The Throwing Shoulder: Biomechanics; Injury Prevention and Treatment

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Disclosure

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I do not have financial or other relationships with the manufacture(s) of any commercial services discussed in this educational activity.

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Overview

- Introduction
- Phases of Throwing
- Physical Characteristics
- Specific Injuries
Introduction

- Overhead throwing is one of the fastest human activities
- Angular velocity of 7,000°/sec
- Transfer of potential energy to kinetic energy of object
Introduction

- Repetitive overhead activities
  - Enormous stress on soft-tissues and bony structures of shoulder

- "Thrower’s Paradox"
  - "Lax enough to allow excessive external rotation, but stable enough to prevent symptomatic subluxations"
Introduction

- “Overhead Activities” often refers to pitching/throwing in baseball

- The phases of throwing are well studied and understood

- Other sports have similar motions
Introduction

- Tennis serve
Introduction

- Volleyball
Introduction

- Javelin
Introduction

- Football
Phases of Throwing
Phases of Throwing

- **The Wind-Up**
  - Coiling phase: potential energy
  - Center of gravity is raised
  - Minimal stress on shoulder
Phases of Throwing

- **Early Cocking**
  - Arm Abducted to 90°
  - ER initiated
  - EMG shows early deltoid and later rotator cuff activation
Phases of Throwing

- Late Cocking
  - Maximum ER of arm
    - Can reach 170°
  - Posterior translation of humeral head
Phases of Throwing

- Late Cocking
  - High RTC activity
    - Early SS/IS/TM
    - Late Subscap
  - Compressive forces up to 650 N
Phases of Throwing

- Late Cocking
  - Maximum stress on anterior restraints
  - Anterior shear forces approach 400 N, or as high as ½ Body Weight
  - Pain = labral pathology > RCT or biceps
Phases of Throwing

- Acceleration
  - Rapid IR up to 7,000°/sec
  - Humeral head returns to neutral position, and capsule uncoils
  - Minimal load to glenohumeral joint
Phases of Throwing

- **Deceleration**
  - Most violent phase
  - From ball release to $0^\circ$
  - Maximal posterior capsule stress
  - Posterior shear stresses of 400 N
Phases of Throwing

■ Deceleration
  ■ Marked eccentric contraction of rotator cuff
  ■ Distraction forces equal to Body Weight
  ■ Pain=rotator cuff injury
Phases of Throwing

- Follow through
  - Rebalancing of muscles
  - Posterior capsule still under stress

- Entire cycle: Approx. 2 seconds
Physical Characteristics
Physical Characteristics

- **Range of Motion**
  - Increased ER, compensatory loss of IR \( (\text{Wilk, AJSM 2008}) \)
    - ER: +9°, IR -8.5° compared to non-throwing arm in pitchers
  - Total Motion (ER to IR) often preserved (180°)

Wilk, JOSPT 2009
Physical Characteristics

- Laxity
  - Increased laxity allows increased ROM
  - Maybe acquired or congenital
    - Anterior structures stretch out over time?
  - Not present in all throwers
Physical Characteristics

- **Osseous Adaptations**
  - Increased retroversion of humeral head in throwers
  - Retroversion greatest in younger athletes
    - Remodeling with open growth plates
Physical Characteristics

- **Muscle Strength**
  - Decreased strength in ER
  - Increased strength in IR
  - Important that ER strength should be at least 65% of IR strength (Wilk, JOSPT 2009)
  - Provides dynamic stabilization
Physical Characteristics

■ Muscle Strength
  ■ Significantly stronger scapular protractors and elevators
  ■ Significantly stronger depressor muscles
  ■ Maintained ratio of elevators/depressors important
    (Wilk. JOSPT 2009)
Physical Characteristics

- **Posture and Scapular Position**
  - Scapula: protracted and anteriorly tilted at rest compared to non-throwing arm
  - Anterior tilt increased with Abd/ER and with fatigue
  - + anterior tilt $\Rightarrow$ loss of IR
Pathologic Conditions
Pathologic Conditions

- Internal Impingement
  - Contact of articular surface of posterior RTC and greater tuberosity with posterior/superior glenoid and labrum
  
- Excessive anterior translation of humerus
  - tight posterior capsule/lax anterior restraints
  - increased external rotation
Pathologic Conditions

- Internal Impingement

Jobe Oper Tech 1996

Conway Orthop Clin 2001
Pathologic Conditions

- Internal Impingement
  - Articular sided rotator cuff tears (~80%)
  - Posterior and SLAP (IIB)
  - Humeral head cysts
    - Rotator cuff insertion
Pathologic Conditions

