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# Shoulder Range of Motion Deficits in Baseball Players With an Ulnar Collateral Ligament Tear

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**Background:** Shoulder range of motion (ROM) deficits are associated with elbow injury in baseball players.

**Purpose:** To compare the ROM characteristics of baseball players with a diagnosed ulnar collateral ligament (UCL) tear with those of a group of age-, activity-, and position-matched healthy controls.

**Study Design:** Cross-sectional study; Level of evidence, 3.

**Methods:** Sixty male competitive high school and collegiate baseball players participated. Thirty athletes (age [mean ± standard deviation], 18.20 ± 1.56 years) with a diagnosed UCL tear were compared with 30 (age, 18.57 ± 0.86 years) age-, activity-, and position-matched players without a UCL injury. Of the 60 participants, there were 44 pitchers, 4 catchers, 5 infielders, and 7 outfielders. Participants were measured for shoulder internal rotation (IR), external rotation (ER), and horizontal adduction (HA) at 90° of shoulder elevation. Participants were also measured for elbow extension in a seated position. Group comparisons were made between participants with and without a UCL injury using independent *t* tests with an $\alpha$ level set at $P < .05$. All measurements were taken bilaterally, and the differences (involved to uninvolved) were used to calculate means for all variables, including glenohumeral internal rotation deficit (GIRD), total rotational motion (TRM), HA, and elbow extension.

**Results:** Baseball players with a UCL tear (UCLInj) exhibited significantly greater deficits in TRM compared with the control group of healthy baseball players (NUCLInj) (UCLInj = −6.67° ± 11.82°, NUCLInj = 0.93° ± 9.91°; *P* = .009). No group differences were present for GIRD (UCLInj = –12.53° ± 5.98°, NUCLInj = –13.63° ± 5.90°; *P* = .476), HA (UCLInj = −3.00° ± 5.01°, NUCLInj = −3.23° ± 5.15°; *P* = .860), or elbow extension (UCLInj = −2.63° ± 7.86°, NUCLInj = −1.17° ± 2.76°; *P* = .339). Pitchers with a UCL tear had significantly greater deficits in TRM (UCLInjPitch = −6.96° ± 11.20°, NUCLInjPitch = 1.29° ± 8.33°; *P* = .0087) and dominant shoulder ER (UCLInjPitch = 112.04° ± 14.35°, NUCLInjPitch = 121.85° ± 9.46°; *P* = .011) than pitchers without a UCL tear.

**Conclusion:** A deficit in TRM is associated with a UCL tear in baseball players. Although GIRD may be prevalent in throwers, it may not be associated with a UCL injury. When examining ROM in baseball players, it is important to assess both TRM and GIRD.

**Keywords:** total rotational motion; overhead athlete; GIRD; UCL

Baseball players frequently exhibit an increase in shoulder external rotation (ER) and a decrease in shoulder internal rotation (IR) while maintaining the total arc of motion of the glenohumeral joint in their throwing arm.[13,20] This has been reported as an adaptation to the exceptionally high demands placed on the shoulder during the overhead throwing motion.[20] There is an excessive torque placed on the glenohumeral joint at maximum ER to counter the IR velocity generated from the throw.[6,26] Because of the repetition of this motion, a baseball pitcher typically displays an increased amount of glenohumeral ER.[26]

In baseball players with an injury, there is an associated alteration in arm range of motion (ROM). Preseason deficits in shoulder IR greater than 25° and in total rotational motion (TRM) greater than 5° have been shown to increase injury risk in high school and professional baseball players.[23,26] This deficit in IR greater than 20° in the throwing shoulder has been defined by Burkhart et al[4] as a glenohumeral internal rotation deficit (GIRD). Other studies describe GIRD as the loss of IR of the throwing arm in comparison with the nonthrowing arm.[5,9,13,17] While GIRD has been documented in the dominant shoulder of throwers,[5,26] it has also been suggested to be pathological and associated with shoulder and elbow injuries.[5,14] In a retrospective case-control study, Dines et al[5] found an increase in GIRD in baseball players diagnosed with ulnar collateral ligament (UCL) deficiency

