SCIENCE MEETS PRACTICE:
Kinetic Chain Influences on Shoulder Function, Performance, and Injury Prevention

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Background:

Core stability (neuromuscular control and muscle capacity of the trunk and pelvis) is theoretically linked to optimal shoulder function during sports-specific tasks despite. Evidence exists supporting the relationship between core stability and shoulder function and performance, and core stability and lower extremity injuries. Impairments in core stability could theoretically result in less than optimal performance and abnormal force dissipation to the shoulder complex that could potentially lead to upper extremity injuries in athletes. However, there is limited evidence supporting that poor core stability may be a risk factor for upper extremity injuries. The use of core stability for the prevention or rehabilitation of upper extremity injuries in athletes needs to be further explored. As this relationship has not been fully established, intrinsic risk factors for the shoulder must be considered.

Time table:
00:00 - 00:05 Overview
00:05 - 00:29 Platforms
00:29 - 00:35 Moderator led Q&A
00:35 - 01:00 Case study
01:00 - 01:22 Dialogue #1: Core, core, core: Evidence supporting how core stability influences UE function and performance
01:22 - 01:44 Dialogue #2: Core is NOT everything: Critical appraisal of KC literature and discussion of shoulder intrinsic risk factors
01:44 - 02:00 Moderator led Q&A/Summary of session
Core, Core, Core: Evidence Supporting how Core Stability influences UE Function and Performance

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1. Definition of core stability
   a. Stability of the core is dependent upon the osteoligamentous elements of the spine that provide static support, trunk musculature which provides dynamic support, and neuromuscular control, or activation of neural units, which determine the imposed demands on the spinal column and provide adjustments through muscular response (Panjabi, 2003)
   b. Pelvic musculature is often considered to be important for core stability as these muscles maintain pelvic position and are the link between the trunk and lower extremities (Akuthota & Nadler, 2004).

2. Identification of clinical examination techniques for core stability
   a. Muscle Capacity (Strength and Endurance)
      i. Isometric endurance
         1. Planks
         2. Side Planks
         3. Sorensen Test
      ii. LE Holds
         1. Sustained Flexor Test
         2. Sustained Extensor Test
         3. Double Leg lowering test
   b. Neuromuscular Control
      i. Y-Balance Test
      ii. Star Excursion Test
      iii. FMS?

3. Core Stability and Upper Extremity Function
   a. Hirashima et al 2002 – Demonstrates core is active prior to upper extremity function.
   b. Hong et al 2001 – Trunk rotation is responsible for ball acceleration through the horizontal adduction of the humerus promoting elbow extension. Trunk acceleration providing a positive moment for humeral acceleration.
   c. Lust et al 2009 – Assessed upper extremity performance in two groups of athletes where one group performed open and closed kinetic chain exercises and the other completed similar exercises in addition to core strengthening.
   d. Okada et al 2011 – Assessed upper extremity functional tasks after before and after a core strengthening program.
   e. Tarnanen 2008
4. Core Stability and Athletic Performance
   b. Okada et al 2011 – Compared core stability, the Functional Movement Screen and performance testing in a group of athletic subjects.
   c. Tse et al 2005 – Studied the effects of 8 weeks of core endurance would affect a variety of performance measures.
   d. Sharrock et al 2011 – Assessed core muscle capacity of the rectus and oblique abdominal muscles and correlated with four performance tests.
   e. Chaudhari et al 2011 – Assessed correlation between lumbopelvic control during a single leg balance task and in game pitching performance. Performance defined as innings pitched, and walks plus hits per innings pitched.

5. Core Stability (Neuromuscular Control) and UE Injury
   a. Garrison et al 2013 – A study of collegiate baseball players showed an increased correlation between poor balance scores on the Y-Balance test and upper extremity injury.
   b. Chaudhari AMW et al. 2014 – Lumbopelvic control was assessed on 47 pitchers during spring training and days missed due to injury was tracked throughout the season.

6. Core and Glute sequencing and UE Function
   a. Oliver GD et al. 2015 – Used EMG to study 20 youth baseball pitchers throwing fastballs to identify the sequencing of hip and scapular activity. Moderately strong correlations exist between serratus and upper trapezius muscles and glute medius muscles during the maximum external rotation and follow through phases of the pitching motion.

