Elbow Biomechanics and Rehab of the Overhead Throwing Athlete

CSM 2019 Educational Session – Sports PT Section

- Biomechanics and Pathology of the Overhead Throwing Elbow and the Current Epidemic of UCL Injuries - Rafael Escamilla, PhD, PT, CSCS
- Relationship of Segmental Energy Flow and Elbow Valgus Load During Baseball Pitching - Arnel Aguinaldo, PhD, ATC
- Rehabilitation Following UCL Surgery: Reconstruction & Repair Internal Brace – Kevin E. Wilk, PT, DPT, FAPTA
- How Baseball Players Can Safely Enhance Performance While Reducing Injuries – Mike Reinold, DPT, SCS, ATC, CSCS
- Functional Return to Sport for the Overhead Athlete, PT, DPT, CSCS

Purpose of Studying Throwing Elbow Biomechanics

MECHANICAL EFFICIENCY

- Prevention of Injury
- Performance Enhancement

- Decreased Energy Expenditure
- Decreased Force & Torque on Joints
- Increased Control
- Increased Velocity
- Decreased Fatigue
- Increased Stamina
- Decrease in Tissue Stress

Quantitative Analysis of Pitching Mechanics

100 x 50 x 25 ft. Indoor Laboratory

Quantitative Analysis of Elbow Pitching Mechanics

- Kinematics - Describes How Motion Occurs
  - Quantifies Elbow Angles, Velocities, & Accelerations
- Kinetics – Explains Why Motion Occurs
  - Quantifies Elbow Forces & Torques
- Electromyography
  - Quantifies Elbow Muscle Activity
ASMI Throwing Tests: 1989-present
1600+ Pitchers Tested

- >300 High School
- >500 College
- >300 Minor League
- >500 Youth
- >50 Recreational
- >200 Major League

1993 Cy Young
2002 Cy Young
2006 Cy Young
2007 Cy Young
2008 Cy Young
2009 Cy Young
2003, 2010 Cy Young

Kinematics at Lead Foot Contact
(Escamilla et al., 1998; Fleisig et al., 1999)

Elbow Flexion

80° 100°

Arm Cocking Forearm EMG
(DiGiovine et al., J Shou Elb Surg, 1992)

- Flexor/Pronator Mass (moderate activity)
  - Pronator Teres – 39% MVC
  - Flexor Carpi Radialis – 47% MVC
  - Flexor Carpi Ulnaris – 41% MVC
  - Flexor Digitorum Superficialis – 47% MVC

- Supinator/Extensor Mass
  (moderate to high activity)
  - Supinator – 54% MVC
  - Extensor Carpi Radialis Longus – 72% MVC
  - Extensor Carpi Radialis Brevis – 75% MVC
  - Extensor Digitorum Communis – 59% MVC

Kinematics During Arm Cocking
(Escamilla et al.,1998; Fleisig et al., 1999)

Max Elbow Flexion

Arm Cocking Elbow Kinetics
(Escamilla et al., 2002; Fleisig et al., 1995)

Elbow
  - Varus Torque = 64 Nm
  - Peak Varus Torque
    Occurs at Max Shoulder
    ER to Resist Valgus Stress

Phases of Pitching

1. Wind-Up
2. Stride
3. Arm Cocking
4. Arm Acceleration
5. Arm Deceleration
6. Follow-Through
Arm Cocking Elbow Pathomechanics

Mediolateral Elbow Injuries

- Medial Tensile Injuries
  - Ulnar Nerve
  - Ulnar Collateral Ligament (UCL)
  - Medial Epicondylitis

- Lateral Compression Injuries
  - Osteochondritis Dissecans

Cain et al, AJSM, 2003
Azar et al, AJSM, 2000

Arm Cocking Elbow Pathomechanics

Primary restraint to valgus from 30-120 deg elbow flexion

UCL and Medial Epicondyle Injuries
- Excessive throwing (overuse injury), throwing high stress pitches such as the curveball and slider, and poor pitching mechanics can all increase stress on the UCL and medial epicondyle (due to excessive activity from flexor/pronator mass)

Valgus Load

Arm Cocking Elbow Pathomechanics

UCL Strain Due to Valgus Loading

- It appears the UCL is loaded maximally with every pitch. However, in-vitro cadaveric strength is likely less than in-vivo strength.
- The flexor/pronator mass generates a varus torque that resists valgus, thus unloading the UCL. However, weak or fatigued muscles may result in increased UCL strain, increasing injury risk.