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TABLE 1
Participant Demographic and Range of Motion Characteristics for the Overall Study[a]

| | Control Group (n = 30) | UCL Tear Group (n = 30) | *P* Value |
|---|---|---|---|
| Age, y | 18.57 ± 0.86 | 18.20 ± 1.56 | .265 |
| Dominant limb, n (%) | | | .694 |
| Right | 27 (90.0) | 26 (86.7) | |
| Left | 3 (10.0) | 4 (13.3) | |
| Years of experience | 14.05 ± 1.30 | 14.0 ± 4.93 | .957 |
| Position, n (%) | | | .719 |
| Pitcher | 21 (70.0) | 23 (76.7) | |
| Catcher | 2 (6.7) | 2 (6.7) | |
| Infielder | 4 (13.3) | 1 (3.3) | |
| Outfielder | 3 (10.0) | 4 (13.3) | |
| Level of play, n (%) | | | .612 |
| College | 13 (43.3) | 15 (50) | |
| High school | 17 (56.6) | 15 (50) | |
| Dominant shoulder, deg | | | |
| ER | 119.70 ± 11.77 | 113.30 ± 13.95 | .060 |
| IR | 20.9 ± 6.08 | 29.83 ± 7.31 | .000[b] |
| Nondominant shoulder, deg | | | |
| ER | 105.13 ± 10.58 | 107.43 ± 15.51 | .505 |
| IR | 34.53 ± 5.88 | 42.36 ± 8.82 | .000[b] |
| GIRD, deg | –13.63 ± 5.90 | –12.53 ± 5.98 | .476 |
| Total rotational motion difference, deg | 0.93 ± 9.91 | –6.67 ± 11.82 | .009[b] |
| Horizontal adduction difference, deg | –3.23 ± 5.15 | –3.00 ± 5.01 | .860 |
| Elbow extension difference, deg | –1.17 ± 2.76 | –2.63 ± 7.86 | .339 |

[a]Values are expressed as mean ± standard deviation unless otherwise indicated. UCL, ulnar collateral ligament; ER, external rotation; IR, internal rotation; GIRD, glenohumeral internal rotation deficit.
[b]Denotes statistical significance at the $P < .05$ level.

when compared with healthy baseball players. This study was one of the first to establish the potential relationship between injury to the UCL and deficits in shoulder IR of the dominant arm.

The TRM has been described as the amount of combined shoulder ER and IR at 90° of abduction.[6,10,19,27] This motion is thought to be clinically important in regard to the overall health of the throwing shoulder in baseball players. Wilk et al[27] suggested that the TRM in the throwing shoulder of baseball pitchers should be within 5° of the nonthrowing shoulder to decrease the risk of injury. Likewise, in professional baseball pitchers with more than 5° TRM difference, there was a 2.5-times greater risk of shoulder injury.[26] These results imply that TRM needs to be considered in the evaluation and treatment of shoulder injuries in baseball players; however, it is unclear what role this may play in UCL injuries.

While previous studies have examined associations between UCL injuries and GIRD,[5] as well as shoulder injuries and TRM deficits,[26] to our knowledge, no prior studies have examined the relationship between a UCL tear and TRM loss. The purpose of this study was to compare the ROM characteristics of baseball players with a diagnosed UCL tear to a group of age-, activity-, and position-matched healthy controls. Our hypothesis was that baseball players with a UCL tear would have (1) a greater GIRD and (2) a deficit in overall TRM on their throwing shoulder when compared with their nonthrowing shoulder.

## MATERIALS AND METHODS

### Participants

This was a prospective case-control study. Sixty male competitive high school and collegiate baseball players volunteered to participate in our study. Participants reported playing baseball for an average of 14.03 years (range, 9-16 years). Table 1 summarizes the complete demographic characteristics of the participants. Thirty participants (age [mean ± standard deviation], 18.20 ± 1.56 years) with a diagnosis of a UCL tear of their throwing arm were compared with 30 (age, 18.57 ± 0.86 years) age-, activity-, and position-matched players without a UCL injury. Participants for the control group were recruited from local high schools and colleges. The diagnosis of a UCL injury was made based upon clinical examination by a board-certified orthopaedic surgeon (J.E.C.) and magnetic resonance imaging (MRI) results. Of the 60 participants, 44 were pitchers, 4 were catchers, 5 were infielders, and 7 were outfielders.

