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ORIGINAL RESEARCH

BASEBALL PLAYERS WITH ULNAR COLLATERAL LIGAMENT TEARS DEMONSTRATE DECREASED ROTATOR CUFF STRENGTH COMPARED TO HEALTHY CONTROLS

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ABSTRACT

Background: Ulnar Collateral Ligament (UCL) tears are common in baseball players. Alterations in rotator cuff strength are believed to be associated with injury to the shoulder and/or elbow in baseball players.

Hypothesis/Purpose: Baseball players diagnosed with a UCL tear will demonstrate decreased internal (IR) and external rotation (ER) force as an indication of isometric muscular strength in the throwing arm compared to IR and ER force of the throwing arm in healthy baseball players. The purpose of this study was to examine isometric IR and ER strength of the shoulder in baseball players with UCL tears at the time of injury compared to healthy baseball players.

Study Design: Case-control study design

Methods: Thirty-three of the participants were diagnosed with a UCL tear and thirty-three were healthy, age- and positioned-matched controls. All of the participants played baseball at either the high school or collegiate level and volunteered for the study. Isometric rotator cuff strength measurements for internal (IR) and external rotation (ER) were performed with the arm held to the side at 0° of shoulder abduction. All measurements were taken bilaterally and the means of the throwing and non-throwing arms for IR and ER in the UCL group were compared to the means of the throwing and non-throwing arms in the healthy group. One-way ANOVAs were used to calculate differences between groups ($p < 0.05$).

Results: Baseball players with UCL tears demonstrated significant rotator cuff strength deficits on their throwing arm IR ($p < .001$) and ER ($p < .001$) compared to throwing arm IR and ER in the Healthy (UCL IR = 131.3 ± 31.6 N; Healthy IR = 174.9 ± 20.7 N) (UCL ER = 86.4 ± 18.3 N; Healthy ER = 122.3 ± 18.3 N). On the non-throwing arm, the UCL group was weaker in both IR (135.0 ± 31.1 N; $p < .001$) and ER (93.4 ± 22.8 N; $p < .001$) than IR (172.1 ± 24.1 N) and ER (122.3 ± 19.1 N) in the Healthy group.

Conclusion: Participants with a UCL tear exhibit lower force values as an indication of isometric rotator cuff strength in both the throwing and non-throwing arms than a healthy cohort.

Level of Evidence: Level 4

Keywords: Overhead athlete, rotator cuff strength, UCL

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INTRODUCTION

Injuries and tears of the ulnar collateral ligament (UCL) are a common occurrence in baseball players; especially pitchers. Currently, there is not one factor that is thought to be the sole contributor to injury of the UCL. Pitching consistently on a year round schedule correlates with an increased risk of injury[1] Throwing over 100 innings in a calendar year is also correlated with a 3.5 times increased risk of an upper extremity injury.[2] Additionally, pitching related injuries are related to overuse and fatigue, high pitch velocity, and throwing in showcase competitions.[3] As baseball players fatigue and continue throwing, their mechanics may change and therefore may be more susceptible to injury. Strength and muscle function of the shoulder complex is necessary to accommodate the many throws that occur over the long season.[4]

Strength of the internal and external rotators of the glenohumeral joint in baseball players is thought to be an important factor in throwing. During the throwing motion, the internal and external rotators function with high concentric and eccentric muscle contractions in order to propel and decelerate the arm.[5] Increased external rotator cuff muscle activity is seen during the late stages of the cocking phase [6] and may help in stabilizing the humeral head in the glenoid.[7] Several studies have shown that there is an increase in internal rotation (IR) strength and decrease in external rotation (ER) strength in the throwing arm compared to the non-throwing arm in baseball players.[8-10] Shoulder IR strength that exceeds 100N may place throwing athletes at risk for elbow injury based upon the increasing arm velocity generated by the IR strength and the accompanying distraction forces occurring at the medial elbow during the acceleration and follow-through phases of the throw.[11] Similarly, alterations or imbalances in rotational strength may be correlated to increased injury risk in the shoulder and elbow. Trakis et al[12] demonstrated that a decrease in supraspinatus and middle trapezius strength and an increase in relative internal rotation strength is associated with an increase in pain with throwing at the elbow and shoulder. Likewise, in a study examining preseason upper extremity strength measurements in professional baseball pitchers, increased weakness in ER strength was associated with throwing related injuries that required surgery.[13] As such, it appears that upper extremity rotational strength of baseball players may play a role in injuries of the throwing arm.