Arm Cocking Elbow Pathomechanics

• Ulnar Nerve Injury (Neuritis)
  - Cubital Tunnel Syndrome
  - as little as 6-10% nerve elongation (strain) can cause neurapraxia
  - Positive Tinel Sign
  - Ulnar Nerve Entrapment Sites

Valgus Loading Counterbalanced by Varus Torque

• Static Contributions to Varus Torque
  (Morrey & An, 1983) - in vitro, so no muscle contribution
  - UCL: 54%
  - Osseous: 33%
  - Soft tissue/capsule: 13%

• Dynamic Contributions to Varus Torque
  (Buchanan et al., 1998) - simulation
  - Pronator Teres: 15%
  - FCR + FCU: 7%

Shoulder Abduction and Lateral Trunk Tilt,
(Escamilla et al., 1998; Fleisig et al., 1999)

- Mean shoulder abduction was approximately 90º (85-105º ± 1 SD)
- Mean Contralateral Trunk Tilt was approximately 25º (15-35º ± 1 SD)
Influence of Shoulder Abduction and Lateral Trunk Tilt on Peak Elbow Varus Torque for College Baseball Pitchers During Simulated Pitching
(Matsuo et al., J Appl Biomech, 2006)

- At 10° lateral trunk tilt, peak varus torque was minimum (61 ± 14 Nm) at 100° abduction and significantly greater at 70°, 80°, and 120° abduction.
- At 20-30° lateral trunk tilt, peak varus torque was minimum (67 ± 19 Nm) at 90° abduction and significantly greater at 70°, 110°, and 120° abduction.
- At 40° lateral trunk tilt and 120° abduction, 125 Nm was generated – approx twice the varus torque generated at 10-30° lateral trunk tilt & 90-100° abduction.

Tommy John

- pitched 1973 season with one episode of pain
- pitching well in 1974 (13-3) when severe pain after slider
- felt elbow “give way”

Initial description of UCL Reconstruction was in 1986

Reconstruction of the Ulnar Collateral Ligament in Athletes
The Journal ofBone and Joint Surgery
Vol. 68-B, No. 8, October 1986

Abstract: Reconstruction of the ulnar collateral ligament using a free tendon graft was performed on eleven athletes. All participated in competitive baseball activities, with the indication for surgery being the instability of the elbow. After reconstruction and rehabilitation, one of the eleven patients returned to full participation, but this patient was not a professional athlete. Despite continued physical activity, there was a high incidence of complications related to the elbow surgery. Two patients had ulnar neuropathy, and two had anterior elbow instability. Four patients required re-exploration for ulnar neuropathy, but they eventually recovered completely. The authors report that the current methods of treatment are successful in stabilizing the elbow.

The anterior portion of the ulnar collateral ligament is a major stabilizing structure in the elbow. When this structure is disrupted or torn, the elbow joint becomes unstable. Occasionally an acute tear in such an athlete can be managed surgically, but usually the surgeon is a highly skilled orthopedic surgeon. The reason for the instability is most often due to a tear in the ligament or a tear in the capsule. These tears are typically associated with a hemarthrosis, and the treatment is usually surgery. The surgical procedure is known as a reconstruction of the ulnar collateral ligament. The procedure is performed arthroscopically, and the surgeon can perform the reconstruction with or without a bone graft. The bone graft increases the stability of the reconstruction, and the patient is able to return to sports much quicker than if the bone graft is not used.

UCL Surgeries in Professional Baseball

![UCL Surgeries in Professional Baseball](www.BaseballHeatMaps.com)

Prevalence of UCL Reconstruction in Professional Baseball Pitchers
(Conte et al 2015)

<table>
<thead>
<tr>
<th>Major League (n=382)</th>
<th>Minor League (n=2324)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCL reconstruction</td>
<td>45%</td>
</tr>
<tr>
<td>No UCL reconstruction</td>
<td>55%</td>
</tr>
<tr>
<td>UCL reconstruction revision rate in MLB: 13.2% between 1999-2014 (Liu et al 2016)</td>
<td></td>
</tr>
</tbody>
</table>
Biomechanics with/without UCLr