Patients were identified during regularly scheduled visits to the participating physician (J.E.C.) and/or physical therapists (J.C.G., M.J.M.). For both the UCL group and control group, patients were considered for study participation if they were a baseball player between the ages of 15 and 25 years. Inclusion criteria for the UCL tear group included the following: (1) the athlete's ability to throw was affected by the injury, (2) the athlete was unable to continue participating in baseball at the level before the

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 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 after treatment. 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.

Patients were included into the study by an investigator in the outpatient sports medicine facility once they were confirmed to meet the inclusion and exclusion criteria. Once a patient was consented into the study, objective measurements were taken on his shoulder and elbow during the initial evaluation. The Institutional Review Board of Texas Health Resources approved the research procedures.

## Testing

With UCL participants, ROM testing was performed at their initial visit to the outpatient sports medicine facility. All control participants were measured before their fall season using the same methods as the UCL group. Measurements were taken by 3 physical therapists and 1 athletic trainer; however, 1 person (J.C.G.) stabilized the scapula for each of the shoulder measurements to ensure consistency. Before testing, reliability standards were established in pilot testing among those participating in measurements for shoulder IR (intraclass correlation coefficient $[ICC]_{2,k}$ = .97; standard error of the mean [SEM] = 1.6), ER ($ICC_{2,k}$ = .97; SEM = 1.51), horizontal adduction (HA) ($ICC_{2,k}$ = .96; SEM = 1.36), and elbow extension ($ICC_{2,k}$ = .97; SEM = 1.00) and were found to be acceptable. Bilateral IR and ER, HA, and bilateral elbow extension were measured in each participant. The shoulder ROM measurement methods utilized have been previously described in the literature.[28] For glenohumeral joint ER, the participant was positioned supine with the arm elevated to 90° of abduction and in the scapular plane. The scapula was stabilized by the therapist, and the arm was taken to the end of available ROM of the glenohumeral joint. This was defined as the point before the participant's scapula moved under the stabilizing hand. Measurements were taken using a bubble goniometer with the stationary arm at 0°, the axis at the elbow, and the moving arm along the ulna to the ulnar styloid process. For IR, the positioning of the participant was the same as for ER, but while the scapula was stabilized, the arm was moved into IR until end range was reached or scapular motion was felt beneath the therapist's hand (Figure 1).

The HA was assessed in the manner described by Laudner et al[12] with the shoulder elevated to 90° and the elbow bent to 90° in a neutral position (without IR or ER). The examiner stabilized the lateral border of the scapula with the heel of his hand. The arm was taken passively into HA until end range was reached (Figure 2). Measurement was taken with the same bubble goniometer from the superior aspect of the shoulder as the axis, the moving arm along the humerus, and the stationary arm perpendicular to the horizontal plane. This method has been shown to be a reliable and valid technique.[12] Elbow extension was measured with the participant in a seated position (Figure 3). The shoulder was elevated to 90° with the elbow in full extension and the wrist in full supination (anatomic position). The stationary arm of the goniometer was parallel to the longitudinal axis of the humerus, pointing toward the greater tuberosity of the humerus; the axis at the lateral epicondyle of the humerus and the moving arm was parallel to the longitudinal axis of the radius, pointing toward the styloid process of the radius.

For this study, GIRD was defined as a deficit of IR of the throwing arm in relation to the nonthrowing arm and was calculated for both groups. Likewise, TRM was determined based on the combination of shoulder ER and IR of the participant's throwing arm in comparison with the nonthrowing arm. This method has been described in earlier studies.[26,27] Elbow extension and HA were measured as the total available ROM at both the elbow and shoulder of the throwing arm compared with the nonthrowing arm. Side-to-side differences for GIRD, TRM, HA, and elbow extension were then calculated in each group and used for analysis.

## Data Analysis

A priori statistical power analysis was performed using TRM deficit as the primary outcome and determined that a total of 40 (20 in the control group and 20 in the UCL tear group) patients would be needed to detect statistical significance based upon an 80% power calculation. Independent *t* tests were used to determine significant differences between the means of GIRD, TRM, HA, dominant shoulder ER, and elbow extension in both the UCL and control groups with significance set at $P < .05$. Likewise, subgroup analyses consisted of pitchers with a UCL injury versus pitchers without a UCL injury and baseball players with a UCL injury who went on to surgery compared with those who were able to rehabilitate without surgery.

