An Evidenced Based Biomechanical Approach to Shoulder and Elbow Rehabilitation and Screening of the Overhead Throwing Athlete
Welcome!!

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Why are we here today?

• During the past few years, there has been an epidemic rise in shoulder and elbow injuries in youth, high school, collegiate, and major league pitchers

• Big Question???
  • Why?
  • What is being done to combat this epidemic?
Who is more likely to hurt their shoulder or elbow?
Injury Prevalence

• Major League Baseball
  • Shoulder injuries account for 28% of all injuries.
  • Elbow Injuries account for 26% of all injuries.
  • In 2014, 18 pitchers had Tommy John Surgery prior to the all-star break (that was one shy of all Tommy John Surgery in 2013).

• College/High School
  • 33% of all elbow injuries involve the UCL.
  • 25% of all shoulder injuries involve the labrum.
  • 15% of all pitchers stated current performance limitations were related to injuries sustained during youth baseball.
Clinical Pearl

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# Current Interventions - Pitch Count

<table>
<thead>
<tr>
<th>Age</th>
<th>2006 USA Baseball Guidelines</th>
<th>2010 Little League Baseball Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Daily Limits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-18</td>
<td>N/A</td>
<td>105/day</td>
</tr>
<tr>
<td>15-16</td>
<td>N/A</td>
<td>95/day</td>
</tr>
<tr>
<td>13-14</td>
<td>75/game</td>
<td>95/day</td>
</tr>
<tr>
<td>11-12</td>
<td>75/game</td>
<td>85/day</td>
</tr>
<tr>
<td>9-10</td>
<td>50/game</td>
<td>75/day</td>
</tr>
<tr>
<td>7-8</td>
<td>N/A</td>
<td>50/day</td>
</tr>
<tr>
<td><strong>Weekly Limits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>N/A</td>
<td>31-45 pitches = 1 day rest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46-60 pitches = 2 days rest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>61-75 pitches = 3 days rest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>76+ pitches = 4 days rest</td>
</tr>
<tr>
<td>13-14</td>
<td>125/week; 1000/season; 3000/year</td>
<td>21-35 pitches = 1 day rest</td>
</tr>
<tr>
<td>11-12</td>
<td>100/week; 1000/season; 3000/year</td>
<td>36-50 pitches = 2 days rest</td>
</tr>
<tr>
<td>9-10</td>
<td>75/week; 1000/season; 2000/year</td>
<td>51-65 pitches = 3 days rest</td>
</tr>
<tr>
<td>7-8</td>
<td>N/A</td>
<td>66+ pitches = 4 days rest</td>
</tr>
</tbody>
</table>

Current Interventions- Pitch Type

• Trouble with the curveball
  • Fact or Fiction?

• Slider
  • In high school and college pitchers, throwing a slider too often and without proper technique resulted in an 86% chance of elbow injury.
Current Intervention- Fatigue Recognition

• Signs of Fatigue
  • Reduction in velocity
  • Loss of command
  • Truck position is more vertical at follow-through (indicator of lower extremity fatigue and increased reliance on the arm)
  • Increased time between pitches
Current Interventions - Fatigue Recognition

• Other measurable indicators of fatigue
  • 1st to 3rd base running time
  • Athletic tracking questionnaire (weight, resting HR, sleep duration, sleep disturbances, pain, perceived preparedness)
  • Vertical jump
  • Body composition

Current Interventions- Other Factors

- Pitching on multiple teams
- Poor pitching mechanics
- Limited off-season rest
- Pitching and catching in the same game (Little League Guideline)
- Poor physical conditioning
Public Perception

Public perceptions of Tommy John surgery.


- 189 players, 15 coaches, and 31 parents
Public perceptions of Tommy John surgery

- 30% coaches, 37% of parents, 51% of high school athletes, and 26% of collegiate athletes believed that Tommy John surgery should be performed on players without elbow injury to enhance performance.
Public perceptions of Tommy John surgery

- 31% of coaches, 28% of players, and 25% of parents did not believe number of pitches thrown to be a risk factor.
- 38% of coaches, 29% of players, and 25% of parents did not relate pitch type (eg, curve balls) with risk of injury.
Public perceptions of Tommy John surgery

• 28% of players and 20% of coaches believed that performance would be enhanced beyond pre-injury level.

