Pitching Flaws and UCL Injury

Brandon J. Erickson, MD
Section Chief, Shoulder & Elbow Surgery
Phelps Hospital
Assistant Team Physician: Philadelphia Phillies
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Disclosures

• AOSSM Committee Member
• Editorial Board PLOS One

As Flawless As You Can Get
Unfortunately, Injuries Occur

Why is the UCL Vulnerable?

- 64 Nm of force is generated at the elbow with each pitch
- Bony and muscular structures see 32 Nm
- UCL sees the other 32 Nm
  - UCL fails at 33-36 Nm of force
  - Approaches failure with each pitch

Define The “Ideal” Pitching Motion

- Pitching motion is a kinetic chain
  - Each subsequent segment receives the potential and kinetic energy received and generated by the previous segment
- Large muscles of the lower extremity and trunk generate force during wind-up and early cocking phases
- This force is transferred to the ball via the shoulder and elbow during the cocking and acceleration phases
Why Is This “Ideal”?  
- Minimize torque on the shoulder and elbow  
- Allows the pitcher to generate:  
  - Forceful pitch  
  - Reproducible pitch repertoire

What is Not “Ideal” for the UCL?  
- Altered knee flexion at FFC and ball release  
- Increased elbow flexion at ball release  
- Early trunk rotation  
- Loss of shoulder rotational ROM  
- Excessive Scapular IR

Throwing Motion
The Pitching Cycle

- Purpose was to examine difference in pitching mechanics between two age groups
  - Young group (10): Avg age: 20; all minor league players
  - Older group (12): Avg age: 30; 10/12 were major league players

- Markered analysis of pitchers throwing 10 fastballs at maximum effort

- Calculated 18 different kinematic variables at different points in the pitching cycle

The relationship between age and baseball pitching kinematics in professional baseball pitchers

Shouchen Dun, Glenn S. Fleisiag*, Jeremy Loifice, David Kingsley, James R. Andrews

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<table>
<thead>
<tr>
<th>Variable</th>
<th>Younger group (n=10)</th>
<th>Older group (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead foot contact</td>
<td>82.5 ± 4.3</td>
<td>77 ± 5.1</td>
</tr>
<tr>
<td>Lead foot position</td>
<td>22.4 ± 6.9</td>
<td>22.7 ± 6.1</td>
</tr>
<tr>
<td>Knee flexion (°)</td>
<td>172.0 ± 9.3</td>
<td>172.0 ± 9.3</td>
</tr>
<tr>
<td>Shoulder internal rotation (°)</td>
<td>47.7 ± 20.5</td>
<td>34.6 ± 13.9</td>
</tr>
<tr>
<td>Knee extension</td>
<td>185.1 ± 13.9</td>
<td>185.0 ± 13.9</td>
</tr>
<tr>
<td>Knee flexion (°)</td>
<td>24.4 ± 9.7</td>
<td>24.6 ± 9.7</td>
</tr>
<tr>
<td>Knee extension</td>
<td>185.1 ± 13.9</td>
<td>185.0 ± 13.9</td>
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</tbody>
</table>

- Maximum pitching angular velocity (°/s) | 365.3 ± 56.6 | 363.2 ± 56.2 |
- Maximum upper trunk angular velocity (°/s) | 308.4 ± 36.9 | 316.4 ± 36.5 |
- Maximum shoulder external rotation (°) | 195.2 ± 14.3 | 195.2 ± 14.3 |
- Elbow extension | 185.2 ± 13.9 | 185.2 ± 13.9 |
- Shoulder adduction | 253.3 ± 108.4 | 259.1 ± 108.9 |
- Maximum shoulder internal rotation angular velocity (°/s) | 725.5 ± 1524 | 662.6 ± 1587 |
- Lead foot velocity (°/s) | 24.4 ± 9.7 | 24.6 ± 9.7 |
- Front shoulder flexion from rear foot (°) | 17.4 ± 9.1 | 23.4 ± 10.2 |
| Lead foot velocity | 47.7 ± 20.5 | 34.6 ± 13.9 |
• Purpose was to determine the biomechanical factors contributing to elbow valgus torque during pitching

• Collected video on 14 youth pitchers throwing fastballs

• Found an increase in elbow valgus torque as elbow flexion angle increased

• Elbow flexion increases the length of the lever arm, the inertial moment of humeral rotation, and elbow valgus torques which in turn increase strain on the UCL

• Purpose was to measure the effects of sequential body motion on elbow valgus torque during baseball pitching

• 69 adult baseball players pitched off an indoor mound during 3-D motion analysis
  • Collegiate (n = 58), minor league (n = 8), major league (n = 3)

• Joint torques of the throwing arm were calculated using the inverse dynamics technique (Feltner and Dapena)
  • Essentially this estimates the forces and torques about a joint based on the kinematics of its movement and the inertial properties of adjacent segments

• Purpose was to measure the effects of sequential body motion on elbow valgus torque during baseball pitching

• 69 adult baseball players pitched off an indoor mound during 3-D motion analysis
  • Collegiate (n = 58), minor league (n = 8), major league (n = 3)

• Joint torques of the throwing arm were calculated using the inverse dynamics technique (Feltner and Dapena)
• GH PROM was recorded over 8 seasons at spring training for all pitchers of a single professional baseball organization
• Total of 505 examinations on 296 pitchers
• Measured IR and ER, and recorded TROM (IR+ER)
• 49 elbow injuries and 8 surgeries in 38 total players

• Pitchers with deficits of >5° in TROM in their throwing shoulders had 2.6x greater risk for injury. Pitchers with deficit of >5° in flexion of the throwing shoulder had a 2.8x greater risk for injury.

