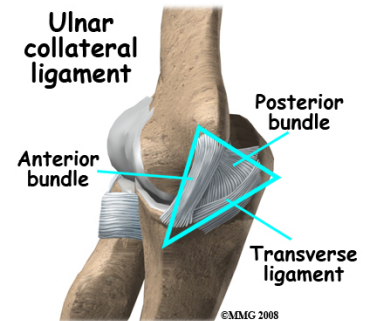


# Primary Injury Factors of Ulnar Collateral Ligament Reconstruction for Major League Baseball Pitchers by Statcast Measures

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• **Background:** Ulnar collateral ligament (UCL) is a thick triangular band at the elbow. According to the previous study, a quarter of Major League Baseball (MLB) pitchers undergo ulnar collateral ligament reconstruction (UCLR) surgery, also known as Tommy John Surgery (TJS) during careers<sup>1</sup>. Recently, MLB pitchers who got UCLR have significantly increased as they want to pitch faster.



Pitching tracking technology, such as PITCHf/x and Statcast, enabled us to measure more pitching-related factors. The proposed risk factors so far are (1) too many pitch counts<sup>2</sup>, (2) greater peak fastball velocity<sup>3</sup>, (3) higher fastball proportion among pitch types<sup>2</sup>, (4) demographics (age, height, and weight)<sup>2</sup>, and (5) release point<sup>2,4</sup>. However, since Statcast radars were installed in all stadiums in 2015, some Statcast measures have never been covered: **extension**, and **spin rate**. Also, we need to reidentify the factor that was already studied but not using the Statcast measure: **peak velocity**. As Statcast data are publicly available and have the greatest consistency among any other measuring methods, this would be a good opportunity to reevaluate the previous studies. The more we can predict UCL tears precisely, the more athletes would avoid the surgery. In a long-term perspective, this study could contribute to developing more scientific and systematic pitcher rotation management.

• **Objective/Hypothesis:** To identify primary injury factors that significantly affect an MLB pitcher's UCL damage among Statcast measures. The primary hypotheses are:

- Pitchers who got UCLR have a longer **extension** than pitchers who do not have UCL injury.
- Pitchers who got UCLR have greater **spin rate** than pitchers who do not have UCL injury.

The secondary hypothesis is:

- Pitchers who got UCLR have higher **peak velocity** than pitchers who do not have UCL injury.

• **Study Design:** Retrospective Case-Control Study

#### 4. What type of study design will you use to evaluate your hypothesis?

**a. Will you use an observational study (indicate whether prospective or retrospective and type), or a randomized controlled trial (RCT)?**

- Retrospective case-control study, one of the types of observational studies. Since we will use the MLB pitching data from 2015 to 2018, the study will be 'retrospective.'

**b. Will your design incorporate controls, multiple arms? (if so, describe)?**

- The study design will be divided into two groups: a case and a control group; A case group will consist of MLB pitchers who got UCLR between 2015 and 2018, whereas a control group will include MLB pitchers with no UCL injury.

**c. Will you be using blinding? (if so, describe how and why?)**

- The study will use blinding. In the process of matching the case to the control individually, if the name of a pitcher in the control were not anonymized, they could bias the matching process and potential result. The blinding procedure will be:
  - Fix the number of control pitchers.
  - Create a data table that consists of anonymized MLB pitchers with no UCL injury.
  - Individual matching based on **age**, **height**, **weight**, and **innings pitched**.

#### 5. Who are your study participants?

**a. Define inclusion/exclusion criteria [be sure to defend your exclusions].**

- As the data are uploaded on a real-time basis and publicly available, the total sample size will be  $n = 162$ ; the UCLR group is 81; the control group is 81. The sample will only consist of major league level pitchers. Major league level non-pitchers (i.e., field players), minor league level pitchers and non-pitchers will be excluded from the sample. The reason that all non-pitchers are excluded is due to the empirical data; Pitchers recorded a significantly higher prevalence of UCLR than non-pitchers (16% vs. 3%)<sup>1</sup>. Also, the previous study already determined that the time when MLB pitchers get UCLR and the time when minor league pitchers get UCLR are

different<sup>1</sup>. Most major league pitchers (86%) got their UCLR after they become professional, while the majority of minor league pitchers (61%) underwent their UCL reconstruction during high school and college.