- Received Research Grant from MLB
- Collected data during 2014 spring training at AZ & FL
- Outdoor data collection
  - 10 camera Motion Analysis system collected 240 Hz data
  - 10 fastballs per pitcher

Biomechanics with/without UCLr

- 40 professional league pitchers with UCLr 1 to 4 years ago
- 40 matched pitchers
  - 1-to-1 match with UCLr pitcher
    - Same organization
    - Same projected level
  - No history of any arm surgery

Results

<table>
<thead>
<tr>
<th>Similar Kinematics and Kinetics Between Groups</th>
<th>UCLr (n=39)</th>
<th>Control (n=38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow flexion (°)</td>
<td>102 ± 15</td>
<td>99 ± 11</td>
</tr>
<tr>
<td>External rotation (°)</td>
<td>176 ± 9</td>
<td>174 ± 9</td>
</tr>
<tr>
<td>Varus torque (N-m)</td>
<td>99 ± 17</td>
<td>99 ± 16</td>
</tr>
</tbody>
</table>

About 20% don’t make it back to previous level
- Prospective research to determine why

Those who make it back
- Same mechanics as those without UCLr
- Same performance as those without UCLr
The Majority of UCLr Now Occur in Adolescent Age Pitchers Age 15-19

Trends in Medial Ulnar Collateral Ligament Reconstruction in the United States: A Retrospective Review of a Large Private-Payer Database From 2007 to 2011
Brandon J. Erickson, Benedict E. Haddad, Sam-Russ, William W. Schaffer, Frank M. McCormick, Bernard R. Steh, Jr, Charles A. Shash-Joseph and Anthony A. Romeo

At J Sports Med 2013 43, 1772
DOI: 10.1177/0363546513496398

P < 0.001

Average incidence per 100,000 people

Age, y

Risk Factors in Adolescent Baseball Pitchers

- When a pitcher regularly threw with arm fatigue, he was 36 times more likely to be in an elbow surgery group as opposed to the non-surgery group.
- When a pitcher engaged in more than 8 months of competitive pitching during a year, he was 5 times more likely to be in an elbow surgery group.
- When a pitcher threw more than 80 pitches in a game/appearance, he was 4 times more likely to be in an elbow surgery group.
- When a pitcher self-reported that he threw more than 85 mph, he was 2.5 times more likely to be in an elbow surgery group.
- Pitchers who threw curveballs or sliders had greater incidence of elbow pain than those who didn't.

ASMI Position Statement
www.asmi.org

1. Watch and respond to signs of fatigue.
2. No overhead throwing of any kind for at least 2-3 months per year (4 months is preferred). No competitive baseball pitching for at least 4 months per year.
3. Follow limits for pitch counts and days rest.

ASMI Position Statement
www.asmi.org

4. Avoid pitching on multiple teams with overlapping seasons.
5. Learn good throwing mechanics as soon as possible.
   - Learn, in order:
     - basic throwing
     - fastball pitching
     - change-up pitching
6. Avoid using radar guns.

ASMI Position Statement
www.asmi.org

7. Avoid pitcher-catcher combination.
8. If elbow or shoulder pain, see a sports medicine physician.
9. Inspire youth pitchers to have fun playing baseball and other sports. Participation and enjoyment of various physical activities will increase the youth's athleticism and interest.

Arm Cocking Elbow Pathomechanics
(Cain et al, AJSM, 2003; Azar et al, AJSM, 2000)

- Lateral Compression Injury of Radiocapitellar Joint
  - Osteochondritis Dissecans

Radiocapitellar Joint Reaction Force
Medial Ulnar Collateral Ligament Force
Valgus Torque
Varus Torque
Force from Flexor Pronator Mass
Lateral Compressive Force

Arm Cocking Elbow Pathomechanics
(Cain et al, AJSM, 2003; Azar et al, AJSM, 2000)
Arm Cocking Elbow Pathomechanics
(Cain et al, AJSM, 2003; Azar et al, AJSM, 2000)

- Lateral Compression Injury of Radiocapitellar Joint
  - Osteochondritis Dissecans
  (Morrey & An, AJSM, 1983)

Arm Deceleration Elbow EMG
(DiGiovine et al., J Shou Elb Surg, 1992)
- Elbow Flexors (highest activity occurred during arm deceleration)
  - Biceps Brachii – 44% MVC
  - Brachialis – 49% MVC
  - Brachioradialis – 46% MVC

Arm Cocking Elbow Pathomechanics
(Cain et al, AJSM, 2003; Azar et al, AJSM, 2000)
- Lateral Elbow Injury Osteochondritis Dissecans of Capitellum with Secondary Degenerative Changes in Radial Head
  - High radiocapitellar compressive forces adversely affect subchondral blood supply in capitellum, resulting in osteochondral injuries and loose bodies.

