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Identification of Throwing Pathomechanics and Their Anatomical Origins

Aaron Struminger, PhD, ATC

Conflict of Interest

- I have no conflicts of interest in this presentation

Learning Objectives

- Describe phases of throwing in which upper extremity loading occurs
- Identify throwing styles associated with injury
- Distinguish underlying anatomical changes associated with pathomechanical throwing styles
- Consider evidence-based interventions to treat potential causes/effects of pathomechanical throwing styles

Epidemiology

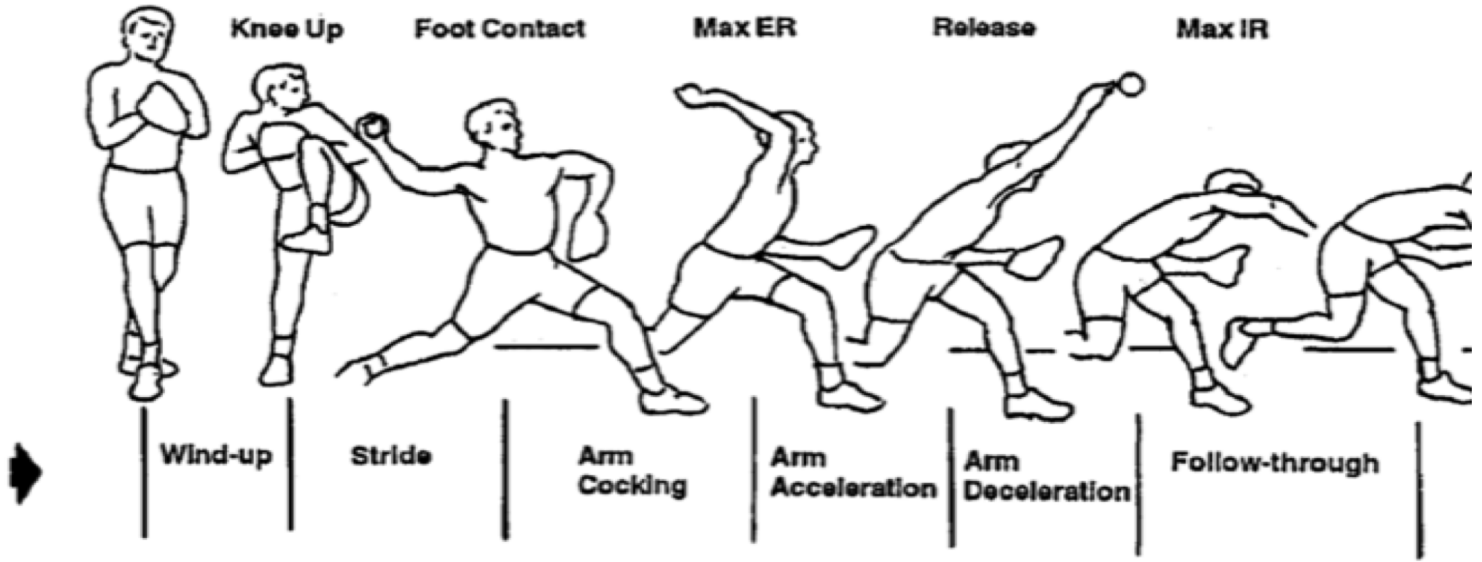
Shoulder

- 30% overhead athletes seek treatment (Laudner '09)
- High recurrence rate (46.2%) (Rechel '10)
- Progressive degenerative change?

Elbow

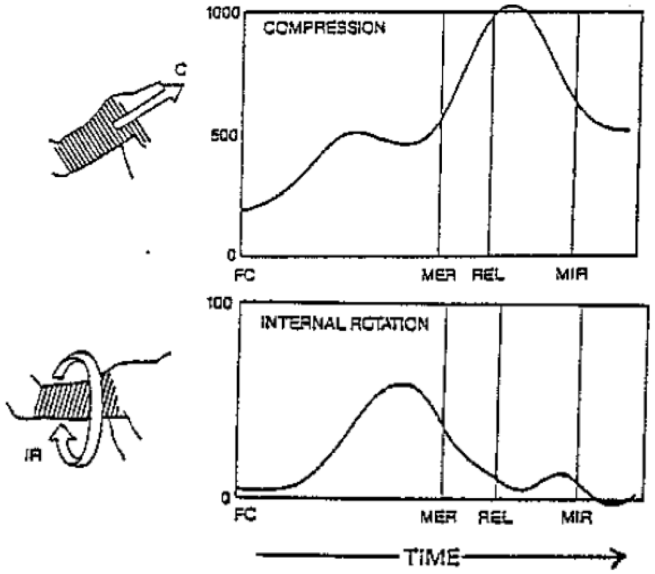
- Chronic valgus stress (Werner '02, Miyashita '08)
- Tommy John "epidemic"
  - Rates more than doubled in past 10 years (Hodgins '16)