- In the UCLR group (i.e., cases), pitchers who got UCLR between 2015 and 2018 will be allocated (n=81). On the other hand, in control group, pitchers who do not have UCL injury will be allocated (n = 81) following the matching procedures abovementioned.
- For those who have other injuries on other spots except UCL, they will be included.

**b. How will they be selected?**

- All cases between 2015 and 2018 will be selected. There are 81 MLB pitchers who got UCLR from 2015 and 2018. When it comes to the control group, it will be generated to match for potential confounders to UCL injury such as **age**, **height**, **weight**, and **innings they pitched** (i.e., role in a team). **Age**, **height**, and **weight** are known as risk factors in the previous studies<sup>4</sup>. Thus, these factors should be considered during the matching process.
- Regarding **innings pitched**, in MLB teams, pitchers are divided into two groups: starting pitchers and relief pitchers. A starting pitcher often pitches about five to six innings per game while a relief pitcher pitches one inning in general. Thus, it is obvious that a starting pitcher pitches more innings than a relief pitcher. The difference originated from a role in a team (starter vs. relief) should also be considered while matching.
- Through these four matching variables, the study can obtain power. In addition, pitchers with no UCLR injury resembles the case and are always at risk of UCL injury. These are essential conditions when determining matching criteria.
- When matching the case with the control individually, the blinding procedure mentioned above will be applied in order to prevent bias.

**6. What if (are) the independent variable(s) of your proposed study?**

- Independent variables are pitching Statcast measures: **extension**, **spin rate**, and **peak velocity**.

- Extension: the distance of a stride during pitching
- Spin rate: the rate of spin after the release of a ball, measured by revolutions per minute (RPM).
- Peak velocity: the fastest pitch in a game

**These may include risk factors/prognostic indicators and/or purposively applied interventions whose effects you wish to explore.**

**a. If your independent variable(s) is (are) a risk/prognostic factor(s), what procedure(s) will you use to measure it (them)? When will you measure it (them)?**

- The Statcast radars installed in all MLB teams' stadiums will automatically measure and save data on a real-time basis. The data is updated after the game on a daily basis and is publicly available [here](#).

**b. If your independent variable is an intervention, how/how long/how often will it be applied?**

- Case-control studies are observational and no intervention is involved.

**7. What are the primary (and secondary, if applicable) dependent variables (e.g., "outcome variables," "endpoints") of your proposed study?**

- **The probability of getting a UCL injury** is the primary dependent variable.

**a. What procedures will you use for measuring your dependent variables?**

- The procedures will be:
  - i. Pitchers who got UCLR (cases) and pitchers with no UCL injury (controls) will be summarized by using descriptive statistics (e.g., means, standard deviations, counts, and percentages).
  - ii. Differences and associations were tested with t-test or chi-square test for the four matching criteria: **age**, **height**, **weight**, and **innings pitched**.
  - iii. Test for each independent variable (i.e., **extension**, **spin rate**, and **peak velocity**) will be made through single-variable logistic regression. Hence three tests will be separate.

- iv. By using likelihood estimator, odds ratios and confidence level of 95% will be calculated.
- v. Report the results of each hypothesis testing and conclusion.

**b. How often/how long will you measure them?** One time during study.

## **8. Bonus questions for extra credit**

**a. What statistical approach will you use to interpret your results?**

- **Descriptive Statistics:** pitchers who got UCLR (cases) and pitchers with no UCL injury (controls) will be summarized by means, standard deviations, counts, and percentages.
- **T-test or chi-square test:** differences and associations will be tested with t-test or chi-square test for the four matching criteria: **age**, **height**, **weight**, and **innings pitched**.
- **Single-variable logistic regression:** test for each independent variable (i.e., **extension**, **spin rate**, and **peak velocity**) will be made through single-variable logistic regression. Hence three tests will be made separately.
- **Likelihood estimator:** odds ratios and confidence level of 95% will be calculated.
- **Hypothesis testing:** to report the results of each hypothesis testing and draw conclusion.

**b. How will you confirm whether your study hypothesis is likely to be correct?**

- For **extension** and **spin rate**, this study will be the first that covered these measures. Thus, we would tentatively confirm that the study hypothesis is likely to be correct until the report of a subsequent study with a larger sample size.
- For **peak velocity**,
  - If there is a conflicting result with the previous studies, we should seek to clarify the conflict by examining a large study sample longitudinally.
  - If the result is similar to that of the previous studies, we can confirm that this study's hypothesis is likely to be correct.