• Return to Play: Individuals underestimated the time required to return to competition. 24% of players, 20% of coaches, and 44% of parents believed that return would occur in < 9 months.
Public perceptions of Tommy John surgery

• Conclusion: “Efforts should be made in our communities to better educate players, coaches, and parents regarding elbow ulnar collateral ligament injury in youth baseball players.”
Tommy John Surgery

- 1970-80’s: 50% returned to sport, high complication rate
- 1990’s to 2000’s: 80-90% return to same level???
Results: Current Data

Performance, Return to Competition, and Reinjury After Tommy John Surgery in Major League Baseball Pitchers: A Review of 147 Cases. Makhni EC\textsuperscript{1}, Lee RW\textsuperscript{1}, Morrow ZS\textsuperscript{1}, Gualtieri AP\textsuperscript{1}, Gorroochurn P\textsuperscript{2}, Ahmad CS\textsuperscript{3}. Am J Sports Med. 2014 Apr 4;42(6):1323-1332.
Am J Sports Med. 2014 Apr

- 80% returned to at least 1 MLB game
- 67% returned to same level
- 57% returned to disabled list
- Performance did not improve compared to prior to injury and declined-- earned run average, batting average against, walks plus hits per inning pitched, percentage of pitches thrown in the strike zone, innings pitched, percentage fastballs thrown, and average fastball velocity.
Call to Action

• Despite current guidelines and precautions (pitch counts, pitch types, off-season rest...), many pitchers are still sustaining overuse injuries to their throwing arm.

• It is vital that we as AT’s, PT’s, MD’s, and coaches develop better ways to identify players who are at risk for injury.
Regional Interdependence

• States that seemingly unrelated impairments in a remote anatomical region may contribute to, or be associated with, the patient’s primary complaint.

GIRD vs TRM

• GIRD
  • Glenohumeral Internal Rotation Deficit
  • A loss of internal rotation range of motion of the throwing arm compared to the non-throwing arm from 12-20°

• TRM
  • Total Rotational Motion
  • The sum of passive glenohumeral external rotation and internal rotation at 90° of abduction in the plane of the scapula
Why GIRD Exists?

• Tightness of the posterior capsule
• Laxity of the anterior capsule
• Osseous changes that result in humeral retroversion


• significantly strong inverse relationship between humeral retroversion of the throwing arm and severe injuries to the shoulder (r=-0.90) and elbow (r=-0.85).

• There was no evidence to support that humeral retroversion would predict injury

• For every 10° of humeral retroversion of the dominant arm compared to the non-dominant arm, there was a 30% reduction in injury risk.
Total Rotational Motion (TRM)
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Odds Ratio for Shoulder Injury</th>
<th>P-Value</th>
<th>Odds Ratio for Elbow Injury</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIRD (&gt;20° deficit of IR)</td>
<td>1.9</td>
<td>0.17</td>
<td>1.0</td>
<td>0.55</td>
</tr>
<tr>
<td>TRM Deficit (&gt;5° side-to-side difference)</td>
<td>2.5</td>
<td>0.03</td>
<td>2.6</td>
<td>0.007</td>
</tr>
<tr>
<td>Passive Shoulder Flexion Deficit (&gt;5° side-to-side difference)</td>
<td>---</td>
<td>---</td>
<td>2.8</td>
<td>0.008</td>
</tr>
</tbody>
</table>


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• What does TRM and GIRD look like after pitching?
  • Measurements taken just before pitching (50-60 pitches), immediately after pitching, and one day after pitching.
  • Significant increases in GIRD and reduction in TRM were present immediately after pitching and one day later

• When it is safe to throw again?
  • Restore TRM!

Exploring the Kinetic Chain
Exploring the Kinetic Chain- Balance

- Single leg balance has often been regarded a test to assess lower extremity stability, core stability, and neuromuscular postural control, and without adequate lower extremity and core stability there can be a compromise of energy transfer through the throwing kinetic chain placing excessive physical stress on distal structure such as the shoulder and elbow.
Exploring the Kinetic Chain- Balance

  • Division III overhead athletes with a non-traumatic shoulder injury demonstrated significantly reduced SLS balance compared to those without a shoulder injury.

  • high school baseball players, mostly pitchers, with a confirmed UCL tear had significantly decreased composite scores on the Y-Balance test on both lower extremities compared to thirty controls without a UCL tear
Exploring the Kinetic Chain- Hip, Pelvis, and Trunk Control

- It has been suggested that the pelvis and torso contribute as much as 50% to the kinetics of throwing.


Exploring the Kinetic Chain- Hip, Pelvis, and Trunk Control

Trail Leg Muscle Activation Pattern During Pitching

Stride Leg Muscle Activation Pattern During Pitching

Exploring the Kinetic Chain- Hip, Pelvis, and Trunk Control

• Throughout the phases of throwing, both the pelvis and the torso rotate toward the direction of throwing.

• There is a statistically significant positive correlation between trail leg gluteus maximus activity and increased pelvic rotation velocity at both cocking phase \( r=0.73 \) and ball release \( r=0.831 \). A negative correlation with gluteus medius activity \( r=-0.824 \)

• The rate of pelvic rotation was significantly related to the rate of torso rotation \( r=0.971 \)

Exploring the Kinetic Chain- Hip, Pelvis, and Trunk Control

• The strong positive correlations between the rate of pelvic rotation and torso rotation, and the fact that there is a strong correlation between gluteus maximus activity and pelvic rotation suggest that adequate hip and gluteal function in the transverse plane is necessary to control pelvic and torso mechanics needed to pitch safely.