Phases of Throwing

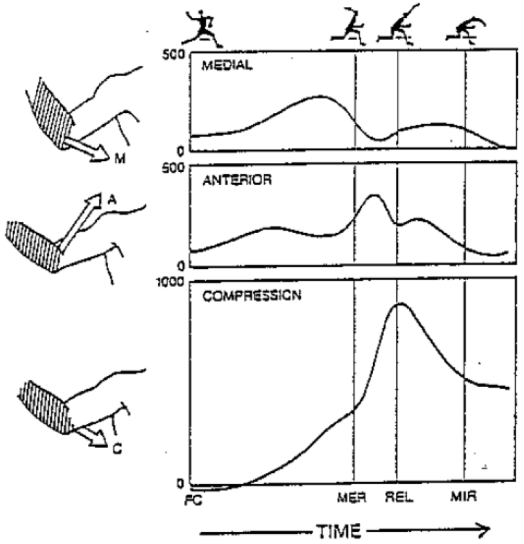


Loading during Throwing

Shoulder



Elbow



Fleisig '95

Cocking

- Lead foot contact to max ER
- Most of shoulder abduction
  - Rotator cuff
  - Deltoid
- All concentric external rotation
  - Infraspinatus
  - Teres minor
- Core muscles
  - Assist with rotation

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Acceleration

- Max ER to ball release
- Transfers energy from cocking
- High rate of internal rotation
  - Subscap
  - Lats
  - Pecs
- Small core rotation

Deceleration

- Ball release to max IR
- Stretch reflex of external rotators
- High eccentric ER activity
  - Teres minor
  - Infraspinatus
  - Posterior deltoid
  - Posterior capsule?

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Consistency of Biomechanics over time

- 7-year study (Fleisig '17)
  - Some changes
    - ER increases (13°)
    - Stride length increases (10% of height)
    - More horizontal abduction (14°)
    - Begin core rotation later

- Upper Extremity kinematics?
  - Don't change much
    - Shoulder abduction (3°)
    - Elbow flexion (2°)
    - Lateral trunk tilt (2°)
  - Mechanical change = something is wrong

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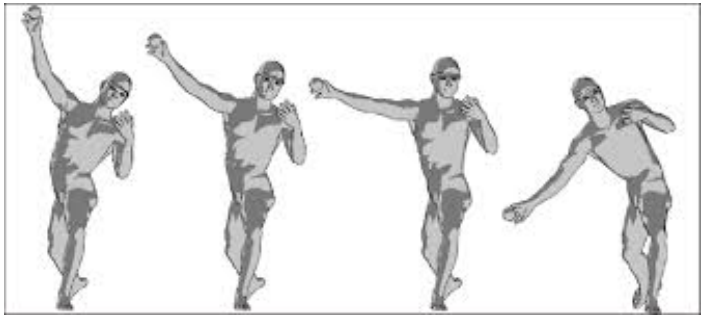
Measurement of Pitching

- Kinematic variables in pitching are almost infinite
  - Elbow Flexion
  - External Rotation
  - Shoulder Horizontal Abduction
  - Hip-shoulder separation
  - Time of phases
  - Lower extremity
    - Stride length
    - Knee angle
    - Ankle angle

- Can measure at several points of pitching motion
  - SFC
  - Max ER
  - Release

Presentation Focus

- Trunk Lateral Flexion
- Shoulder Abduction
- Why?
  - Variability of measures
  - Measured at discrete time points
  - Linked to clinical implications
- Problem: Few prospective studies
  - Solution: look at forces/moments



Trunk Lateral Flexion

- What is normal?
- At SFC
  - Relatively neutral position
- At max ER
  - 18 ± 10°
  - Near maximum (19 ± 10°)
- More neutral at release
  - 12 ± 11°

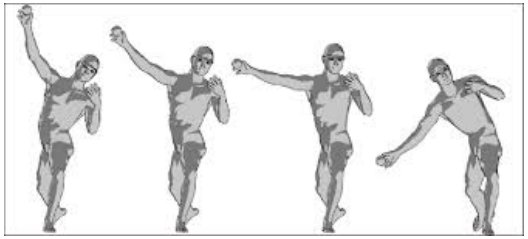
Normal

Excessive

Solomito '15

Trunk Lateral Flexion-Simulation

- 33 pitchers
  - **College**
- Simulated different lateral trunk tilt angles
- No significant correlation to elbow valgus
  - Didn't agree with simulation