Kinematics During Arm Acceleration
(Escamilla et al., 1998; Fleisig et al., 1999)

- Elbow
  - Max Extension Ang Vel
    - 2,120 – 2,730 °/sec

Arm Deceleration Elbow Kinetics
(Escamilla et al., 2002; Fleisig et al., 1995)
(Body Weight = 900 N, or approx 200 lbs)
- Elbow
  - Compressive Force = 900 N
  - Flexor Torque = 60 Nm

Arm Deceleration Forearm EMG
(DiGiovine et al., J Shou Elb Surg, 1992)
- Flexor/Pronator Mass (moderate to high activity)
  - Pronator Teres – 51% MVC
  - Flexor Carpi Radialis – 79% MVC
  - Flexor Carpi Ulnaris – 77% MVC
  - Flexor Digitorum Superficialis – 71% MVC
- Supinator/Extensor Mass (moderate to high activity)
  - Supinator – 59% MVC
  - Extensor Carpi Radialis Longus – 43% MVC
  - Extensor Carpi Radialis Brevis – 43% MVC
  - Extensor Digitorum Communis – 47% MVC
Elbow Pathomechanics
Posteromedial Injuries – Valgus Extension Overload
(Andrews et al, 1983; Cain et al, 2003)

• Impingement of Posteomedial Olecranon with Posteromedial Trochear Groove and Olecranon Fossa

Valgus Extension Overload
(Andrews et al, 1983; Cain et al, 2003)

• May result in posteromedial olecranon osteophytes & loose bodies
• May be exacerbated by UCL insufficiency/tear or pronator/flexor weakness or fatigue
• May result in osteochondroses of capitellum or radial head

Conclusion

• Poor pitching mechanics, overuse, or muscle weakness or fatigue can result in increased elbow force and torque, with a subsequent increase in injury risk to the medial, lateral, or posterior elbow.

Sample of Throwing Biomechanics Publications

• Escamilla, Barrentine et al., American Journal Sports Medicine, 2007
• Escamilla, Fleisig et al., American Journal of Sports Medicine, 2006
• Fleisig, Kingsley, et al., American Journal of Sports Medicine, 2005
• Fleisig, Nicholls, et al., Sport Biomechanics, 2003
• Escamilla, Fleisig et al., Sports Biomechanics, 2002
• Escamilla, Fleisig et al., Journal of Sports Science, 2001
• Matsuo, Escamilla et al., Journal of Applied Biomechanics, 2001
• Escamilla, Fleisig et al., Sports Medicine, 2000
• Fleisig, Barrentine, et al., Journal of Biomechanics, 1999
• Escamilla, Fleisig et al., Journal of Applied Biomechanics, 1998
• Fleisig, Escamilla et al., in Injuries in Baseball (Lippincott Raven), 1998
• Fleisig, Escamilla et al., Journal of Applied Biomechanics, 1996

Thank You!
Relationship of segmental energy flow and elbow valgus load during baseball pitching

Arnel Aguinaldo, Ph.D., ATC
Assistant Professor
Director, Biomechanics Laboratory
Department of Kinesiology
Point Loma Nazarene University
San Diego, CA, USA

Elbow Valgus Torque

Varus Resistance

- forward dynamics simulation estimated 35% varus moment due to muscle-tendon actuators

- flexor-pronator muscles (FDB, PT, FCR, FCU)

Six out of 13 parameters found to significantly predict elbow valgus torque:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation Coefficient</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset Trunk Rotation</td>
<td>-0.28</td>
<td>0.019</td>
</tr>
<tr>
<td>Max Shoulder Ext Rotation</td>
<td>0.60</td>
<td>0.000</td>
</tr>
<tr>
<td>Max Elbow Flexion Time</td>
<td>-0.32</td>
<td>0.012</td>
</tr>
<tr>
<td>Elbow Flexion at Peak Valgus</td>
<td>-0.36</td>
<td>0.004</td>
</tr>
<tr>
<td>Elbow Flexion at Ball Release</td>
<td>-0.35</td>
<td>0.000</td>
</tr>
<tr>
<td>Valgus Loading Rate</td>
<td>0.74</td>
<td>0.000</td>
</tr>
</tbody>
</table>


Theoretical Framework

Primary risk factors of pitching-related elbow injuries are mechanical and modifiable.

