Biomechanics of Overarm Throwing

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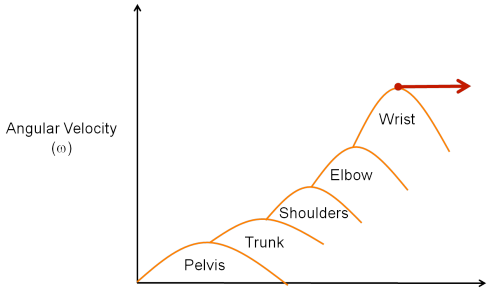
Outline

- Review Fundamental Concepts
- Breakdown Throwing Motion
  - Identify Key Movements
  - Examine Joint Loads
- Buildup Throwing Motion
  - Maximize Performance
  - Minimize Injury Risk
- Summary

Summation of Speed/Kinetic Chain

- Energy of proximal segment transfers to distal
- Distal segment starts movement when proximal reaches maximum angular velocity
- As distal reaches maximal velocity, proximal will have lost its energy
- Smaller distal segment achieves higher angular velocity due to smaller moment of inertia
- Progressive increase in distal end point velocity
- Critical feature is lagging of joint rotations letting energy from one segment move the adjacent segment.

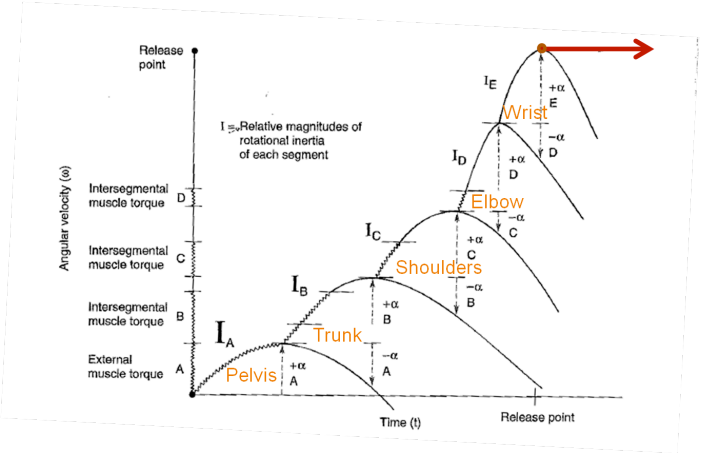


Well timed muscle actions can:

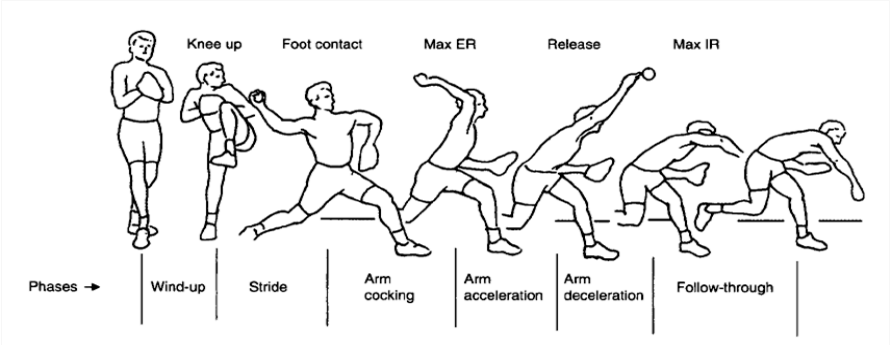
- Increase velocity of distal segment by introduction of + muscle torque
- Increase velocity of distal segment via stretch shorten cycle (previous eccentric action)

Poorly timed muscle actions can:

- Absorb energy decreasing transfer to adjacent segment
- Increase work done by proximal muscles
- Increase load on joint structures



Skill Breakdown



Four Primary Motions Responsible for Power Generation

- Trunk (2 separate motions)
    - Forward translation
    - Rotation
- Shoulder Rotation
- Elbow Extension
- Wrist Flexion

Trunk

- Forward translation followed by
- Rotation 100 to 200 ms prior to release
- Stems from GRFs and trunk torque

Timing of Trunk Motion is Important

- Faster throws tend to **rotate trunk later**
  - Allows better transfer of momentum to upper arm
  - Less int. rot. torque at shoulder
  - Less elbow valgus torque
- **Early rotation** results in
  - Shoulder musculature absorbing energy from trunk
  - Increased work done by shoulder (IR) to compensate for lost energy
  - Inefficient transfer of energy to hand & ball
  - Potentially harmful torques at shoulder

