The Science of Understanding and Preventing Baseball Injuries

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Technology is changing the way we analyze athletes
Sports biomechanics uses tools to assess athletes to improve performance and prevent injuries.
The Science of Understanding and Preventing Baseball Injuries

1. Injury epidemic in baseball
2. Biomechanical tools
3. Applying tools to prevent injury and increase performance

Injury Epidemic in Baseball

- Throwing elbow injuries common at all levels of baseball
- Ulnar Collateral Ligament Injury
  - "Tommy John" injury

Injury Epidemic in Baseball

- What is the UCL?
  - Ligaments are strong bands of tissue
    - hold bones together
    - help control the movement of joints
  - When torn, the tether is too long and the bones move too much
  - UCL complex located on inside of elbow
  - Pitchers UCL larger from throwing
Injury Epidemic in Baseball

– What are the risk factors for UCL injury?(1-5)

• Age
• Pitch velocity
• Pitch type
• High pitch counts
• Pitching year round
• Pitching consecutive days
• Pitching when fatigued

• Geography
• Sports Specialization
• Poor mechanics


Injury Epidemic in Baseball

– How is the UCL repaired?

• UCL Reconstruction = Tommy John surgery
• Named after first player to undergo procedure, performed in 1974 by Dr. Frank Jobe
• Tendon taken from somewhere else in body, or from a donor, to serve as new UCL
Injury Epidemic in Baseball

– Injury rates
  • Injury trends in MLB over 18 seasons: 1998 – 2015 (6)

Injury Epidemic in Baseball

– Return to Play rates
  • Performance and Return to competition after Tommy John (7)
    – 80% returned to pitch at least 1 MLB game
    – 67% of established pitchers (>10 games) returned to same level of competition
    – 57% returned to DL due to throwing arm injury
  • Prevalence of UCL surgery in professional baseball players (8)
    – 25% of MLB pitchers have history of UCL reconstruction
    – 15% of MLB pitchers

Injury Epidemic in Baseball

– Injury rates and Return to Play rates
  • MLB pitchers make up a small percentage of the overall patient population undergoing Tommy John surgery (9)
    – 0% of high school baseball players play in college
    – 0.5% of high school baseball players play in MLB
    – 15 to 19-year-old age group account for significantly more Tommy John procedures than any other age group (58% of all procedures)
    – Incidence of procedures increased at rate of 9% per year
    – Pitchers age 20 to 24 account for 22% of all procedures

Injury Epidemic in Baseball

– Public Perception of Tommy John (10)
  • 30 - 51% coaches and players believe Tommy John should be performed without elbow injury to enhance performance
  • 28 - 31% coaches and players did not believe number of pitches thrown to be a risk factor
  • 20 - 28% coaches and players believe performance would be enhanced beyond pre-injury level
  • Alarming misconceptions about Tommy John surgery

Injury Epidemic in Baseball

– Injury epidemic is very concerning
– What is being done about it?
  • Sports biomechanists are working to understand how we can reduce/predict injuries

Biomechanical Tools

– What is Biomechanics?
  • Study of movement (kinematics) and the effects of forces (kinetics) on living bodies
Biomechanical Tools

- Kinetics: Forces and Moments

- Force plates
  - Have force transducers that determine force
  - Forces measured:

- Motion analysis systems
Biomechanical Tools

- Motion Analysis Systems
  - Used to capture 3D movements in digital form
  - Considered gold standard
  - Body modeled as system of rigid links connected at joints
  - Used in clinical gait, sport analysis, entertainment industry

Biomechanical Tools

- Equipment
  - Infrared cameras
  - Markers
  - Software

Biomechanical Tools
Biomechanical Tools

• Calibration
  – Enables image coordinates of each camera to be converted to real world 3D coordinates of each marker
  – 2 step process:
    • Static Calibration (L-frame)
    • Dynamic Calibration (wand)

Marker Sets

• Minimum of 3 markers required per segment
• Each marker must be seen by 2 cameras
• Marker set selection
Biomechanical Tools

• Data Analysis
  – Going from marker trajectories to kinematics
  – Biomechanical Model: mathematical model that describes motion

• Biomechanical Model
  – Markers used to define segments
  – Define each segment LCS
  – Kinematics calculated
  – Motion analysis measures position, calculations to determine joint angles, velocity, acceleration

\[ x \rightarrow \dot{x} = \frac{dx}{dt} = v \rightarrow \ddot{x} = \frac{d^2x}{dt^2} = a \]

• How do we calculate forces?
  – Mass of body segment calculated as % of total body mass
  – Newton’s 2nd law: acceleration of object dependent on force and mass
    • Force = mass x acceleration \( F = m \cdot a \)
Biomechanical Tools

• Using biomechanical tools, we can analyze pitching mechanics
  – Able to quantify joint angles, velocity, acceleration and forces
• Apply these methods to assess injury risk in pitchers

Applying Tools

– First 3D kinematic and kinetic analysis of pitchers was conducted in 1989 by Feltner and Dapena

Applying Tools

Applying Tools

- Fleisig examined elbow and shoulder kinetics of mound pitching on 26 highly skilled, healthy adult pitchers (12)
  - Found 2 critical instants during pitch
  1. Just prior to maximum external rotation (MER)
     - 67 Nm of shoulder torque generated
     - 64 Nm of elbow torque generated
  2. Just after ball release (BR)
     - 1090 N of shoulder force produced

Applying Tools

- Critical Instant #1
  - During arm cocking phase, just prior to MER
    - Shoulder 165° external rotation
      - Large Shoulder Torque
    - Elbow: 95° flex
      - Large Elbow Torque
      - UCL load near maximum capacity

Applying Tools

- Number of Baseball Pitching Publications per Year
Applying Tools

<table>
<thead>
<tr>
<th>Pitch Count Limits and Required Rest Recommendations</th>
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<tbody>
<tr>
<td>Age</td>
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<tr>
<td>-----</td>
</tr>
<tr>
<td>0-9</td>
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<td>10-19</td>
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<td>≥20</td>
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https://www.mlb.com/pitch-smart

Applying Tools

- Use Motion Analysis to assess pitcher’s mechanics
  - Player with high torques or forces, look in depth at mechanics
Sports biomechanics uses tools to assess athletes to improve performance and prevent injuries.