# RESULTS

The participants with a UCL tear (UCLInj) exhibited significantly greater deficits in TRM compared with the control group of healthy baseball players (NUCLInj) (UCLInj = −6.67° ± 11.82°, NUCLInj = 0.93° ± 9.91°; $P$ = .0091). No group differences were present for GIRD (UCLInj = −12.53° ± 5.98°, NUCLInj = −13.63° ± 5.90°; $P$ = .4761), HA side-to-side difference (UCLInj = −3.00° ± 5.01°, NUCLInj = −3.23° ± 5.15°; $P$ = .860), dominant shoulder ER (UCLInj = 113.30° ± 13.95°, NUCLInj = 119.70° ± 11.77°; $P$ = .060), or elbow extension side-to-side difference (UCLInj = −2.63° ± 7.86°, NUCLInj = −1.17° ± 2.76°; $P$ = .339).

When only pitchers with a UCL injury (UCLInjPitch; n = 23) were compared with pitchers without a UCL injury (NUCLInjPitch; n = 21), there was a significant difference in TRM (UCLInjPitch = −6.96° ± 11.20°, NUCLInjPitch = 1.29° ± 8.33°; $P$ = .0087) and dominant shoulder ER (UCLInjPitch = 112.04° ± 14.35°, NUCLInjPitch =

**Figure 1.** Testing position for shoulder internal rotation with the arm positioned at 90° of abduction.

121.85° ± 9.46°; $P$ = .011). Similar to the overall group findings, there were no significant differences in GIRD (UCLInjPitch = −12.26° ± 6.08°, NUCLInjPitch = −13.76° ± 6.41°; $P$ = .4302), HA side-to-side difference (UCLInjPitch = −2.30° ± 3.36°, NUCLInjPitch = −3.71° ± 3.68°; $P$ = .1911), or elbow extension side-to-side difference (UCLInjPitch = −2.78° ± 5.59°, NUCLInjPitch = −0.67° ± 2.04°; $P$ = .1102) in pitcher groups. Table 2 outlines the findings for the subset of pitchers in the study.

Of the 30 baseball players with a UCL tear, 18 went on to have surgery to reconstruct the ligament. There were no significant differences in dominant shoulder ER, GIRD, TRM, HA, or elbow extension between surgery (UCLInjSurg) and nonsurgery (UCLInjNSurg) groups (Table 3).

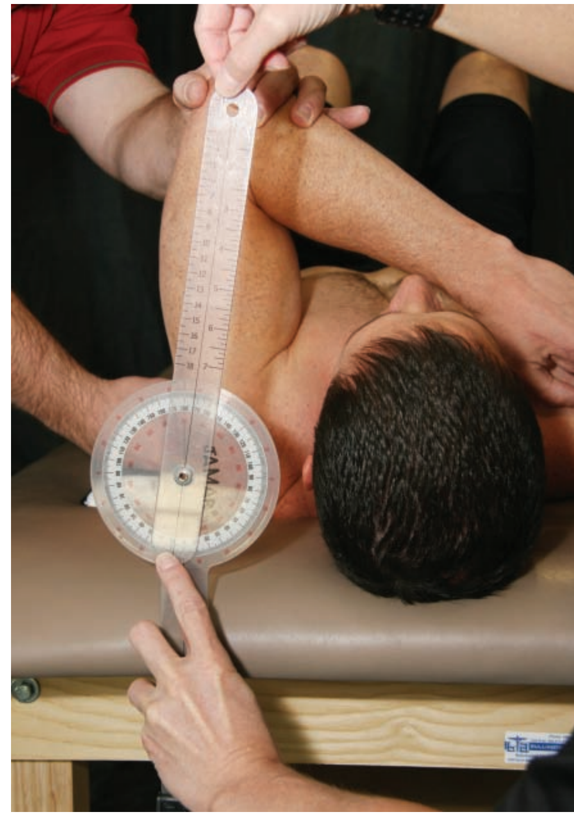

**Figure 2.** Testing position for shoulder horizontal adduction with the arm positioned at 90° of shoulder elevation and elbow flexion.