While rotational strength has been examined and shown to be related to injuries and pain of the shoulder and elbow in baseball players,[4,11,14,15] to date no study has specifically examined the relationship between altered rotational strength and UCL tears in baseball players. The purpose of this study was to examine isometric IR and ER strength of the shoulder in baseball players with UCL tears at the time of injury compared to healthy baseball players. It was hypothesized that baseball players diagnosed with a UCL tear would demonstrate decreased internal and external rotation strength in the throwing arm compared to internal and external rotation strength of the throwing arm in healthy baseball players.

METHODS

Participants

This was a case-control study of male baseball players. Sixty-six participants (19.3±1.6 y/o) volunteered to be part of this study and all competed at either the high school or collegiate level. Thirty-three participants with a diagnosis of a UCL tear of the throwing arm were compared with thirty-three age-, activity-, and position- matched controls without a UCL tear (Table 1). The control group was recruited from local high school and colleges and all were healthy at the time of the study. The diagnosis of UCL tear was based upon clinical examination by a fellowship-trained, board-certified orthopaedic surgeon (JEC) and magnetic resonance imaging (MRI) results.

Table 1. *Participant Demographic Characteristics for the Overall Study*

	UCL Tear (N = 33)	Control (N = 33)	*P* value
Age	19.1±1.8 years	19.4±1.4 years	0.483
Dominant Limb			0.720
Right	28	29	
Left	5	4	
Years of Experience	14.1±1.8	14.4±1.4	0.483
Position			0.210
Pitcher	23	18	
Catcher	3	6	
Infielder	4	6	
Outfielder	3	6	

* Denotes statistically significant difference at the $p < 0.05$ level.

Participants who sustained a UCL tear were recruited during the evaluation by the participating physician (JEC) and physical therapists. For both the UCL and control groups, individuals were considered for study participation if they were a baseball player between the ages of 13 and 25 years of age. The UCL tear group were included in the study if they met the following criteria: (1) the athlete's ability to throw was affected by the injury, (2) the athlete was unable to continue participating in baseball at the same level as before the UCL tear, (3) clinical examination results were positive for a UCL tear, (4) there was confirmation of a UCL tear diagnosis via MRI, and (5) the athlete was attempting to return to his 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 at a competitive level following the injury. If, after a patient was enrolled, it was discovered that he was experiencing one of the previously listed conditions, then he was removed from data collection. The same exclusion criteria were applied to the control participants.

Subjects were consented into the study by an investigator in the outpatient sports medicine facility once they were confirmed to meet the inclusion and exclusion criteria. Following informed consent, objective isometric strength measurements were taken on the shoulder during the initial evaluation. For purposes of this study, strength was defined operationally as isometric hand-held dynamometric (HHD) measures of shoulder IR and ER force. The Institutional Review Board of Texas Health Resources approved the research procedures.