Matsuo '06

Trunk Lateral Flexion-3D

- 3D analysis
- 99 pitchers
  - **College**
- Trunk lean ↑ = Elbow valgus moment ↑
  - Every 10˚ = 3.7Nm valgus force
- More lateral flexion increases lever arm
  - Allows for greater throwing velocity

Solomito ‘15

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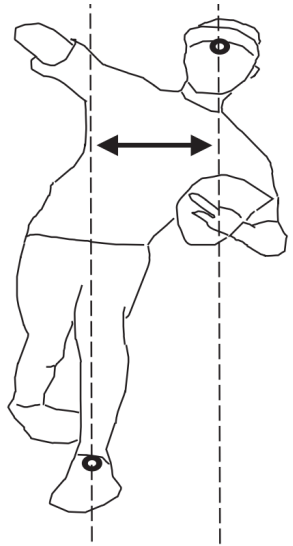
Trunk Lateral Flexion-3D

- Caveat
  - Every 10˚ increase (3.7 Nm)
    = 1.1 mph increase
- Requires arm modification to find “slot”
- Same increase in trunk lateral flexion angle
  - 1.5% increase in velocity
  - 4.8% increase in elbow valgus moment

Solomito ‘15

Trunk Lateral Flexion-2D

- 2D analysis works as well
- 72 pitchers
  - **High school**
- Video clips rated by experts
  - At maximum ER
  - Head contralateral more than one “heads width” from vertical line from stride foot
  - More concretely >25˚



Oyama ‘13

Trunk Lateral Flexion-2D

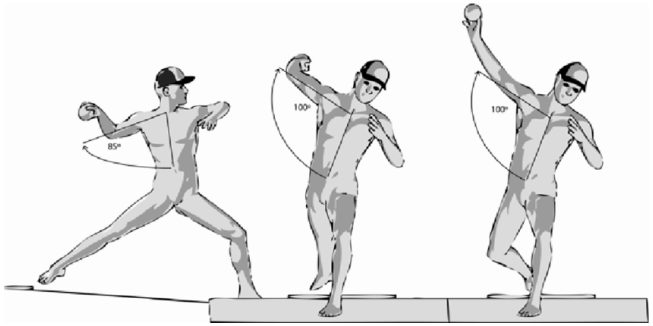
- Those with “excessive” contralateral tilt
  - Greater valgus stress
  - Greater shoulder distraction force
  - Higher ball speed

- Gravity assists contralateral flexion during pitching
  - Strength deficits?

Oyama ‘13

Trunk Flexion and Shoulder Abduction

- Trunk doesn't act in isolation
- Ideal angle for lowest load
  - 10˚ Trunk lateral flexion
  - 100˚ Abduction
- Angles of 90-100˚ "best"



Matsuo '06

Shoulder Abduction

- Literature contradictory
- More abduction = More valgus moment
  - Average ABD = 109° (Werner 2007)
- More abduction = Less valgus moment
  - Average ABD = ?? (Aguinaldo 2009)
- "Sweet spot"

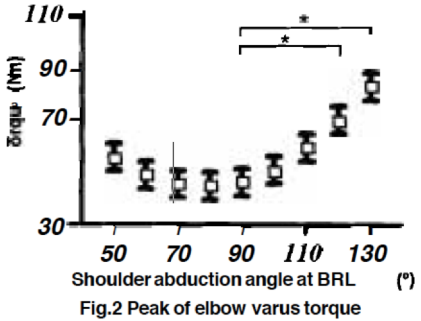


Fig.2 Peak of elbow varus torque

From Matsuo '99

Shoulder Abduction and Previous Injury

- Is there use in identifying this?

- Yes!
  - Pre-existing biomechanics
  - Changed biomechanics

- Professional baseball
  - UCL = same biomechanics (Fleisig 2015)
  - SLAP only reduced ER (Laughlin 2014)

???

