball athletes with shoulder injuries demonstrate a 17° difference in HA between those with injured shoulders and those without injury. While these findings provide the sports medicine professional with parameters for necessary ROM adaptation in the baseball athlete, they do not account for the role of glenohumeral abduction (GH-ABD) as an injury risk factor in the thrower.

During the throwing motion, appropriate GH-ABD ROM is necessary for scapular positioning.[18] Baseball players with limited GH-ABD ROM at stride foot contact (SFC) exhibit lower levels of valgus stress at the elbow.[19] Likewise, a combination of shoulder abduction and trunk tilt is needed in order for a thrower to achieve a proper arm slot.[20] Mathematical simulation models suggest that if this relationship deviates too much (greater than 10° of trunk tilt and 100° of shoulder abduction), valgus stresses across the elbow may increase.[21] No previous studies have examined the relationship between glenohumeral abduction (GH-ABD) and UCL injury. The purpose of this study was to compare the passive GH-ABD ROM measures of baseball players with a diagnosed UCL tear (UCL group) to a group of age, activity, and position matched healthy controls (CONT group). The primary hypothesis was that baseball players with a UCL tear would have a greater loss of passive GH-ABD ROM on their throwing shoulder when compared to healthy controls. A secondary hypothesis was that baseball players with a UCL tear would demonstrate similar GH-ABD ROM in their non-throwing arm and increased side-to-side glenohumeral abduction differences (GH-ABD Diff) compared to the healthy controls.

METHODS

This was a retrospective case-control study; the Institutional Review Board of Texas Health Resources approved the research procedures. A total of 134 male competitive high school and collegiate baseball players volunteered to participate in this study from 2015 to 2017 during a 26-month timeframe. Sixty-seven baseball players with a UCL tear were compared with 67 age, experience, and position-matched healthy baseball players (Table 1).

Participants were identified during regularly scheduled visits to the participating physician and/or physical therapist. For both the UCL group and CONT group, participants were considered for study participation if they were a baseball player between the ages of 14 and 22 years. Inclusion criteria for the UCL tear group included the following: (1) the

Table 1. *Patient Demographics.*

Group	Baseball Players with UCL tear (UCL group)	Healthy Baseball Players (CONT group)	p Value
Number of Subjects:	67	67	
Age:	17.5 ± 1.8 y.o.	17.9 ± 1.1 y.o.	p = 0.06
Height:	182.1 ± 7.4 cm	182.4 ± 7.0 cm	p = 0.78
Weight:	81.4 ± 13.7 kg	82.4 ± 11.1 kg	p = 0.63

athlete's ability to throw was affected by the injury, (2) the athlete was unable to continue participating in baseball at the level before UCL tear, (3) clinical examination results were positive for a UCL tear, (4) there was confirmation of a UCL diagnosis via MRI, and (5) the athlete was attempting to return to sport at a competitive level. Exclusion criteria were (1) a previous UCL reconstruction that failed, (2) a previous shoulder surgery for labral or rotator cuff involvement, and (3) if the patient did not plan to return to baseball after treatment. The same exclusion criteria were applied to the control participants. Participants were enrolled and consented into the study by an investigator in the outpatient sports medicine facility once they were confirmed to meet the inclusion and exclusion criteria (Figure 1).

With UCL participants, ROM testing was performed at their initial visit to the outpatient sports medicine facility. All control participants were measured before their season using the same methods as the UCL group. Measurements were taken by four physical therapists all of whom had undergone training and demonstrated good reliability (intraclass correlation coefficient [ICC]2,k = 0.98; standard error of the mean [SEM] = 2.1). For GH-ABD, two clinicians participated in the measurement process (one to measure while one stabilized the shoulder and moved the arm). The participant was positioned supine while the physical therapist stabilized the scapula in a retracted position. Once scapular stabilization was achieved the participant's arm was placed in neutral rotation with the elbow in extension and the physical therapist abducted the participant's arm to the available range. This was defined as the point before the participant's scapula moved under the therapist's stabilizing hand. The physical therapist also maintained the participant's arm in neutral rotation and did not