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• Measured shoulder ROM over 6 seasons (2010-2015) on all pitchers invited to MLB Spring Training for a single organization
• Included 136 pitcher seasons
• 53 injuries occurred: 28 elbow and 25 shoulder

• Most significant risk factor for elbow injury was shoulder flexion deficit >5°

• Risk of elbow injury increased by 7% for each degree of increased shoulder ER deficit and 9% for each degree of decreased shoulder flexion
Purpose: compare lower extremity balance and shoulder ROM of baseball players with and without a UCL tear

60 male HS and Collegiate baseball players were included

- 30 w/ Hx of UCL tear and 30 healthy controls
- Measured IR and ER, and calculated TROM (IR+ER)
- Also performed Y Balance Test as a measure of trunk and lower extremity function
- Stance limb is trail leg

Purpose: evaluate increased scapular IR and shoulder ER on elbow valgus load

- Cadaveric study (7 specimens)
- Increases in scapular IR >5° significantly decreased shoulder ER
- To compensate for ER deficit at 40° of scapular IR, 25.3 N m of valgus torque was necessary to reach the original forearm position compared to 5.25Nm with intact condition (P < .01)

Purpose: compare biomechanics of pitchers w/ Hx of UCLR to controls with no Hx to their throwing elbow or shoulder

Authors hypothesized that pitchers with Hx of UCLR would have:

- Significantly different throwing elbow and shoulder biomechanics
- Excessive shoulder horizontal adduction
- Late shoulder rotation
- Improper shoulder abduction and trunk lateral tilt

Pitchers threw 10 fastballs at 100% effort for analysis
No difference in biomechanics between groups

<table>
<thead>
<tr>
<th>Biomechanical Comparison Between the UCL and Control Groups</th>
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<tbody>
<tr>
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<tr>
<td>Arm extension</td>
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<tr>
<td>Maximum elbow flexion, deg</td>
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<tr>
<td>Maximum shoulder external rotation, deg</td>
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<tr>
<td>Maximum elbow external torque, Nm</td>
</tr>
<tr>
<td>Maximum shoulder internal rotation, deg</td>
</tr>
<tr>
<td>Maximum shoulder horizontal adduction torque, Nm</td>
</tr>
<tr>
<td>Maximum elbow extension velocity, deg</td>
</tr>
<tr>
<td>Maximum elbow internal rotation velocity, deg</td>
</tr>
<tr>
<td>Maximum shoulder internal rotation velocity, deg</td>
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<tr>
<td>Flexion associated with &quot;setting back&quot;</td>
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<tr>
<td>Trunk forward lift at ball release, deg</td>
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<tr>
<td>Arm rearing</td>
</tr>
<tr>
<td>Shoulder external rotation at foot contact, deg</td>
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<tr>
<td>Forearm plane adduction</td>
</tr>
<tr>
<td>Anterior at ball release, deg</td>
</tr>
<tr>
<td>Trunk forward lift at ball release, deg</td>
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</tbody>
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A Biomechanical Comparison of Youth Baseball Pitchers

<table>
<thead>
<tr>
<th>Comparison of Arm Force and Torque Among Pitch Types (n = 20)</th>
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<tbody>
<tr>
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<tr>
<td>Arm cocking phase</td>
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<tr>
<td>Elbow flexion torque (Nm)</td>
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<tr>
<td>Shoulder internal rotation torque (Nm)</td>
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<tr>
<td>Arm repositioning</td>
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<tr>
<td>Wrist flexion torque (Nm)</td>
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<tr>
<td>Forearm adduction torque (Nm)</td>
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<tr>
<td>Elbow flexion force (N)</td>
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<tr>
<td>Shoulder external rotation force (Nm)</td>
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<td>Shoulder horizontal adduction force (Nm)</td>
</tr>
<tr>
<td>Shoulder adduction force (Nm)</td>
</tr>
<tr>
<td>Shoulder adduction torque (Nm)</td>
</tr>
</tbody>
</table>

Significant at P < 0.1. No difference was found between the fastball versus curveball, fastball versus change-up, and curveball versus change-up.

Bring It Home

- Altered knee flexion at FFC and ball release
- Increased elbow flexion at ball release
- Early trunk rotation
- Loss of shoulder rotational ROM
- Excessive Scapular IR
Changes in pitching mechanics after ulnar collateral ligament reconstruction in major league baseball pitchers

- Used pitch tracing data to evaluate fastball percentage, release location, velocity, and movement of each pitch type before and after UCLR in 50 MLB pitchers
- Pitch selection, pitch velocity, and pitch accuracy do not significantly change after UCLR
- Pitch release location is more medial after UCLR for all pitch types except sliders
- Breaking movement of fastballs, sliders, and curveballs changes after UCL reconstruction