**Figure 3.** Testing position for elbow extension in a seated position.

## DISCUSSION

Baseball players with UCL tears in this study displayed a deficit in TRM when compared with a group of age-, activity-, and position-matched healthy baseball players. These results are similar to previous findings of loss of TRM in baseball players with UCL insufficiency[5] and in professional baseball players who suffered a shoulder injury.[26] When professional pitchers had a deficit in TRM greater than 5°, they were 2.5 times more likely to sustain an injury to the shoulder.[26] In our study, all baseball players with a UCL injury exhibited a mean deficit of 6.67° of TRM on the throwing arm, which is outside the proposed acceptable range of 5° or less of TRM loss.[26,27] In comparison, the healthy controls in our study were well within (0.93°) the acceptable range of TRM loss. As a subset, pitchers in our study who had suffered a UCL injury also had a deficit of TRM when compared with pitchers without injury. Likewise, a previous study in baseball players diagnosed with UCL insufficiency revealed a deficit of TRM; however, this was a comparison of the injured dominant shoulder to the dominant shoulder of the control group.[5] While the Wilk et al[26] study observed the relationship between discrepancies of shoulder motion and injuries at

TABLE 2
Range of Motion Comparison of Pitchers: UCL-Injured Versus Noninjured Groups[a]

| | Control Group (n = 21) | UCL-Injured Group (n = 23) | *P* Value |
|---|---|---|---|
| Age, y | 18.71 ± 0.90 | 18.26 ± 1.18 | .165 |
| Dominant shoulder, deg | | | |
| ER | 121.85 ± 9.46 | 112.04 ± 14.35 | .011[b] |
| IR | 20.61 ± 5.97 | 30.73 ± 7.58 | .000[b] |
| Nondominant shoulder, deg | | | |
| ER | 106.81 ± 11.23 | 106.73 ± 17.17 | .987 |
| IR | 34.38 ± 6.52 | 43.00 ± 9.67 | .001[b] |
| GIRD, deg | –13.76 ± 6.41 | –12.26 ± 6.08 | .430 |
| Total rotational motion difference, deg | 1.29 ± 8.33 | –6.96 ± 11.20 | .009[b] |
| Horizontal adduction difference, deg | –3.71 ± 3.68 | –2.30 ± 3.36 | .191 |
| Elbow extension difference, deg | –0.67 ± 2.04 | –2.78 ± 5.59 | .110 |

[a]Values are expressed as mean ± standard deviation. UCL, ulnar collateral ligament; ER, external rotation; IR, internal rotation; GIRD, glenohumeral internal rotation deficit.
[b]Denotes statistical significance at the $P < .05$ level.

TABLE 3
Range of Motion Comparison of Players: UCL-Injured Group With Surgery Versus UCL-Injured Group Without Surgery[a]

| | UCL-Injured Group Without Surgery (n = 12) | UCL-Injured Group With Surgery (n = 18) | *P* Value |
|---|---|---|---|
| Age, y | 17.50 ± 1.98 | 18.66 ± 1.02 | .043[b] |
| Dominant shoulder, deg | | | |
| ER | 116.0 ± 14.46 | 112.0 ± 13.72 | .396 |
| IR | 30.0 ± 5.54 | 29.72 ± 8.45 | .921 |
| Nondominant shoulder, deg | | | |
| ER | 112.08 ± 10.57 | 104.33 ± 17.68 | .185 |
| IR | 42.25 ± 7.10 | 42.44 ± 10.01 | .954 |
| GIRD, deg | –12.25 ± 6.51 | –12.72 ± 5.77 | .836 |
| Total rotational motion difference, deg | –8.33 ± 10.33 | –5.55 ± 12.88 | .538 |
| Horizontal adduction difference, deg | –2.58 ± 4.25 | –3.28 ± 5.56 | .717 |
| Elbow extension difference, deg | –2.83 ± 6.29 | –2.50 ± 8.93 | .912 |

[a]Values are expressed as mean ± standard deviation. UCL, ulnar collateral ligament; ER, external rotation; IR, internal rotation; GIRD, glenohumeral internal rotation deficit.
[b]Denotes statistical significance at the $P < .05$ level.

a different joint (shoulder) and in a different population (professional baseball players), the significant deficits of TRM in these studies suggest that this variable should be considered when looking at injuries in baseball players.