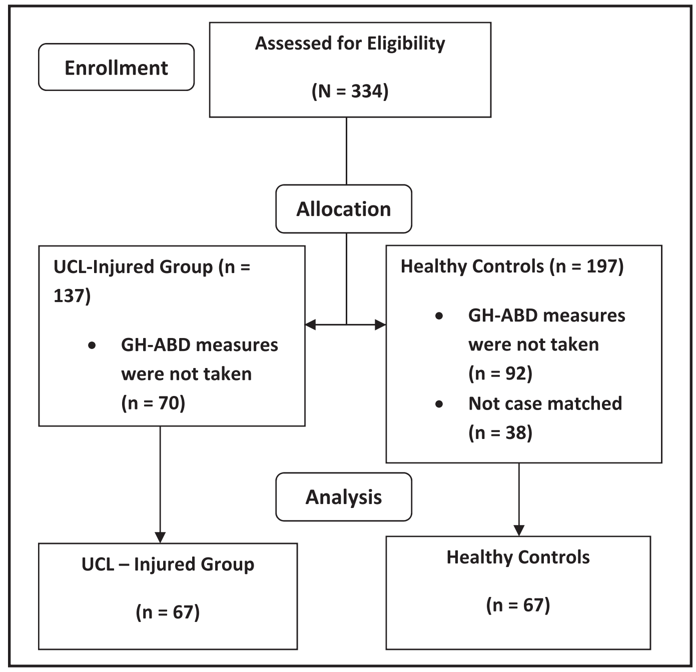

Figure 1. *Flow Diagram for Allocation of Healthy Controls vs. UCL-Injured.*

allow the arm to externally or internally rotate during this abduction movement. Measurements were taken by a second therapist with the axis at the center of the humeral head, the stationary arm parallel to the trunk through the ASIS, and the moving arm bisecting the humerus through the middle of the elbow (Figure 2). GH-ABD ROM Diff was calculated by subtracting GH-ABD ROM of the non-throwing arm from the GH-ABD ROM of the throwing arm.

STATISTICAL METHODS

An a priori statistical power analysis was performed using GH-ABD Diff as the outcome, and determined that a total of 40 participants (20 in the control group and 20 in the UCL tear group) would be needed to detect statistically significant differences based on

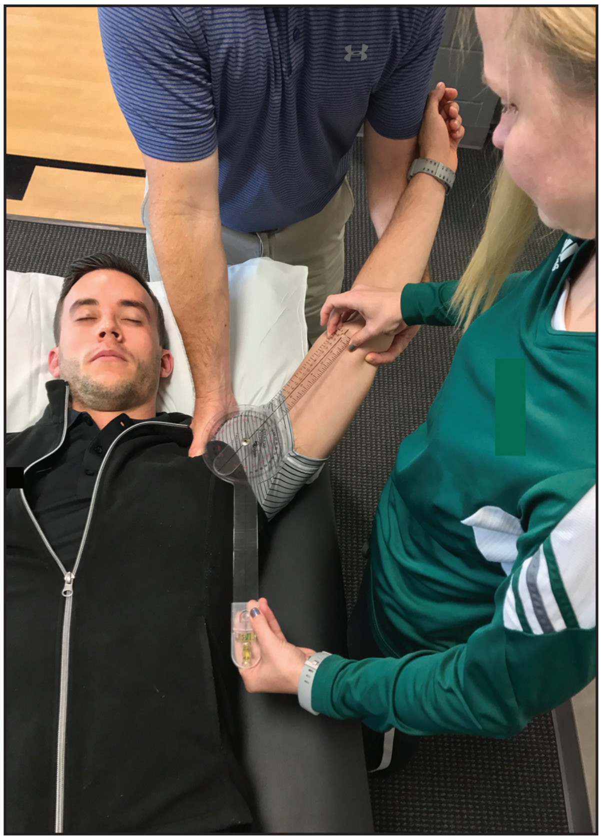

Figure 2. *FlowUse of goniometer to measure Glenohumeral Abduction with scapular stabilization.*

an 80% power calculation. Independent t-tests were used to assess for between-group differences in GH-ABD ROM in the throwing and non-throwing arms and GH-ABD Diff.

RESULTS

Table 2 provides the shoulder ROM findings between the two groups. The UCL group had significantly greater GH-ABD ROM on their throwing shoulder than the CONT group ($p < 0.001$). Similarly, the UCL group had increased GH-ABD ROM on their non-throwing shoulder compared to the CONT group ($p < 0.001$). Additionally, the UCL group had a greater GH-ABD Diff than the CONT group ($p = 0.001$).