Shoulder Rotation

- Muscles are primarily responsible for shoulder internal rotation

Elbow Extension

- Induced by motions of trunk and shoulder
- Trunk and upper arm angular velocity create elbow extension (late cocking phase)
- Elbow extension velocity increases which increases forearm angular velocity
- Forearm angular velocity further increases elbow extension (acceleration phase)

Wrist Flexion

- energy originally from trunk & shoulder
- enhanced with elbow & forearm energy

<u>Typical Motions</u>

Initial shoulder motion (Stride & Cocking) is about:

- 90 degrees AB
- 15 horizontal AB
- 170 deg external rotation

Muscle Activity:

High:

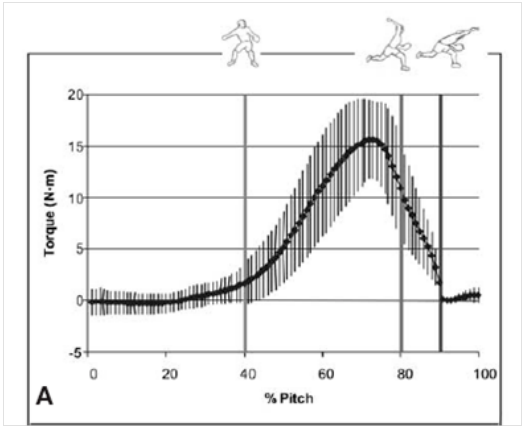
- Deltoid, Traps, Supraspinitus

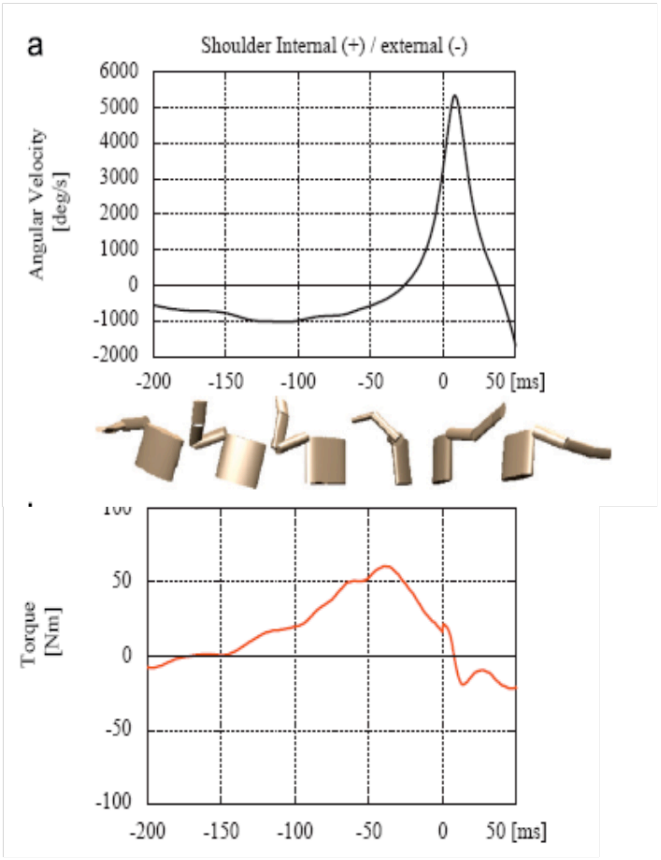
Moderate:

- Infraspinitus, Teres Minor, Serratus

External rotation torque on humerus at elbow with subsequent internal rotation torque at shoulder from musculature

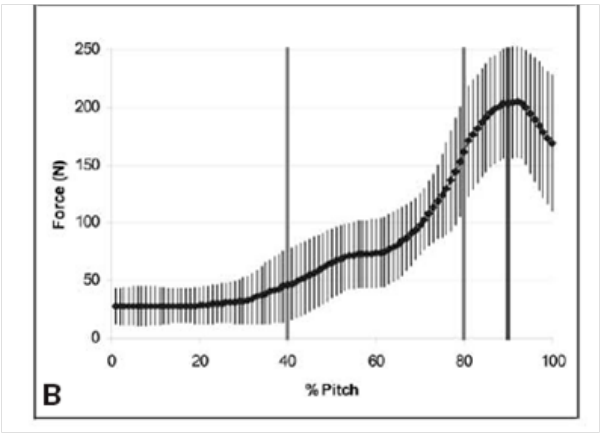
- 17+ Nm in kids
- 30 - 60 Nm in adults





Shoulder distraction force

- Half body weight in kids
- 1- 1.75 BW in adolescents & adults



Arm Acceleration

- Rapid internal shoulder rotation of 80 degrees occurs in .03 to .05 seconds
- Scapular protraction occurs to maintain humeral head positioning
- GH Joint forces can be 860 N