Interestingly, our study does not show a difference in GIRD in relation to age-, activity-, and position-matched controls for the whole group, the subset of pitchers, or the surgery group. Preseason deficits in IR have been shown to increase arm injury risk[23] and are associated in retrospective studies with overhead throwers with internal impingement,[14] professional pitchers with a history of shoulder injury,[22] and injured high school baseball players.[23] In addition, baseball players with a UCL injury displayed increased GIRD when compared with a healthy control group.[5] Moreover, the Dines et al[5] study contained a combination of professional, college, and high school players, while our study was made up of only college- and high school–level players. Although the lack of difference in GIRD between the UCLInj and NUCLInj groups may seem counterintuitive, previous data on uninjured baseball players have demonstrated similar measurements of GIRD at the high school (15°),[9] college (12.7°),[2] and professional (11.6°)[26] levels. Likewise, there were differences in measurement techniques employed during the testing procedures, which could explain some of the discrepancies in the findings. Testing in the Dines et al[5] study included standard goniometric measurements based on earlier descriptions of motion assessment for the shoulder[15]; however, we used a manual scapular stabilization technique, which positioned the shoulder in the scapular plane of motion and has previously been shown to be a reliable method.[28] This technique restricts scapular movement in an attempt to isolate available glenohumeral joint motion and, as such, may account for some of the differences between our study and the Dines et al[5] study. While GIRD in preseason has been shown to increase injury risk,[23] in our sample, it was not associated with UCL tears. Nevertheless, deficits in TRM were present in these players.

A deficit in TRM in this study appears to be associated with a deficit in dominant shoulder ER in those players with a UCL injury. Although dominant shoulder ER deficit was not statistically significant for the total group of baseball players ($P$ = .060), there was a trend toward this being a significant finding. In the same way, when the subset of pitchers was compared, a deficit in dominant shoulder ER was found ($P$ = .011) in those with a UCL injury (112.04° ± 14.35°) when evaluated against healthy pitchers (121.85° ± 9.46°). These results are different than those of both Dines et al[5] and Wilk et al[26] in which a deficit in TRM was attributed to a deficit in IR of the dominant shoulder. In the Shanley et al[23] study, baseball players who were injured (shoulder and elbow) had less ER on their dominant shoulder when compared with the dominant shoulder of uninjured baseball players; however, the difference was not significant. This trend in deficits in ER of the dominant shoulder in our study suggests that there could be an underlying mechanism.

Increased magnitudes of shoulder ER have been suggested to be potentially injurious to the elbow.[3] In the throwing motion, a greater degree of shoulder ER is associated with increased valgus torque at the elbow.[7,21] Because the UCL is thought to provide an inherent varus restraint to high valgus elbow torques experienced during the late cocking phase,[25] it is likely that this structure may be injured at this point. As such, it is plausible that baseball players with a UCL injury in this study have experienced neuromuscular adaptive changes to minimize stresses across the elbow. In a study examining the effect of throwing mechanics on valgus load at the elbow, maximum shoulder ER was significantly correlated with elbow valgus torque.[1] As such, the authors suggested that one biomechanical condition of reducing this valgus load across the elbow was to reduce shoulder ER. Although we did not evaluate the throwing motion of the participants in this study, it is possible that those athletes with a UCL injury gradually developed a loss of shoulder ER as a means of minimizing valgus stress at the elbow.

A deficit of shoulder HA is often considered to be a potential risk factor for injury in baseball players. This is believed to be caused by posterior shoulder tightness often experienced by overhead-throwing athletes.[14,24] In our study, we found no differences in side-to-side differences in HA between UCLInj and NUCLInj groups. These results are in contrast to Shanley et al,[23] who showed a 17° side-to-side difference in HA between those with injured shoulders and those without injury. However, this preseason HA deficit did not exhibit an association with an increased injury risk to the shoulder or elbow.[23] In contrast, Myers et al[14] showed a relationship between posterior shoulder tightness and internal impingement in overhead-throwing athletes; however, the side-lying technique used in their study differs from the method we used in which the participant was positioned supine with the scapula stabilized.[12] Posterior shoulder tightness has been suggested as a possible contributing factor to shoulder injury.[12,14,24] Theoretically, even though a deficit of HA may affect the kinetic chain with decreased shoulder IR and subsequent stresses across the elbow,[7] it has not been directly connected to the development of UCL injury.