- Internal Impingement
  - Insidious onset of pain
    - Increases during season
  - Pain posterior during late cocking
    - Anterior pain often
  - Increased ER most common finding on physical exam
Pathologic Conditions

- **Internal Impingement**
  - **Treatment**
    - Increase IR
      - Posterior capsule stretching
      - Sleeper stretch
    - Rotator Cuff Program
    - Scapular stabilization

Wilk JOSPT 2009
Pathologic Conditions

- **Internal Impingement**
  - Surgery last resort (~80% return to play)
    - Debridement of RTC vs. Repair
    - Labral debridement vs. Repair
    - Anterior capsular plication?
    - Posterior capsular release
      - Posterior band in IGHL
Pathologic Conditions

- **GIRD**
  - Loss of > 25° of IR compared to contralateral arm
  - Due to posterior capsular contracture
    - Repetitive shear/deceleration?
  
  [Image: Tyler AJSM 2010]
Pathologic Conditions

- GIRD
  - Causes posterior-superior shift in contact point
  - Leads to increased ER

Burkart Arthroscopy 2003
Pathologic Conditions

- **GIRD**

  - Increased ER
    - increases in shear and Peel-back forces
  
  - SLAP/posterior labral injury

Burkart Arthroscopy 2003
Pathologic Conditions

- GIRD
  - Posterior capsular stretching
    - Sleeper stretch
    - ~90% successful Burkhart
Pathologic Conditions

- **GIRD**
  - Posterior capsular release as last resort
    - 70% return to pre-injury level
    - 100% if no other lesions

Yoneda 2006
Pathologic Conditions

- Rotator Cuff Tendinitis/Bursitis
  - Pain during late cocking or at deceleration
  - Weakness noted 2° to pain
  - Early in season (poor conditioning) or late as an overuse syndrome
Pathologic Conditions

- **Rotator Cuff Tendinitis/Bursitis**
  
  - **Treatment:**
    - NSAIDs
    - Rest
    - Rotor Cuff program
    - Corticosteroid injection
Pathologic Conditions

- **Rotator Cuff Tendinitis/Bursitis**
  - Surgery only after conservative trx. fails
  - Bursectomy
  - Subacromial (bone) decompression rarely needed
  - R/O underlying causes
    - MDI
    - GIRD
Pathologic Conditions

- Rotator Cuff Tears
  - Pain in acceleration or deceleration
  - Full-thickness tears rare
  - Articular sided partial thickness tears more common
Pathologic Conditions

- Rotator Cuff Tears Treatment
  - Full-thickness tears
    - Surgical repair in athletes
  - Partial thickness
    - Rest / NSAIDs
    - Rotator Cuff program
    - Posterior capsular stretching
Pathologic Conditions

- Rotator Cuff Tears
  - Partial thickness
    - Surgery only after failure of conservative trx
    - Debridement vs. repair
      - Repair if > 50%
  - Anterior capsule plication?
  - Posterior capsule release?
Pathologic Conditions

- Rotator Cuff Tears
  - Return to play unpredictable after surgery
    - Becoming more predictable with arthroscopic techniques
  - 10-80% return to play in pitchers
SPAP tears

- Tears of superior labrum at biceps anchor

- 10 “types”
  - Type 2B most common in throwers
Pathologic Conditions

- SLAP tears
  - “Peel back mechanism”
Pathologic Conditions

- SLAP tears
  - Vague pain in late cocking
  - Physical exam has poor predictive value
  - MRI/Arthrogram and arthroscopy are gold standard
Pathologic Conditions

- **SLAP tears**
  - **Treatment**
    - Trial of NSAIDs / Rest
    - Cuff/scapular stabilizers
  - Surgical Repair if symptoms persist
  - Outcomes good
    - ~75-87% return to preinjury activity
Pathologic Conditions

- Bennett’s lesion
  - Bony overgrowth on posteroinferior glenoid
  - Insertion of posterior inferior glenohumeral ligament
  - Repetitive traction during throwing

Meister AJSM 1999
Pathologic Conditions

- Bennett’s lesion
  - Posterior pain during release
  - Most do not develop symptoms
  - Treated with posterior capsulotomy and burring down

Meister AJSM 1999
Conclusions

- Throwing places enormous stress on the shoulder

- There are adaptive changes to the stress that may lead to pathologic processes

- It is important to understand the biomechanics of throwing to diagnose, treat, and ensure return to play

- Surgery should be reserved to players who have failed conservative treatment
Thank You