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Major League Baseball pitch velocity and pitch type associated with risk of ulnar collateral ligament injury

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Background: The number of Major League Baseball (MLB) pitchers requiring ulnar collateral ligament (UCL) reconstructions is increasing. Recent literature has attempted to correlate specific stresses placed on the throwing arm to risk for UCL injury, with limited results.

Methods: Eighty-three MLB pitchers who underwent primary UCL reconstruction were evaluated. Pitching velocity and percent of pitch type thrown (fastball, curve ball, slider, and change-up) were evaluated 2 years before and after surgery. Data were compared with control pitchers matched for age, position, size, innings pitched, and experience.

Results: The evaluation of pitch velocity compared with matched controls found no differences in pre-UCL reconstruction pitch velocities for fastballs (91.5 vs. 91.2 miles per hour [mph], $P = .69$), curveballs (78.2 vs. 77.9 mph, $P = .92$), sliders (83.3 vs. 83.5 mph, $P = .88$), or change-ups (83.9 vs. 83.8 mph, $P = .96$). When the percentage of pitches thrown was evaluated, UCL reconstructed pitchers pitch significantly more fastballs than controls (46.7% vs. 39.4%, $P = .035$). This correlated to a 2% increase in risk for UCL injury for every 1% increase in fastballs thrown. Pitching more than 48% fastballs was a significant predictor of UCL injury, because pitchers over this threshold required reconstruction ($P = .006$).

Conclusion: MLB pitchers requiring UCL reconstruction do not pitch at higher velocities than matched controls, and pitch velocity does not appear to be a risk factor for UCL reconstruction. However, MLB pitchers who pitch a high percentage of fastballs may be at increased risk for UCL injury because pitching a higher percent of fastballs appears to be a risk factor for UCL reconstruction.

Level of evidence: Level III; Case-Control Design; Epidemiology Study

Keywords: Pitching; Major League Baseball; UCL injury; elbow; velocity; ligament

Injuries to the medial ulnar collateral ligament (UCL) are common in overhead-throwing athletes. Major League Baseball (MLB) pitchers, in particular, are at high risk for injuries about the throwing elbow.[1,4,19] Recent literature supports that the number of MLB pitchers requiring UCL reconstruction (UCL-R) continues to increase, with estimates near 25% of all MLB pitchers undergoing UCL-R.[4]

Recent investigations have attempted to analyze factors that contribute to UCL injuries with the aim to decrease the rate of injury. Studies have suggested that possible risk factors

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include pitching mechanics, pitch type (curve ball, fastball, etc), glenohumeral internal rotation deficit, pitching fatigue, chronic overuse, and pitch velocity, among other factors.[1,5,8,10,20] Specifically, increased pitch velocity has been implicated as a risk factor for UCL injury[3,14,15,18] However, no study has exclusively attempted to assess whether MLB pitchers who required UCL-R pitch at a higher velocity than matched controls.

Pitch type (fastball, curveball, slider, etc) is another significant factor that has been investigated as a contributor to UCL injuries. Various biomechanical studies have attempted to correlate pitch types with torque across the throwing elbow,[1,17] with contrasting results: some suggest fastballs create more torque, whereas others found off-speed pitches produce increased stresses.[6,8,17] Beyond not evaluating MLB pitchers, these previous studies also failed to evaluate the volume or amount of a specific pitch type thrown by these pitchers that may contribute to UCL injuries.

This study evaluated whether MLB pitchers who require UCL-R have higher pitching velocities compared with matched MLB controls and assessed whether pitch velocity is a specific risk factor for subsequent UCL injury. We also aimed to assess whether pitchers requiring UCL-R had different pitching patterns in regards to the percentage of specific pitch types thrown and whether pitching more of a specific pitch increased the risk of injury.

Materials and methods

We conducted a retrospective, case-controlled study.

UCL-R pitchers

A cohort of 83 MLB pitchers who had undergone primary UCL-R between 2008 and 2015 were identified. Players who underwent UCL-R were identified in similar methods to previous studies.[7,9,12,15,16] The UCL pitchers were indentified via team Web sites, press releases indicating players had undergone UCL-R, personal Web sites, and baseball statistical Web sites, including baseballreference.com and fangraphs.com. To verify each pitcher's year of surgery, we cross-referenced each pitcher's reported surgical date with a gap in pitching statistics.

Statistics were obtained using two independent statistical sources (http://www.baseballreference.com and http://www.fangrafts.com) to maximize completeness and accuracy. Pitcher demographics included handedness, date of birth, age at surgery, position (reliever or starter), height, and weight. We also collected each pitcher's MLB experience.

Pitching performance statistics were collected for 2 seasons before the UCL injury to establish appropriate, uninjured performance velocities.[12] Pitching velocities were also evaluated for 2 years after UCL-R to assess any change in velocity attributable to reconstructive surgery. Only MLB statistics were evaluated, minor league data were excluded. Specific metrics collected included innings pitched, average seasonal pitch velocities (including fastballs, curveballs, sliders, and change-ups), and percentage of pitch types thrown (including fastballs, curveballs, sliders, and change-ups).

Control pitchers

A control group was created to match for potential confounders to UCL injury, which included size (height and weight), age, and overuse (pitching role: starter vs. reliever, innings pitched, and major league experience).[19] As such, a group of MLB pitchers matched for year, age, position, size, MLB experience, and innings pitched were identified in a blinded process. We identified 83 control pitchers. The controls were selected by first creating a database of deidentified MLB pitchers. Players with a known history of UCL-R were removed from the group of possible controls. Pitchers were not excluded from the control group if they had sustained other injuries to the elbow, shoulder, or other extremities. Controls were then selected via a regression model that first selected for index year, followed by age, size (height and weight), innings pitched, position (reliever vs. starter), and MLB experience. The index year was based on the last season of play before UCL-R for the respective pitcher in the original cohort.

Statistical pitching data for controls were then collected similar to cases for 2 years before the index year and 2 years after the index year for an adequate trend. Pitcher demographic data included handedness, date of birth, age at index year, and position (starter or relief). MLB years played before the index year were collected. The same pitching performance metrics (speed and pitch type percentages) as used in the UCL-R cohort were collected in the control group.

Statistical analysis

The primary aim of the analysis was to investigate predictors of UCL injury using a case-control design. Cases (pitchers with UCL injury) and controls (no UCL injury) were first described using means, standard deviations, counts, and percentages. Differences and associations were tested with a Welch t test or χ^2 test for the 6 matching criteria. The testing of predictors of UCL-R was done via univariate conditional logistic regression, testing each pitching parameter separately. Odds ratios and 95% confidence intervals were computed via exact partial likelihood estimation.

For the secondary goal of comparing pitching speeds before and after surgery, univariate generalized estimating equations were used with pitching speed as the dependent variable and time (before, after) and the independent variable, clustering on match identification. Statistical significance was set at $P < .05$. Analyses were performed using R 3.2.0 software (The R Foundation for Statistical Computing, http://www.r-project.org/foundation/). Conditional logistic regression was performed using the survival package, and generalized estimating equations were performed using the gee package.