Testing

Rotator cuff strength testing was performed at the initial visit to the outpatient sports medicine facility. All normal control participants were measured before their fall season using the same methods as the UCL group. Bilateral internal rotation (IR) and external rotation (ER) isometric rotator cuff force was measured with a hand-held dynamometer (MicroFET 2, Hoggan Scientific, LLC) using "break test" methodology. Measurements were taken by the same physical therapist (JCG) to ensure consistency and the intra-rater reliability was found to be good (ER: $ICC_{2,1} = 0.94$, SEM = 1.3; IR: $ICC_{2.1} = 0.93$, SEM = 2.1). During testing of isometric rotational strength, the participant sat at the end of a treatment table and faced the testing therapist with the arm positioned at the side (0° of shoulder abduction) and elbow fixed at 90 degrees. Isometric strength was measured using the HHD placed proximal to the dorsal surface of the wrist for ER and volar surface of the wrist for IR. The participant was instructed to sit tall with shoulders retracted and to rotate their arm outward (ER) or inward (IR) with maximum effort for up to five seconds in duration while maintaining the testing arm at the side with the elbow flexed to 90° (Figure 1A and B). A visual analog scale (VAS) scored from 0 to 10, with 10 being the greatest, was used to monitor any reports of pain during the testing. If any of the subjects reported pain levels greater than 2/10 during testing, their measurements were excluded from the results. An average of two trials were taken for both IR and ER and all measurements were taken bilaterally and recorded in newtons. If there was a wide discrepancy in measurement during one of the trials, an additional trial was recorded for consistency.

Data Analysis

A priori statistical power analysis was performed using throwing arm ER strength as the primary outcome and determined that a total of 20 (10 in the control group and 10 in the UCL group) participants would be needed to detect statistically significant differences based upon an 80% power calculation. The strength means of the throwing and non-throwing arms for IR and ER in the UCL group were compared to the strength means of the throwing and non-throwing arms of the normal controls. One-way ANOVAs were used to calculate mean differences between groups for continuous data while a Chi-Square Test was used to determine differences between categorical data ($p < 0.05$).

RESULTS

There were no significant differences in height ($p = 0.75$) or weight ($p = 0.19$) between groups (Table 2). Baseball players with diagnosed UCL tears demonstrated significant rotator cuff strength deficits on their throwing arm IR ($p < .001$) and ER ($p < .001$) compared to throwing arm IR and ER in the Healthy (UCL IR = 131.3 ± 31.6 N; Healthy IR = 174.9 ± 20.7