Muscle Activity:

Start of Acceleration:

- Anterior Muscles Concentric - Pec & Deltoid

End of Acceleration

- Posterior Muscles Eccentric – Trapezius, Subscapularis, Latisimmus, Serratus

Arm Deceleration

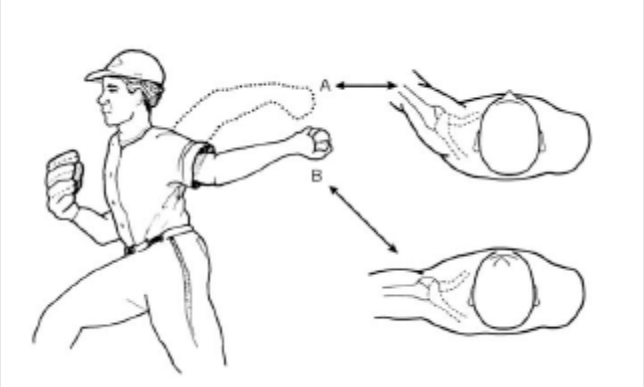
- Adduction & internal rotation continue but slowing
- Joint loads high as arm decelerates
  - Posterior & inferior shear (near .5 BW) & compressive forces (just > BW)
- Motion in deceleration & follow through critical for dissipating forces over larger ROM
- See peak rotation velocities in deceleration before muscles begin to slow arm

Muscle Activity:

- Posterior muscles have high eccentric forces - Infraspinitus, teres major and minor, latisimus

Scapula - Critical Link from Trunk to Shoulder Motions

- Allow transfer of energy from force generating leg muscles to force delivery motions of
- Protract and retract to maintain congruous socket for head of humerus
  - safety zone for glenohumeral angulation



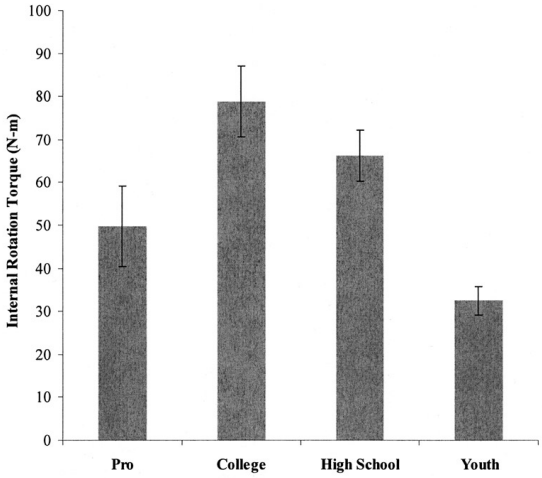
- Stable base for origin of arm muscles that control arm motion & provide joint compression
- Correct & active positioning & movement throughout motion critical
- Incorrect positioning & movement = Scapular dyskinesia
  - Poor alignment of humeral head – stress (tension/compression) on joint capsule, labrum, rotator cuff

- Over compensation of shoulder muscles – fatigue, further dyskinesia, increased incongruence, increased joint capsule, labrum, rotator cuff stress, …

<u>Skill Build-up</u>

Techniques associated with good power delivery to ball & reduces joint loads

- Skilled players with faster throws can have less torque

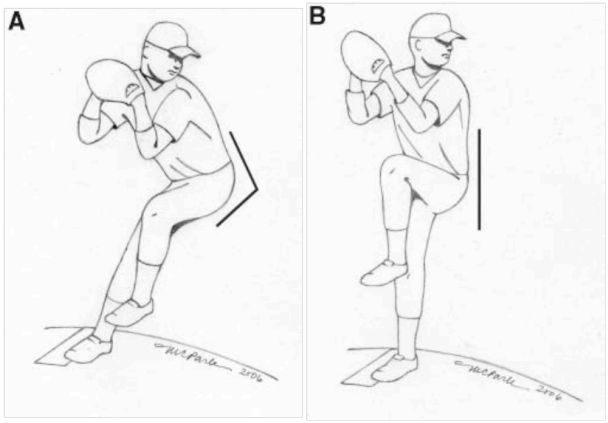


- Timing of trunk rotation are key
  - Later trunk rotation = Less shoulder torque
  - Later trunk rotation, less shoulder external rotation, and less elbow flexion at peak valgus = Less elbow valgus torque