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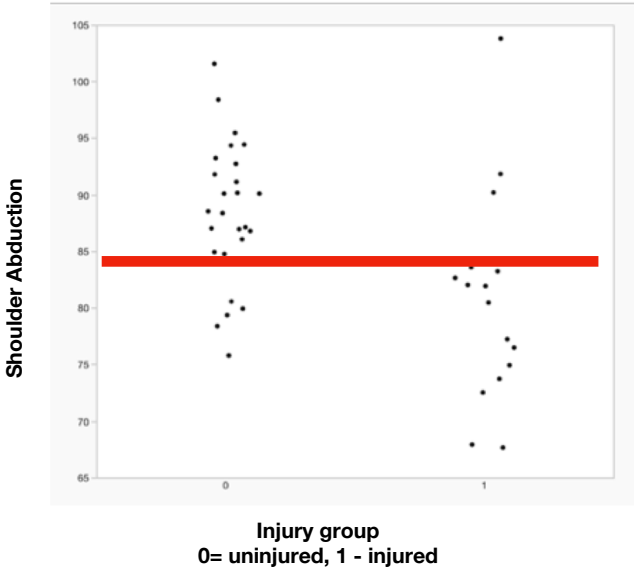
Shoulder Abduction and Previous Injury

- High school baseball

- High school baseball
  - Limited abduction = previous injury
  - Properly predicts 78.6% of injured athletes



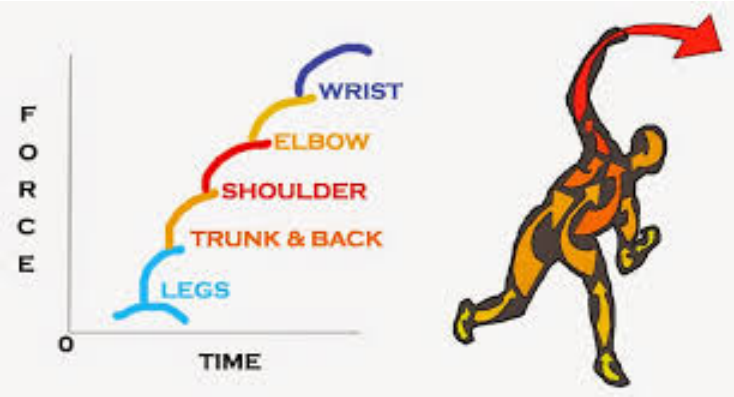
Struminger unpublished

Next Steps

- Identified potentially injurious biomechanics
- Anatomical origins?
- What can we do about it as clinicians?

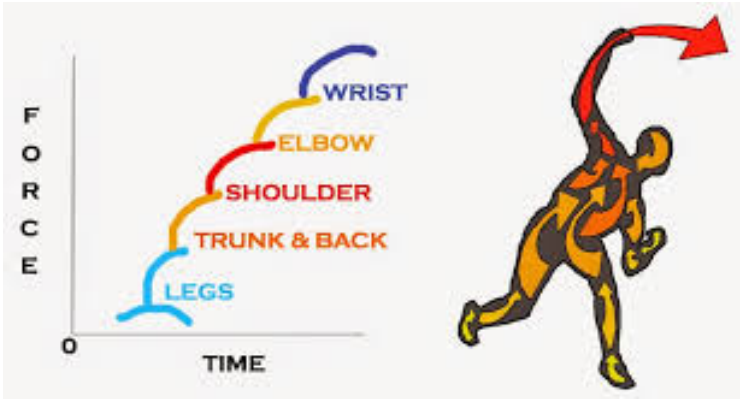
Excessive Trunk Flexion and Implications down Kinetic Chain

- Transfer of energy down kinetic chain
- Early cocking
  - External oblique active on non-dominant side
  - Helps rotation toward hitter (Hirashima 2002)



Excessive Trunk Flexion and Implications down Kinetic Chain

- Late cocking and acceleration
  - Dominant side external and internal oblique
  - Eccentrically control contralateral trunk tilt
  - Likely help energy transfer



Excessive Trunk Tilt- Intervention

- Excessive contralateral tilt linked to core weakness (Oyama '17)
  - Specifically: trunk rotation strength ratio
  - 83%

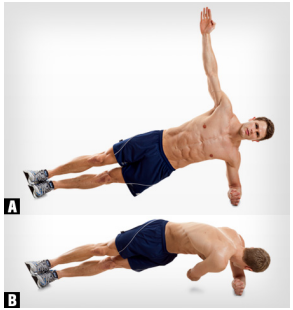
- Potentially associated with dominant internal oblique (Oyama '17, Ng 2001)

Excessive Trunk Tilt- Intervention

- 7 week core training can increase throwing velocity (Palmer '15)
  - Likely prevent injury too
- Can incorporate into shoulder rehab
  - Stay tuned
- General stability may be important too