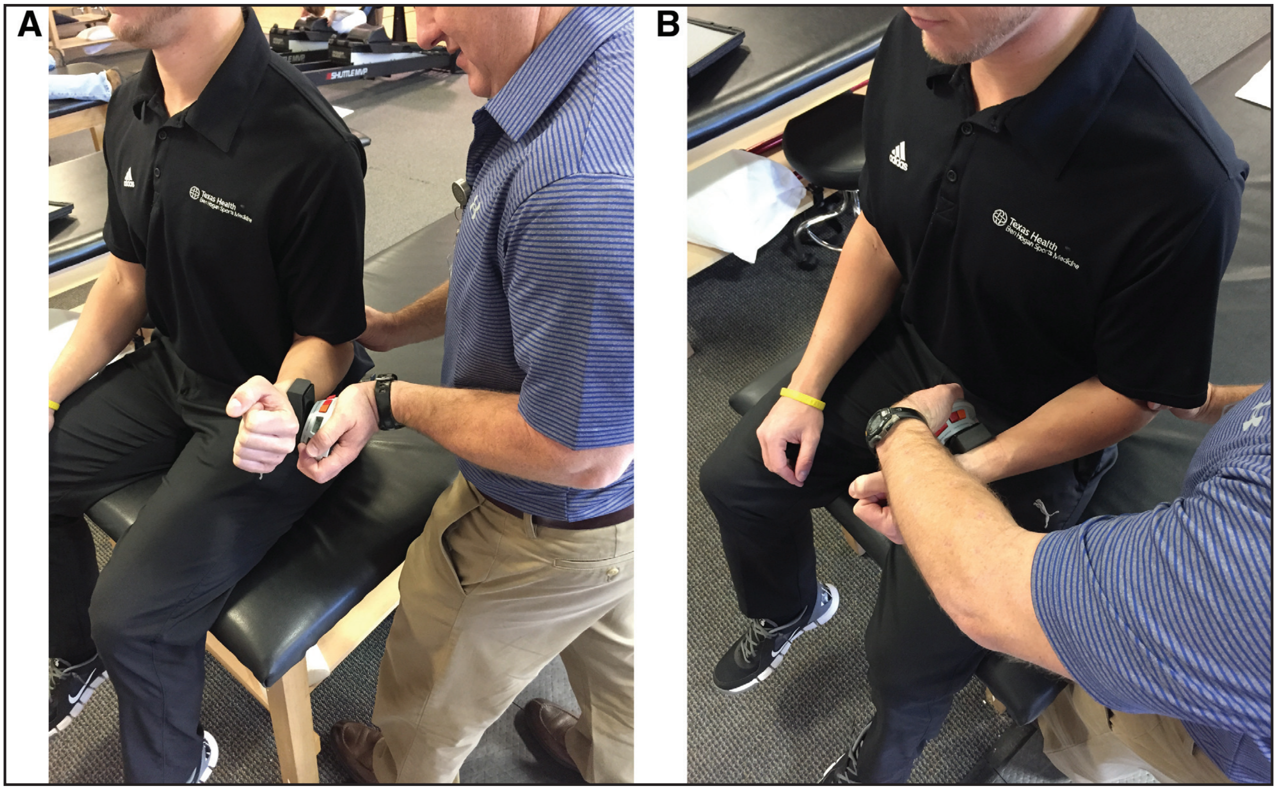

Figure 1.

Table 2. *Participant Heights and Weights*

	UCL Tear (N = 33)	Control (N = 33)	*P* value
Height	184.2±4.9cm	185.9±6.8cm	0.75
Weight	84.5±11.8kg	85.2±8.7kg	0.19

* Denotes statistically significant difference at the p < 0.05 level.

N) (UCL ER = 86.4 ± 18.3 N; Healthy ER = 122.3 ± 18.3 N). On the non-throwing arm, the UCL group was weaker in both IR (135.0 ± 31.1 N; p < .001) and ER (93.4 ± 22.8 N; p < .001) than IR (172.1 ± 24.1 N) and ER (122.3 ± 19.1 N) in the Healthy group. Table 3 demonstrates the comparison of force measures as an indication of isometric strength, between groups.

Table 3. *Isometric IR and ER force values as an indication of muscular strength of the Throwing Arm and Non-Throwing Arm between groups. (measured in newtons)*

	UCL Tear (N = 33)	Healthy (N = 33)	*P* value
Throwing Arm IR	131.3±31.5 N *	174.9±20.7 N	< 0.001
Throwing Arm ER	86.4±18.3 N *	122.3 ±18.3 N	< 0.001
Non-Throwing Arm IR	135.0±31.1 N *	172.1±24.1 N	< 0.001
Non-Throwing Arm ER	93.4±22.7 N *	122.3±19.1 N	< 0.001

* Denotes statistically significant difference, at the p < 0.05 level.

DISCUSSION

In this study, baseball players diagnosed with a UCL tear demonstrated decreased isometric rotator cuff strength (IR/ER) in the throwing and non-throwing arms when compared to a healthy control group without a UCL tear. While there is limited information on rotator cuff strength in baseball players with UCL tears, previous studies have provided baseline measurements for rotator cuff strength in little league,[11] high school,[14,16], and professional[17] baseball players. In a group of 165 uninjured high school aged (16±1 y/o) baseball pitchers, rotator cuff strength normative profiles were established for internal and external rotation strength using a handheld dynamometer with the humerus positioned at 90°of shoulder abduction.[16] Throwing arm external rotation strength was lower than the non-throwing arm while internal rotation strength was higher in the throwing arm. Conversely, adolescent baseball pitchers who were tested at the end of their season demonstrated greater internal and external rotation strength on their throwing arm compared to the non-throwing arm.[15] When pain that had previously occurred in their baseball careers (prior to testing) was considered for these pitchers, internal rotation strength was found to be higher than those pitchers who had not experienced pain. These results suggest side-to-side differences in rotator cuff strength and a possible association between shoulder/elbow pain and strength.