## • References

1. Conte SA, Fleisig GS, Dines JS, et al. Prevalence of Ulnar Collateral Ligament Surgery in Professional Baseball Players. *Am J Sports Med.* 2015;43(7):1764-1769

The study is a descriptive study which is the result of an online questionnaire distributed to all 30 teams. Each team's professional physical trainers answered the questionnaire to all players in the organization. However, this study includes not only 722 major league level players, but also 4366 minor league level players. (Total: 5088 players) There are six levels of minor leagues. Also, this study included both pitchers and field players. Continuous variables (age, years of professional baseball, and origin of country) are compared with Student t-tests ( $P < 0.05$ ), while categorical variables (level and position) were compared using chi-square test ( $p < 0.05$ ). The result showed that:

- (1) Pitchers (16%; 437 of 2706) recorded a significantly higher prevalence of UCLR than non-pitchers (3%; 60 of 2382). ( $P < 0.01$ )
- (2) Regarding the prevalence, major league pitchers recorded 25% (96 of 382) of UCLR, while minor league pitchers showed a 15% (341 of 2324). ( $P < 0.01$ )
- (3) Major league pitchers (28.8  $\pm$  3.9 years) are significantly older than minor league pitchers (22.8  $\pm$  3.0 years). ( $P < 0.01$ )
- (4) Most major league pitchers (86%) got their UCLR after they become professional, while the majority of minor league pitchers (61%) underwent their UCL reconstruction during high school and college ( $P < .001$ ).
- (5) There is no significant difference in prevalence concerning players' country of origin.
- (6) While minor league pitchers

2. Whiteside D, Martini DN, Lepley AS, Zernicke RF, Goulet GC. Predictors of Ulnar Collateral Ligament Reconstruction in Major League Baseball Pitchers. *Am J Sports Med.* 2016.

The study is a case-control study that consists of 104 MLB pitchers who got UCLR surgical treatments compared to 104 control group. The sample is matched by age and position, and it used the logistic regression model to identify predictors of UCLR among MLB pitchers. The result indicates six risk factors.

Pitchers would be highly likely to get UCL injury as:

- (1) there are fewer rest days between games.
- (2) a pitcher has smaller repertoire (i.e., a smaller number of pitch types).
- (3) a pitcher has less pronounced horizontal release point.
- (4) a pitcher has a shorter height.
- (5) a pitcher has greater average pitch velocity.
- (7) a pitcher has greater average pitch counts per game.

**3. Chalmers PN, Erickson BJ, Ball B, Romeo AA, Verma NN. Fastball Pitch Velocity Helps Predict Ulnar Collateral Ligament Reconstruction in Major League Baseball Pitchers. Am J Sports Med. 2016.44(8):2130-5**

The study is a case-control study to determine factors predictive of UCLR among MLB pitchers. The hypothesis was that pitchers who underwent UCLR would have higher preinjury peak fastball pitch velocity. The data were about 1327 MLB pitchers' average pitch velocity, peak fastball velocity, pitch counts, pitch types, and demographics from 2007 to 2015. The researcher put those pitchers in three categories, 'control,' 'pre-injury,' and 'post-operative.' Out of 1327 pitchers, 309 (26.8%) were in UCLR group; 145 (10.2%) were in pre-injury group; and the rest, 873 (65.8%) were allocated to the control. The study used the multivariate regression model, and the result demonstrated that:

- (1) Peak fastball velocity is statistically significant and primary independent predictor of UCLR.
- (2) Average pitch velocity, body mass index, and age are secondary predictors in order.
- (3) Pitch counts were not statistically significant.

**4. Portney DA, Lazaroff JM, Buchler LT, Gryzlo SM, Saltzman MD. Changes in Pitching Mechanics After Ulnar Collateral Ligament Reconstruction in Major League Baseball Pitchers. J Shoulder Elbow Surg. 2017;26(7):8**

The objectives of this study are (1) to compare the pre-injury throwing mechanics of pitchers who require UCLR surgery with those of pitchers who have never undergone UCLR and (2) to demonstrate the value of PITCHf/x data for understanding pitching-related injuries in MLB players. The study is a case-control study that consists of 166 MLB pitchers who got UCLR surgical treatments compared to 166 control group. The sample is matched by age and pitch counts, and it used the regression model. The result indices that:

- (1) Lateral release location and progressive lateralization of release point are significant risk factors of UCLR among MLB pitchers.
- (2) Pitch type and pitch velocity were not statistically significant between pitchers who underwent UCLR and pitchers in control group.