  
  • positive correlation between total rotational hip motion of the lead leg measured in prone with shoulder external rotation torque in Division I collegiate baseball pitchers (r=0.56)
  
  • significant relationship was also found with total rotational hip motion of the trail leg and shoulder horizontal adduction during throwing (r=0.43).
Momentum Baseball Pitcher Shoulder and Elbow Injury Screen
Passive Shoulder Flexion

A passive glenohumeral flexion range of motion side-to-side difference of more than 5° is significantly more likely to develop an elbow injury (odds ratio=2.8).

Athlete lays supine with hips and knees flexed with the scapula lightly stabilized as the humerus is passively flexed to end-range.

Goniometric placement: axis= acromion process, through the head of the humerus. Stationary arm= parallel to the trunk. Moving arm= longitudinal axis of the humerus.
Passive Total Arc of Motion (Total Rotational Motion)

Sum of passive glenohumeral external rotation and internal rotation at 90° of abduction in the plane of the scapula. If there was a side-to-side difference of more than 5°, the odds ratio for the development of a shoulder or elbow injury in a pitcher was 2.5 and 2.6 respectively.

78% of those that developed a shoulder injury had a throwing arm TRM greater than 176° suggesting that there is a limit to how much motion should be achieved.

Goniometric Placement: Axis= olecranon process of the ulna. Stationary arm= perpendicular to the ground. Moving arm= along the ulnar shaft to the styloid process.

The humeral head and coracoid process are palpated, but not stabilized, to determine the end-range of rotation.
Single Leg Stance Balance

Measure of static core and LE stability, neuromuscular postural control.

Momentum standard of 30sec bilaterally with eyes open looking toward direction of pitch. Hands together, hip flexion to 90°, no Trendelenburg or trunk lean, no major loss of balance.

Performed with shoes off.
Single Leg Stance Anterior Reach

Assess dynamic balance, lower extremity range of motion, core stability, and postural control

Performed without shoes, stance leg heel remains flat, reaching leg slides the box forward without touching the ground and then returns to the starting position. Momentum standard of less than or equal to 4cm difference side-to-side. Record best of 5 reaches.


Single Leg Stance Total Lower Extremity Rotation Mobility and Stability

If the pitcher does not have adequate transverse plane mobility and stability of the pelvis and lower extremity, the athlete risks throwing in a more “open” or “closed” position.

A grid was created that has two lines 15° below the horizontal. The athlete’s lower extremity to be tested is placed in the center of the grid with the medial malleolus aligned with the horizontal line and the second metatarsal over the line that would bisect the intersection of the two taped lines.
Single Leg Stance Total Lower Extremity Rotation Mobility and Stability

The athlete flexes the contralateral hip to 90° with the tibia held perpendicular to the ground. Two markers are placed along the arc of motion the athlete’s raised tibia will follow in the transverse plane. One marker is placed on the horizontal line in the direction that the stance leg would move into relative external rotation, and the other on the line 15° below the horizontal in the direction that the stance leg would move into relative internal rotation.
Single Leg Stance Total Lower Extremity Rotation Mobility and Stability

The athlete will move the pelvis and torso into relative internal rotation of the stance leg so that contralateral, vertical lower leg contacts the marker at 15° below the horizontal, and then moves the pelvis and torso into relative external rotation of the stance leg to contact the other marker on the horizontal line.

This is a pass/fail test, and the athlete must keep the airborne tibia vertical, contact both markers, and do so without a loss of balance three times.

Test is performed bilaterally.
Single Leg Stance
Cross Over Reach

There is a gradual increase in trial leg muscle activity from foot contact to ball release, and the peak values of stride leg muscle activity peaks from ball release through the follow-through phase. This suggests that the pitcher does not “push off the rubber” when throwing, but rather is more a “controlled fall.”

Tests for dynamic lower extremity and core mobility and stability during the follow-through phase of throwing.

Momentum standard of no major loss of balance, trail leg remains in the air at all times, cannot reach down to touch the ground, must successfully complete 10/12 attempts bilaterally.
Clearing Tests

Pain provocation indicates failure of the tests, and it is recommended the athlete seek further evaluation from a healthcare professional.

- Yocum’s Test for Shoulder Impingement
- Milking Maneuver (valgus elbow stress at 90° of elbow flexion)

Both tests are performed bilaterally.
Summary

• Despite current guidelines and precautions (pitch counts, pitch types, off-season rest...), many pitchers are still sustaining overuse injuries to their throwing arm.

• It is vital that we as AT’s, PT’s, MD’s, and coaches develop better ways to identify players who are at risk for injury.

• Athletic Trainers: Pre-season screening of the throwing kinetic chain is vital to reduce injury risk and maintain performance. Treatment and conditioning exercises should include aspects of the kinetic chain.
  • If an athlete demonstrates a positive screen: further examination is warranted, possible referral to PT and/or MD.
Summary

• Coaches: Appreciate that there is a strong association with throwing liking system deficits not only with injury risk, but also with performance.
  • Screening of the linking system can identify “performance leaks”
  • Dynamic warm-up prior to activity can prepare the linking system for optimal performance.