3D kinematic and kinetic data operationally define these factors.

Energy flow through the kinetic chain influences elbow valgus torque and ball velocity.

Energy due to muscular torques

Energy due to non-muscular torques
Aims:

- To examine the relationship between the energy flow across body segments with elbow valgus loading during baseball pitching
- To determine the influence of these segmental powers on ball speed
- To identify the timing of maximal rotational velocities of pelvis, trunk, and shoulder during pitching
- Hypothesis: Powers of trunk and shoulder rotational torques are key predictors of elbow valgus torque and ball speed

Methods:
- N = 24; 8 college, 16 pro players
- Age: 21.9 ± 3.7 years
- Height: 1.88 ± 0.06 m
- Weight: 89.5 ± 9.0 kg
- BMI: 25.3 ± 2.0 kg/m²
- 8-camera Raptor-4s NIR motion capture system (Motion Analysis, Santa Rosa, CA) @ 300 Hz
- 38 (14 mm) reflective markers; 16 segment rigid-body model
- Bullpen regulation mound


Data extraction of kinematics and kinetics with Cortex and PitchTrak software (Motion Analysis, Santa Rosa, CA)

- Segmental power (rate of KE):
  \[ P_t(i) = \sum_j (T_j(i) \cdot \omega_j(i) + F_j(i) \cdot v_j(i)) \cdot N_j \]

- Multiple linear regression (stepwise):
  - IV: powers of the trunk, upper arm, and forearm segments
  - DV: maximum elbow valgus (MEV) torque and ball speed

- Timing of maximum values of pelvis, trunk, shoulder, and elbow kinematics assessed with repeated-measures ANOVA (α = 0.05)


Results:
- Ball speed = 36.9 ± 3.3 m/s (82.7 ± 7.5 mph)
- MEV torque = 76.7 ± 27.6 Nm
- Peak rotational powers:
  - Trunk (3275 ± 1188 W)
  - Upper arm (-1430 ± 657 W)
  - Forearm (-2088 ± 849 W)
- Ball speed predictors:
  - Trunk power (r = 0.84, p < 0.001)
- MEV torque predictors:
  - Trunk power (r = 0.85, p < 0.001)
  - Shoulder power (r = 0.11, p < 0.001)

Conclusions:
- Trunk and upper arm power are significant predictors of MEV
- Confirms proximal-to-distal energy flow through kinetic chain with trunk as primary power source

Aim: To examine how segmental energy flow (power) influences elbow valgus torque and ball speed in professional versus high school baseball pitchers.

Methods:
- N = 16 professional pitchers (22.3 ± 3.8 years)
- N = 15 high school pitchers (15.3 ± 1.2 years)
- 3D motion analysis
- Segmental Power Analysis (Article 1)
- Ball speed, maximum elbow valgus torque (MEV), temporal parameters, and the mechanical powers of the trunk, upper arm, and forearm were extracted.


Methods:
- Between group: independent t-tests
- MEV prediction: linear regression
- Temporal parameters: 6x2 RM-ANOVA