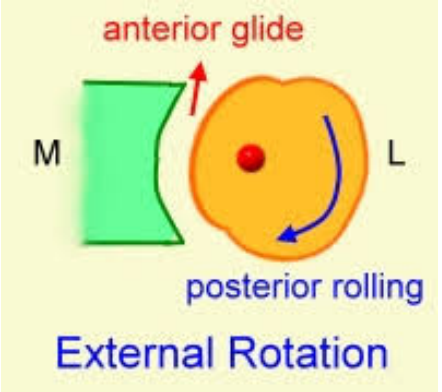
Excessive Trunk Tilt- Exercises

- High plank (Beazley '17)
  - Both stability and obliques
- Side planks
  - Stability directly for obliques
  - Add rotation?
- Bicycle crunches
- Russian twists

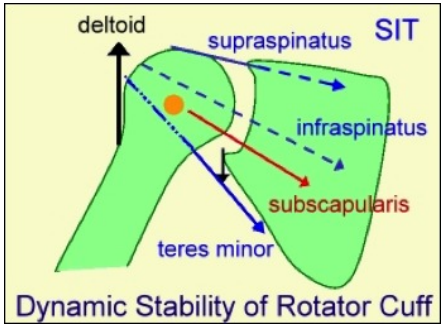


Pitching: Anatomical Movement

- Cocking phase
  - Global motion: External rotation
  - Local motion: Humerus glides anteriorly



- RC must maintain contact in glenoid



Limited Shoulder Abduction and Elbow Injury

- Continued excessive load on elbow
- Mechanics remain consistent over time
- May lead to recurrence

Shoulder Abduction: Strength

- Weakness and fatigue
  - Activation deficit in infraspinatus (Gandhi '12)
  - Abnormal humeral head translation
  - Protective mechanics to reduce injury risk?

- Fatigue
  - Flexion, ABD, IR strength deficits (Chou '15)
  - Lead to decreased abduction
  - Learned motor pattern?

Shoulder Abduction: Strength

- Lingering pain
- Rotator cuff pathology (Diederichsen '09, Lawrence '14)
  - When arm abducted past 90°
    - Anterior humeral head slide
    - RC activity decreases
    - Compensatory biomechanics?
- Impact function, change form slightly?
  - We aren't pitching coaches
  - We have other tools

Shoulder Abduction: Exercises

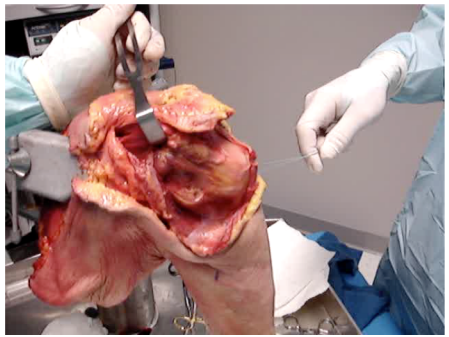
- Infraspinatus
  - Side-lying external rotation (85%)
  - Horizontal abduction in external rotation (“T”) (88%)
- Teres Minor
  - Side-lying external rotation (80%)
  - Horizontal abduction in external rotation (“T”) (74%)
- Supraspinatus
  - Military press (80%)
  - Empty can (74%)
  - Flexion (67%)

Townsend ‘91

Shoulder Abduction: Flexibility

- Posterior shoulder tightness
  - From eccentric overload
  - Can present as deficit in abduction

- Leads to humeral head position closer to RC
  - Increases chances of impingement



Anterior View of Shoulder

Shoulder Abduction: Flexibility

- Normal stretching exercises
  - May not impact posterior capsule
- Joint mobilization
  - Posterior glide
- Mobilization with movement

Back to Objectives

- Describe the phases of throwing in which upper extremity loading occurs
  - Cocking (Late)
  - Acceleration
  - Deceleration

- Identify throwing styles associated with injury
  - Excessive contralateral trunk tilt
  - Limited shoulder abduction

Back to Objectives

- Distinguish the underlying anatomical changes associated with those throwing styles
  - Trunk tilt: poor core strength
    - Especially rotation to non-dominant side
  - Shoulder abduction: strength and flexibility

- Consider interventions to treat the potential causes/effects of those throwing styles
  - Trunk tilt: core stability, rotational exercises
  - Shoulder abduction: SL ER, “T” in ER, joint mobilization

Final Points

- Evaluation of pitching biomechanics adds to clinical exam
- Don’t try to mess with biomechanics
  - Often leads to more injury
  - Putting high risk athletes on preventative program better option
- Build rapport with coaches
  - They are at every session
  - They can notice changes

Questions?

- Email: astrumin@emich.edu

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