Title: Pitch-Specific Spin Rate, Velocity, and Movement Profiles Lead to Increased Odds of Undergoing Ulnar Collateral Ligament Reconstruction in Professional Baseball Pitchers

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Introduction: Ulnar collateral ligament (UCL) reconstruction (UCLR) is increasingly prevalent among Major League Baseball (MLB) pitchers. While workload and pitch count are known risk factors, advanced pitch-specific metrics have not been extensively analyzed for their role in UCL tears. This study examines pitch-specific velocity, spin rate, and movement characteristics for their association with undergoing UCLR.

Materials and Methods: A retrospective analysis was conducted using MLB pitchers who underwent UCLR between 2017 and 2024. Pre-injury pitch metrics, including velocity, spin rate, movement profiles, and pitch usage, were collected from Baseball Savant, a baseball metrics database, and compared to healthy league averages. Mann-Whitney U tests and logistic regression models were used to assess statistical differences and identify significant predictors of undergoing UCLR.

Results: A total of 132 pitchers who underwent UCLR were analyzed against 6,001 healthy league-average pitchers. Significant differences were observed in pitch velocity, with UCLR pitchers displaying higher average velocities for fastballs, sliders, changeups, and curveballs ($p < 0.001$). Increased spin rate for four-seam fastballs ($p = 0.0004$) and changeups ($p = 0.04$) was also associated with a greater likelihood of UCLR. Pitch movement characteristics, including decreased glove-side horizontal break on cutters ($p < 0.0001$) and increased arm-side movement on changeups ($p = 0.01$), were significant predictors of undergoing UCLR.

Discussion: This study demonstrates that specific pitch characteristics, including velocity, spin rate, and horizontal movement may be associated with an increased likelihood of undergoing UCLR.

Table 2. Comparisons between league averages and pitchers who underwent Tommy John		
Pitch Mix	Tommy John (N=number of pitchers who threw the respective pitch)	League Average (N=number of pitchers who threw the respective pitch)
4-Seam %	**42.9 (127)**	**38.1 (5655)**
Sinker %	21.2 (71)	24.8 (4106)
Cutter %	19.8 (34)	20.0 (1746)
Changeup %	12.6 (97)	13.2 (4645)
Slider %	26.4 (110)	24.4 (4518)
Curveball %	12.8 (72)	15.1 (3627)
Splitter %	16.7 (15)	16.7 (511)
Sweeper %	22.5 (11)	20.7 (531)
Fastball %	57.8 (132)	58.7 (6000)
Breaking ball %	30.8 (132)	29.3 (6000)
Off speed %	11.1 (132)	11.7 (6000)
Horizontal Movement (inches)		
4-Seam	-8.2 (127)	-7.7 (5655)
Sinker	-14.5 (71)	-14.4 (4106)
Cutter	**1.3 (34)**	**3.0 (1746)**
Changeup	**-14.1 (97)**	**-13.2 (4645)**
Slider	5.4 (110)	5.4 (4518)
Curveball	8.5 (72)	8.7 (3627)
Splitter	**-8.1 (15)**	**-10.3 (511)**
Sweeper	15.1 (11)	14.0 (531)
Vertical Movement W/ Gravity (inches)		
Slider	**-36.0 (110)**	**-37.1 (4518)**
Curveball	-52.9 (72)	-54.0 (3627)
Sweeper	-40.4 (11)	-41.1 (531)
Vertical Movement Induced (inches)		
Slider	1.8 (110)	1.9 (4518)
Curveball	-8.9 (72)	-8.5 (3627)
Sweeper	1.1(11)	0.6 (531)
Velocity (mph)		
4-Seam	**94.6 (127)**	**93.2 (5655)**
Sinker	**94.4 (71)**	**92.7 (4106)**
Cutter	**90.0 (34)**	**88.6 (1746)**
Changeup	**86.9 (97)**	**85.3 (4645)**
Slider	**85.5 (110)**	**84.4 (4518)**
Curveball	**79.7 (72)**	**78.5 (3627)**
Splitter	86.1 (15)	85.8 (511)
Sweeper	81.5 (11)	81.4 (531)
Spin Rate (rpm)		
4-Seam	**2301.3 (127)**	**2253.2 (5655)**
Sinker	2197.0 (71)	2170.3 (4106)
Cutter	2341.6 (34)	2333.1 (1746)
Changeup	**1810.8 (97)**	**1757.4 (4645)**
Slider	2384.6 (110)	2359.7 (4518)
Curveball	2451.1 (72)	2448.3 (3627)
Splitter	1285.4 (15)	1403.3 (511)
Sweeper	2566.2 (11)	2527.5 (531)