DISCUSSION

The results of the current study indicate that those individuals that sustained a UCL tear had significantly greater GH-ABD ROM on their throwing shoulder (UCL group 132.5° ±8.3°, CONT group 120.19° ±11.2°) and their non-throwing shoulder (UCL group 141.2° ±9.5°, CONT group 124.1° ±11.4°) compared to healthy controls. Previous data has shown that GH-ABD ROM at SFC is one of 4 variables that contribute to elbow valgus stress.[19] Specifically, baseball pitchers with lower GH-ABD ROM values at SFC had lesser valgus stresses at the elbow. These findings suggest that higher numbers of GH-ABD ROM in the throwing arm may lead to greater valgus stresses at the elbow during the throwing motion. Throwing mechanics were not assessed in the present study, and as such, a cause and effect relationship is not able to be established. Future studies of GH-ABD ROM in the throwing athlete should include a 3D biomechanical motion analysis of throwing to determine what effects GH-ABD ROM has on the throwing motion. Nevertheless, the results point to the fact that GH-ABD ROM in baseball players with a UCL tear may need to be considered when assessing and treating these athletes.

In addition, the results of the current study indicate that those baseball players that had sustained a UCL

Table 2. *GH-ABD ROM measures between UCL and CONT group.*

Variable	GH-ABD ROM Throwing Arm	GH-ABD ROM Non-throwing Arm	GH-ABD Difference
UCL group	132.5º±8.3º (p = 0.000)	141.2º ± 9.5º (p = 0.000)	-8.7º ±8.4º (p = 0.001)
CONT group	120.19º ±11.2º (p = 0.000)	124.1º±11.4º (p = 0.000)	-3.8º±7.7º (p = 0.001)

Legend
GH-ABD ROM = glenohumeral abduction range of motion
UCL = ulnar collateral ligament
CONT = control

tear presented with a GH-ABD Diff of -8.7° ± 8.4°. To the authors knowledge this is the first study to assess GH-ABD ROM in a population of baseball players with a UCL tear. Prior studies have identified shoulder adaptations present in the throwing athlete that include GIRD, ER gain, ER loss, TRM loss, HA deficits, flexion loss, and HT[1-5,8,10,11] and are commonly included in the literature to guide the screening, evaluation, and treatment of the throwing athlete by sports medicine providers.[22-27] With the exception of ER gain, each one of these shoulder adaptations has been identified as a potential risk factor in the baseball player with a UCL tear.[9,14,28-30] While the current finding of a GH-ABD Diff of -8.7° ± 8.4° in the UCL group cannot be considered with the previously mentioned risk factors, it may provide the clinician with criteria for GH-ABD ROM changes that could potentially place the baseball athlete at increased risk of UCL injury.

The GH-ABD Diff noted in the UCL group could possibly be the result of protective neuromuscular changes in order to decrease stress along the medial elbow during throwing. GH-ABD is a component of the maximum shoulder ER achieved by the throwing athlete during the cocking phase and maximum shoulder ER is correlated with increased valgus torque at the elbow.[31] Previous data in baseball players with a UCL tear suggests that these individuals may develop neuromuscular adaptive changes to minimize stresses across the elbow.[9] In the present case, it is possible that baseball players in the UCL group gradually developed a loss of shoulder abduction (component of arm cocking) on the throwing arm (when compared to the non-throwing arm) as a means of minimizing valgus stress at the elbow.

Limitations to the current study include that, although this study did find a GH-ABD Diff in those with UCL deficiency, it did not determine what was contributing to this ROM loss. Whether this ROM loss was a result of previously mentioned neuromuscular changes or soft tissue adaptations was not identified. Neither throwing volume at time of measurement nor the time of the year the measurements were documented, both of which could have an effect on shoulder ROM, were not controlled for during data collection.[32,33] The current study population was high school and college age baseball players so further studies will need to be performed in order to determine whether the findings of this study are seen in professional or little league athletes. The primary limitation to the current study is that it did not determine a cause and effect relationship but only that baseball players with a UCL tear were more likely to have deficits in GH-ABD Diff ROM. Now that an association has been established between GH-ABD Diff and UCL tears in baseball players future studies can be directed at potential methods to determine what role this ROM loss may play on altering throwing or pitching mechanics and how this alteration may place additional stress on the UCL.

CONCLUSIONS

In contrast to the original hypotheses, the results of the current study indicate that high school and collegiate baseball players that sustained an ulnar collateral ligament injury demonstrated significantly greater glenohumeral abduction range of motion in both their throwing and non-throwing shoulders compared to healthy controls. However, the finding of greater side-to-side glenohumeral abduction range of motion (GH-ABD Diff) deficits in the ulnar collateral ligament group when compared to the matched healthy controls confirms the secondary hypothesis. This information supports that GH-ABD ROM may need to be considered as part of the assessment of baseball athletes and provides the sports medicine professional a side to side ROM loss range that may be related to an increased risk of UCL injury.

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