Shoulder rotator cuff strength has been studied as a risk factor for shoulder and elbow injuries in baseball players.[11,14,17] A total of 294 young baseball players between the ages of 9 and 12 years were tested for internal and external rotation strength using a handheld dynamometer and followed for elbow injuries over multiple baseball seasons.[11] There were no differences in internal and external rotation strength between the throwing and non-throwing arms. One hundred and fourteen of the 294 participants reported elbow pain and sixty of those were diagnosed with either medial epicondylar fragmentation or osteochondritis dissecans of the capitellum via diagnostic ultrasound. Those individuals who experienced elbow pain were classified into the "elbow injury" group and demonstrated significantly greater internal and external rotation strength measurements in both the throwing and non-throwing arms than the normal group.[11] The odds ratios for elbow pain were 4.11 for shoulder external rotation strength exceeding 80 N and 2.04 for shoulder internal rotation strength exceeding 100 N. These strength values were similar to the findings of the current study in an older population of baseball players of internal (131.3±31.6 N) and external (86.4±18.3 N) rotation strength in the UCL group but lower than those in the healthy group (IR - 174.9 ± 20.7 N; ER - 122.3 ± 18.3 N). Whereas the Harada et al[11] study included young baseball players with reported elbow pain, the current study specifically examined high school and college baseball players with confirmed UCL tears via MRI who demonstrated decreased strength values when compared to a healthy cohort.

In addition to decreased strength measurements in throwing arm in the UCL group, a decrease in non-throwing arm rotator cuff strength was found when compared to the healthy group. These results are not quite as clear, but could plausibly be related to a lack of normalization of strength values to body weight across the subjects in both groups. However, these results more likely may indicate a possible change in central neural involvement in those individuals who experience a UCL tear of the throwing arm. Peripheral and central nervous system activation assists with voluntary muscle contraction, and thus, if impairments occur along the pathway, reductions in the ability to generate muscle force may occur.[18] Previous studies have demonstrated deficits in voluntary muscle activation following joint injuries[19] and immobilization in the lower extremity.[20] Additionally, decreased voluntary activation of the infraspinatus has been shown following a fatigue protocol in the shoulder.[18] Although the current study did not look at voluntary activation or its underlying effects on non-throwing shoulder strength, this theory may have potentially played a role in our findings.

The majority of these participants with UCL tears presented to the sports medicine facility with a reported average duration of symptoms of 4.5 weeks. From the time of injury or beginning of duration of symptoms, these participants halted any throwing or baseball related activities, including any strengthening programs. This decrease in activity may have contributed to an overall de-training of the participant in regards to muscle strength which could have potentially contributed to deficits in non-throwing arm rotational strength via cross education.[21,22]

Limitations

Isometric rotator cuff strength was measured at time of injury with these baseball players diagnosed with a UCL tear. As such, it is not possible to define the lack of strength in the throwing and non-throwing arms as a causative factor that may have contributed to the UCL tear. Prospective research, measuring rotator cuff strength prior to the season with tracking of the development of UCL tears, is needed. Similarly, pain during rotator cuff strength testing in these athletes may have played a role in the deficits seen between groups. Although constraints were implemented within the methods to control for pain contributions to strength testing, and none of the UCL group reported any pain during testing, the authors cannot be absolutely certain that pain did not influence the strength results. Finally, rotator cuff strength in the current study was evaluated isometrically with the participant in a seated position and the testing arm held to the side with the elbow flexed. This position is not representative of the functional throwing motion, however, it does allow for better standardization and reliability between measures than testing the shoulder at 90° of abduction; and at least for this study was sensitive enough to detect rotator cuff strength deficits.

CONCLUSION

Baseball players diagnosed with a UCL tear demonstrate decreased rotator cuff strength on both their throwing and non-throwing arms when compared to healthy age- and position-matched controls. These data do not necessarily indicate a causal factor for UCL tear, although these results may help clinicians by providing a framework for assessment and treatment of this population of baseball players. Early recognition of rotator cuff strength deficits in a baseball player with a UCL injury is important, and should be evaluated and managed as part of non-operative care. Knowledge of strength deficits may assist the clinician in exercise prescription for the UCL injured athlete.

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