<table>
<thead>
<tr>
<th>Biomechanical Parameter (unit)</th>
<th>Professional Pitchers (n = 16)</th>
<th>High school Pitchers (n = 15)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow Valgus Torque (Nm)</td>
<td>71.3 ± 20.0</td>
<td>50.7 ± 14.6</td>
<td>0.005*</td>
</tr>
<tr>
<td>Normalized Elbow Valgus Torque (Nm bw-h)</td>
<td>0.04 ± 0.01</td>
<td>0.04 ± 0.01</td>
<td>0.467</td>
</tr>
<tr>
<td>Ball Speed (m/s)</td>
<td>36.3 ± 2.9</td>
<td>30.4 ± 3.5</td>
<td>0.001*</td>
</tr>
<tr>
<td>Trunk Rotation Time (%PC)</td>
<td>39 ± 9.8</td>
<td>24 ± 12.3</td>
<td>0.001*</td>
</tr>
<tr>
<td>Pelvis Power (W/kg)</td>
<td>20 ± 9</td>
<td>14 ± 15</td>
<td>0.001*</td>
</tr>
<tr>
<td>Trunk Power (W/kg)</td>
<td>-15 ± 9</td>
<td>-15 ± 9</td>
<td>0.001*</td>
</tr>
<tr>
<td>Upper Arm Power (W/kg)</td>
<td>-24 ± 10</td>
<td>-17 ± 7</td>
<td>0.054</td>
</tr>
<tr>
<td>Forearm Power (W/kg)</td>
<td>50.7 ± 14.6</td>
<td>50.7 ± 14.6</td>
<td>0.001*</td>
</tr>
<tr>
<td>Normalized Forearm Power (W/kg bw-h)</td>
<td>0.04 ± 0.01</td>
<td>0.04 ± 0.01</td>
<td>0.467</td>
</tr>
</tbody>
</table>


Conclusions:

- Trunk rotation significant predictor of MEV and ball speed in both groups
- MEV different between groups but not when normalized by height and weight
- Proximal-to-distal segmental motion different
- HS pitchers adapt segmental motion that induces comparable ETV torque but slower ball speed
- Segmental power analysis limited by single-joint muscular torques only. Need novel techniques (IPA) for detailed energy decomposition.

No UCL adaptations (38 Nm elbow valgus torque)
Unilateral UCL adaptations (53 Nm elbow valgus torque)

Induced Acceleration Analysis (IAA)
- net torques (T)
- velocity-dependent torques (V):
  - Coriolis
  - Centrifugal
  - gravity (g)

Induced Power Analysis

Table 1

<table>
<thead>
<tr>
<th>Body Segment</th>
<th>Mean (°/s)</th>
<th>Mean (°/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower extremities</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Shoulder</td>
<td>31.0</td>
<td>16.1</td>
</tr>
<tr>
<td>Elbow</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Waist</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Gravity</td>
<td>37.8</td>
<td>37.8</td>
</tr>
</tbody>
</table>


Induced Power Analysis

Aim:
- To develop and implement an induced power analysis (IPA) to decompose the muscular and velocity-dependent torques contributing to the mechanical power of elbow valgus torque in adult baseball pitchers.

Methods:
- N = 10; MiLB, MLB players
- Age: 22.9 ± 4.1 years
- Height: 1.87 ± 4.93 m
- Mass: 86.5 ± 7.4 kg
- 3D motion analysis
- Induced Power Analysis (IPA)
- State-space energy analysis
- 10-DOF segment model
- Complete decomposition of mechanical power
- Time-integration to estimate mechanical work

Induced Power Analysis

- **Segmental Power Analysis**
  - energy flow due to muscular joint torques and forces only:

\[ P_i(t) = \sum F_i \omega_i(t) + T_i \theta_i(t) \]

- **Induced Power Analysis (IPA)**
  - examines contributions of muscular and non-muscular torques to the energy of elbow valgus loading
  - velocity-dependent interactive torques due to Coriolis and centrifugal effects:

\[ P_i(t) = \sum F_i \omega_i(t) - T_i \theta_i(t) = \sum F_i \omega_i(t) - T_i \omega_i(t) \]

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PT = \( \sum F_i \omega_i(t) - T_i \omega_i(t) \nabla_i \)

PT = Power absorption associated with elbow valgus loading

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20-DOF system
- trunk flexion/extension (r1)
- trunk lean (r2)
- trunk rotation (r3)
- shoulder elevation (r4)
- shoulder horizontal adduction/abduction (r5)
- shoulder internal/external rotation (r6)
- elbow flexion/extension (r7)
- elbow varus-valgus (r8)
- wrist flexion/extension (r9)
- wrist deviation (r10)
Induced Power Analysis

Results:

- Elbow valgus torque: 70.1 ± 2.2 Nm
- Ball speed: 35.8 ± 3.1 m/s

Induced Power Analysis

Results:

- Trunk flexion (r1), tilt (r2), rotation (r3) are the main contributors
- Muscle-dependent torque generated 1018 ± 261 W
- Velocity-dependent torque absorbed 701 ± 233 W
Results:
- Trunk flexion (r1), tilt (r2), rotation (r3) are the main contributors.
- Muscle-dependent torques contributed 44.5 ± 23.4 J.
- Velocity-dependent torque contributed -69.6 ± 37.1 J (66% total work).
Rehabilitation Following UCL Surgery: Reconstruction & Repair Internal Brace

Kevin E Wilk, PT, DPT, FAPTA
Champion Sports Medicine
Birmingham, AL

I. Introduction:
A. Elbow injuries appear to be increasing
   1. Approximately 24% of all injuries in MLB players are elbow
   2. 25% of all MLB pitchers have undergone UCL surgery
      Conte, Wilk: AJSM ‘15
   3. 14% of all minor league pitchers undergone UCL surgery
   4. 193% increase in UCL recon in NY state from 2002-2011
      Hodgins, Ahmad, AJSM ‘16

II. Rehabilitation
A. Comparison Rehab Program UCL reconstruction vs. repair (internal brace)
   1. Brace: both procedures – patient’s in brace 1 week locked at 90 degrees
   2. Motion: both procedures – PROM & AROM starts week 2
   3. Full PROM: Recon: 6-8 weeks, Ibrace: 4-6 weeks
   4. Plyometrics: Recon: initiate week 12, Ibrace: initiate week 6
   5. ITP Phase I: Recon: initiate week 16-20, Ibrace: initiate week 8-10
   6. RTP: Recon: 9.6 to 12 mos. Ibrace: 4-5 mos

III. Rehabilitation Following UCL Reconstruction
   1. 4 Phase Program:
      a. Post-op Phase (weeks 0-8) protect graft, PROM, shoulder & arm strengthening
      b. Subacute Phase (9-12): thrower’s ten program, core & legs, stretching
      c. Advanced Phase (13-16) advanced throwers ten program, plyometrics
      d. Return to Activity (17+): gradually increase throwing (intensity & effort)
         interval throwing program

IV. Rehabilitation Following UCL Repair with Internal Brace
   1. 4 Phase Program:
      a. Post-Op Phase: (weeks 0-4): PROM, shoulder & arm strengthening
      b. Strengthening Phase: (weeks 3-5): thrower’s ten program
      c. Advanced Strengthening Program (weeks 6-10): advanced throwers, plyos, stretching
      d. Return to Activity Phase: (weeks 10+): interval throwing program

V. Conclusion:
A. Key Points:
   1. Common injury in baseball players (especially pitchers)
   2. Other sports – athletes sustain UCL injuries (javelin, gymnast, wrestler, fball)
   3. Several surgerical options: reconstruction ------ repair
   4. Rehabilitation must match the surgery
   5. Outcomes:
Outcome of UCL Reconstruction in 1281 Athletes
83% return to play at same level
RTP: 11.6 mos.

Dugas, et al: AOSSM ‘18
Outcomes of UCL Repair with Internal Brace
158 patients with 2 yr follow-up
93% return to play at same level
RTP: 5.8 mos.

References:


1 How Baseball Players Can Safely Enhance Performance While Reducing Injuries  
   Mike Reinold, DPT, SCS, ATC, CSCS

2 No Financial Disclosures

3 Baseball Pitching Injuries Rising at an Alarming Rate

4

5

6 Why The Increase?

7 We are Simply Overdosing

8 The New Baseball Era: Emphasis on Velocity

9

10 Velocity and Elbow Stress
   • Correlation between velocity and elbow stress has been shown
   • High School
     –Hurd: Sports Health ‘12
   • Professional
     –Bushnell: AJSM ‘10

11

12 Training Focused on Velocity Development

13

14

15 Weighted Ball Programs
   Long Toss Programs

16

17

18 Similar to Greater Strain as Pitching
Weighted Ball Programs

- Reinold, Macrina, Fleisig, Andrews: 2016
  - 2.8 MPH increase in velocity
  - Significant increase in shoulder ER by 5-10 degrees
  - Almost 25% injury rate

Overdosing

To Prevent Injuries We Need to Understand How Injuries Occur

> 100 Innings Per Year

Average > 80 Pitches Per Game

Pitching > 8 Months Per Year

Overuse Injuries

- Injured players:
  - Pitch more months, games, and pitches per year
  - Pitch more innings, pitches, and warm-ups per game
  - Olsen AJSM '06
  - Fleisig AJSM '11
  - Register-Mahlick - Athl Train ‘12