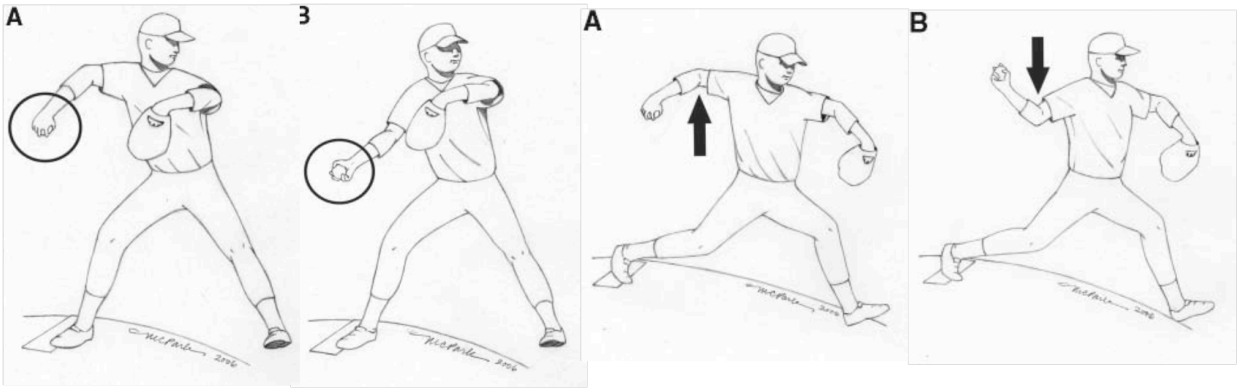
What to look for on the field:

May depend on age but:

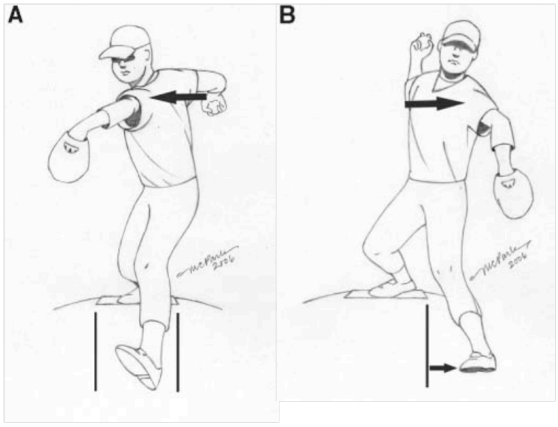
- Not leading towards plate with hip with adolescent players associated with less torque and greater efficiency



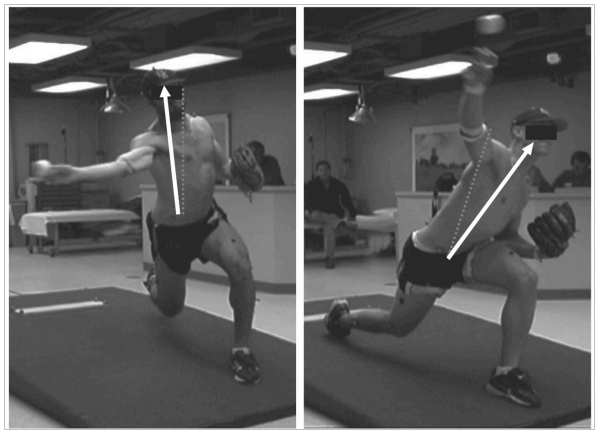
- Hand on Top & Arm in Throwing position – may reduce hyperangulation – association with lower torque and greater pitch efficiency



- Closed shoulder & stride to home, closed shoulder specifically associated with less torque & increased efficiency



- Contralateral trunk lean, overarm versus sidearm, is associated with less torque



Summary

Summation of Speed or Kinetic Chain critical for developing power & reduces torque on shoulder

- 4 joint motions are responsible for power: trunk translation & rotation, shoulder internal rotation, elbow extension, & writs flexion
- Trunk rotation occurring after stride contact helps increase speed & decrease torque at shoulder and elbow
- Scapula must be able to maintain positioning and movement to:
    - funnel energy from legs to arm for delivery
    - maintain congruence between glenoid fossa and humeral head with safety zone
    - Provide stable base for arm muscles to create force
- Observable techniques such as:
    - Later trunk rotation
    - Hand & top & closed shoulder
    - Overarm versus side arm throwing motion
- Have less torque & greater efficiency

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