Elbow extension loss of the dominant arm is thought to be a common finding in baseball players. As throwing increases throughout the season and across the career of a player, dominant arm elbow extension decreases when compared to the nondominant arm.[18,29] These changes are attributed to musculotendinous adaptations from high load eccentric muscle contractions.[16] The consequences, however, are not fully understood in regard to the relationship with injury at the elbow. In this study, the UCLInj group (–2.63° ± 7.86°) had slightly greater loss of elbow extension of the dominant arm when compared with the NUCLInj group (–1.17° ± 2.76°), but the difference was not statistically significant. These results appear to be consistent with the loss of dominant arm elbow extension in professional baseball players[18,29]; however, the implications for UCL injury are still unknown.

For the subset of those UCL-injured baseball players in this study, 18 required surgery for UCL reconstruction, while the other 12 were able to rehabilitate without surgery. Although there were no differences in ROM measurements of the shoulder and elbow in these 2 groups, there was a difference in age (UCLInjNSurg = 17.50 ± 1.98, UCLInjSurg = 18.66 ± 1.02). It is unlikely that the slightly younger mean age of the nonsurgery group contributed to their ability to avoid surgery at the time of this study. The factors that determine whether a baseball player with a UCL tear is able to undergo rehabilitation instead of surgery are multifactorial in nature and are not easily predicted. Although there is some evidence that signal intensity of MRI may be useful in predicting outcome, that discussion is beyond the scope of this article.[11]

## Limitations

In previous studies that have examined TRM deficit in the throwing arm, the losses have been attributed to a decrease in dominant arm IR.[5,23,26] In this study, there was not a significant difference in GIRD between the UCLInj and NUCLInj groups, which suggests that differences in TRM are coming from a loss in ER of the dominant arm. This finding is different than that of the Dines et al[5] study in which differences in GIRD accounted for TRM deficit. From a clinical standpoint, a TRM deficit of 6.67° may not seem like much and could be construed as an error measurement. For this reason, we tried to ensure consistency with our measurements through training, reliability testing, and using only 1 person (J.C.G.) to stabilize the shoulder with each participant. In addition, it is more than likely that it is not the specific number of the TRM deficit but rather the recognition of changes or differences in ER of the throwing shoulder which may help the clinician to identify those with a UCL injury.

It is also important to consider the time of year and season when each of these participants was measured. The fact that ROM of the shoulder can vary within 24 hours of throwing must be taken into account.[18] For the UCLInj group, none of the participants had thrown within 24 hours of evaluation, and most had taken a break from throwing because of their injury. The exact throwing patterns of the NUCLInj group are not clear; however, an effort was made to ensure that no participant threw before testing. Previous research suggests that baseball players experience adaptations of increased shoulder ER[8] and decreased shoulder IR[8,18] with throwing. This would suggest that "in-season" throwers would have greater shoulder ER than during the "off-season" when not as much throwing is occurring. Because all of our control measurements were taken during the fall (off-season) and before the fall season had even started, the possible differences in the timing of measurements between groups should have been minimized and thus, in our opinion, was not responsible for the differences in TRM. Finally, similar to the Dines et al[5] study, we used a mixture of position players and pitchers, which could potentially influence the ROM findings, although pitchers in our study demonstrated comparable findings at the shoulder and elbow.

## CONCLUSION

There was a statistically significant difference in shoulder TRM in UCLInj baseball players compared with NUCLInj players. Clinically, recognition of a deficit in TRM may be an important factor in identifying those players with UCL injuries. Although GIRD was not found to be significantly different between the 2 groups, it was present in both groups and should not be ignored as a potential risk factor for injury. Similarly, loss of dominant arm elbow extension does not appear to be related to injury to the UCL in baseball players, but the implications are still unclear. Findings of dominant shoulder deficit of TRM in baseball players with a UCL injury in this study are in a specific age group of high school and college baseball players and may not necessarily translate to a younger or older population.

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