Throwing a Baseball is not Good For Your Body
How to Enhance Performance and Reduce Injuries in Baseball Players

Mike Reinold, DPT, SCS, ATC, CSCS

MikeReinold.com
EliteBaseballPerformance.com

32 Velocity Programs Stress Arm All Year

33 Performance Enhancement Can’t Be Solely Focused on Throwing

34 Research has shown that arm care programs, strength and conditioning programs, core programs, plyometric programs, improved mechanics, and long toss all increase velocity

35 There are Safe Ways to Increase Velocity and Reduce Injuries

What Do Injured Baseball Pitchers Look Like?

Tight and Tired

Performance Enhancement
• Restore and maintain mobility
• Maximize total body strength and conditioning
• Incorporate arm care programs for strength and dynamic stability
• Integrate proper function and balance of the entire body together
• Enhance pitching mechanics through proper throwing and coaching

Manual Therapy

What Happens to the Body When You Throw?

Loss of Mobility
• Well established, especially in throwing athletes
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EliteBaseballPerformance.com

51  Manual Therapy Program

52  Manual Therapy Program
   • End of Season – rebalance your body
   • Offseason – maximize your potential for gains
   • During Offseason Throwing – Manage the adaptations from new stress
   • Inseason – Maintain range of motion

54  Strength and Conditioning

57  What Takes the Load?

64  Strength and Conditioning Must Include Arm Care Program
Stop Overdosing on Throwing

Work with a good strength coach, physical therapist, and pitching coach

My Performance Enhancement Program

- Reduce the stress, increase efficiency
  - Biomechanics, coaching
- Manage the stress
  - Manual therapy
  - Physical therapy
- Maximize potential
  - Arm care
  - Dynamic stability
  - Strength and conditioning
  - Integration of kinetic chain

My Injury Prevention Program

- Reduce the stress, increase efficiency
  - Biomechanics, coaching
- Manage the stress
  - Manual therapy
  - Physical therapy
- Maximize potential
  - Arm care
  - Dynamic stability
  - Strength and conditioning
  - Integration of kinetic chain

Thank You!
FUNCTIONAL RETURN TO SPORT FOR THE OVERHEAD ATHLETE
CSM 2019
Kyle Yamashiro, PT, DPT, CSCS, PRESIDENT
RESULTS PHYSICAL THERAPY AND TRAINING CENTER

SACRAMENTO REPUBLIC FC

SACRAMENTO RIVER CATS
The Sacramento River Cats are the proud triple-A affiliate of the San Francisco Giants

Sacramento State Athletics
QUICK SHOULDER / ELBOW EXAM

• Shoulder and elbow mobility
• Rotator cuff, scapular and forearm strength
• Strengthening program UE’s, LE’s and Core

SCAPULAR AND ROTATOR CUFF

ESTABLISH FOUNDATION

• Shoulder and elbow mobility
• Rotator cuff, scapular and forearm strength
• Strengthening program UE’s, LE’s and Core

PNF TO UE AND TRUNK
TUBING ROUTINE

PITCHER ASSESSMENT

PRE-THROWING PREPARATION

- Dynamic warm-up and stretch
- Facilitate fast twitch: PNF and Tubing
- Integrate entire body
  - Two hand non throwing med ball
  - Two hand throwing med ball
  - Single arm
- Shadow Throwing

NON THROWING PLYOBALL ROUTINE

TWO HAND PLYOBALL THROW
ONE ARM PLYO’S

PITCHER THROWING PROGRAM

VOLLEYBALL

RETURN TO BASEBALL POSITION

SUMMARY OF SEQUENCE
- Shoulder Stretch
- Rotator cuff and scapular strength
- PNF
- Dynamic warm up
- Form run
- Tubing
- Med ball
- Single arm med ball
- Weighted ball throw
- Towel Throws
**Biomechanical Evaluations**

**CLINICAL PEARLS**

- Throwing too hard in warm ups
- Arm dominant and less use of legs and trunk
- Violent elbow snap at release
- Short arming the release
- Excessive elbow flexion in cocking phase

- Communicate the obvious to the pitching coach
VIDEOS ARE AVAILABLE ON WWW.RESULTSTHERAPY.COM
<EDUCATION>

THANK YOU

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