References


Kinetic Chain Influences on UE Function, Performance, & Injury

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Kinetic Chain: There is no question

Pitching motion: Progression of Power

Functionally: Specifically: Baseball Pitch

- Perfect linking of Kinetic chain
- Huge forces generated in legs/ trunk/ core transferred to shoulder during pitch

Core is NOT Everything

- Components of core stability
- Mobility versus stability
- Function requires close to normal mobility

Building Blocks

- Mobility ⇒ Stability ⇒ Controlled Mobility ⇒ Skill
- Movement ⇒ Skill ⇒ Performance


- Status:
  - BMI
  - History
  - Maturity
- Competition:
  - Competition level
  - Position
Pitch mechanics/type/velocity

- Physical Status:
  - ROM
  - Torsion
  - Strength
  - Kinetic chain

  - Upper extremity factors
    - ROM
    - Dyskinesis
    - Torsion
    - Strength
    - Endurance
  - Other factors

Professional Risk Profiles? (Chambless, 2000; Byram, 2010; Noonan, 2016)
  - Upper extremity factors
    - ROM
    - Dyskinesis
    - Torsion
    - Strength
    - Endurance
  - Other factors

Shoulder Specific Risk Factors
  - Evidence: IR difference
  - Evidence: S-S TARC
  - Posterior Shoulder Tightness (Myers ‘06; Shanley ’15)

Summary of the ROM Evidence
  - IR- risk factor in adolescent & professional players
  - Total Arc difference as a risk factor
  - ER deficit-a risk factor in professional pitchers
  - Horizontal Adduction- High School, Collegiate, Professional
  - Humeral Torsion & Influence on ROM

### Humeral Retrotorsion in Injured Pitchers

<table>
<thead>
<tr>
<th></th>
<th>Torsion</th>
<th>Comparison Group (without GIRD)</th>
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<tbody>
<tr>
<td>Pitches with GIRD</td>
<td>4.5° D Humeral torsion</td>
<td>10.4°D Humeral torsion</td>
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<tr>
<td>Pitches with GIRD</td>
<td>S-S difference: 20°</td>
<td>S-S difference: 12.3°</td>
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<tr>
<td>Pitches with GIRD</td>
<td>ER ROM=132°</td>
<td>ER ROM=132°</td>
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<tr>
<td>Pitches with GIRD</td>
<td>TARC = 161°</td>
<td>TARC = 171°</td>
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### Humeral Retrotorsion in Injured Pitchers

<table>
<thead>
<tr>
<th></th>
<th>Dominant</th>
<th>Comparison</th>
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<tbody>
<tr>
<td>Shoulder Injuries (n=30)</td>
<td>4° &lt; humeral retrotorsion</td>
<td>Non- Injured (n= 195)</td>
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<tr>
<td>Elbow injuries (n=30)</td>
<td>5° &gt; humeral retrotorsion</td>
<td>Non- Injured (n= 195)</td>
</tr>
<tr>
<td>UCL injury (n = 17)</td>
<td>4° &gt; humeral retrotorsion &amp; 5° &lt; ND retrotorsion</td>
<td>Non- Injured (n= 195)</td>
</tr>
<tr>
<td>Severe arm injuries(n= 8; ≥30 days)</td>
<td>8° &lt; humeral retrotorsion</td>
<td>Non- Injured (n=17)</td>
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Strength in Youth/Adolescent Populations
- Youth- 9-12 yo (Harada 2010)
  - Elbow pain (38%)
    - Increased cuff strength as risk factor
- High School (Trakis ’08, Tyler ’14)*
  - **Supraspinatus weakness trend toward injury**

Strength & UE Injury Factors- Professional Pitchers
Strength & Shoulder Injuries Factors- Professional Pitchers

If everything probably matters…
- Stiffness; poor motor control; lack of endurance
- Health status and goals determines screening

Is there a clear cut best test that assesses core stability?

Difference between Adaptation & Pathology
- Good genes
- Balanced loading, exposure & recovery

*So while we know the foundation is always critical; a building cannot serve its purpose with only a foundation.*