A Clinical Guide to Pitching Mechanics and Kinetic Chain Deficits: How to Integrate Both into a Comprehensive Program

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Conflict of Interest

• No conflicts of interest with this presentation.
Introduction

• “Throwing is the most violent motion the human body can produce” Arthur Pappas, MD

• The shoulder rotates at over $7000^\circ/\text{sec}$
  Equivalent to the arm doing about 20 “360s” in 1 second
Pitching is a violent motion!
Phases of Pitching

WIND UP  EARLY COCKING  LATE COCKING  ACCELERATION  DECELERATION  FOLLOW-THROUGH
Wind-up

• Biomechanical Goals
  1. Initiate lower extremity involvement
     • Leg kick
       • Raises COM to increase potential energy
     • Rotate pelvis toward 2nd base
       • Pre-stretch hip external rotators on stance leg
  2. Energy generation
     • Lateral trunk tilt toward 2nd base
     • Create ground reaction forces “Loading the back leg”
  3. Maintain balance
     • Alignment of lower extremity
     • Balance joint torques
Wind-up
Wind-up: Common Abnormalities

- Poor Balance
  - Previous injury
    - Ankle or knee instability
  - Weak core & hip abductors
    - Causes lead hip to drop
    - Lack of pelvic control
- Poor energy generation
  - Cant position pelvis & trunk to “load back leg”
  - Energy wasted on attempting to control body
Kinetic Chain Assessment

- Functional Assessments
  - Single Leg Squat
- Isolated Assessments
  - Hip Abduction strength
    - HHD
  - Core strength
    - Single leg bridge
  - Hip ROM
    - IR & ER
Early Cocking

• Biomechanical Goals
  1. Generate large amounts of energy with the stance leg
  2. Create momentum of the entire body
  3. Properly time the lower and upper bodies
  4. Properly position the stride leg to maximize elastic energy
Generate large amounts of energy with the stance leg

- Loading the back leg
  - COM lowering
  - Converting potential to kinetic
  - Pre-stretch ankle, knee, and hip extensors
- COP
  - Over back heel
  - “Sit into back leg”
  - Resultant force on driveline
Common Abnormalities

• Not loading the back leg
  • Weak or neuromuscular control deficit
  • Quads
  • Glutes

• Leads to:
  • Increased reliance on ankle motion
  • Moves COP to front of foot
  • Knee over toes
  • Resultant force not on driveline
  • Land “closed off”
Kinetic Chain Assessment

• Functional Assessment
  • Single leg squat
  • Examine ability to load through heel

• Isolated Assessments
  • Knee extension & hip flexion strength
    • HHD
  • Ankle dorsiflexion
    • Lunge test (< 35° restricted)
    • Isolated ROM
Create momentum of the entire body

• Linear momentum = mass X velocity
  • Triple extension
    • Explosive hip, knee, and ankle extension
    • Created from stretch reflex following squat
  • Mass is gas!
    • Larger body mass shown to increase ball velocity
    • Body composition doesn’t matter
• Poor triple extension
  • Compensation to generate energy
  • Smaller upper extremity muscles
  • “Catching up”
Properly time the lower and upper bodies

- **Stride length**
  - A minimum of 85% of pitcher's height
  - Greater distance to apply force
  - Gives shoulder time to get in position
    - 60° - 90° ER at stride foot contact
  - Pre-stretching of hip & core muscles
  - Will decrease shoulder forces at follow-through
  - Can measure on the mound with footprints in the dirt
  - Most impactful aspect of pitching mechanics
Common Abnormalities

- Short stride lengths
  - Lower extremity weakness
    - Quads & Glutes
    - Unable to absorb impact at stride foot contact
  - Soft landing
    - Knee and hip sink into flexion
- Limited ROM
  - Hamstring tightness stride leg
  - Hip flexor tightness trail leg
Kinetic Chain Assessment

• Functional Assessment
  • Forward lunge with 85% of height
  • Inability to reach distance = flexibility issue
  • Watch ability to control lowering and raising

• Isolated Assessments
  • Strength
    • Quadricep
    • Hip extension
  • Flexibility
    • Hamstring on stride leg (SLR)
    • Hip flexors on trail leg (Thomas test)
Late Cocking

• Biomechanical Goals
  1. Lower extremity stiffness to absorb impact
  2. Pre-stretch of the abdominal muscles
  3. Proper positioning of the upper extremity
  4. Pre-stretch of the shoulder internal rotators
Lower extremity stiffness to absorb impact

• Stride foot contact
  • Large ground reaction force
  • Muscles co-contract to absorb impact force
  • Causes linear momentum to transfer to upper half
    • Remove lower extremity mass making velocity increase (L=mass X velocity)
• Lower extremity weakness
  • Causes collapse of knee and hip
  • Unstable pelvis/hips
Pre-stretch of the abdominal muscles

- **Hip-trunk separation**
  - Front foot contact
    - Pelvis rotates to face Homeplate
    - Trunk remains in position
  - Creates stretch reflex of abdominal muscles
  - Explosive rotational contraction
  - Allows arm to passively “lay back”
    - Momentum pushes arm back
    - Pre-stretch of shoulder IR muscles
    - Ex. Race car start pushes you into seat

- **Lateral trunk tilt**
  - Reduces MOI to increase rotation velocity
  - Ex. Figure skater spinning
Common Abnormalities

- Trunk & pelvis stay together
  - Reduced energy created through trunk
  - Timing of arm action earlier
  - Lack of pelvic control
  - Disassociation trunk/pelvis
- Arm not in correct position
  - Created from short stride
  - Momentum pushes arm into IR
  - External rotators actively get arm into "lay back"
  - Increased shoulder & elbow torques
  - Leads to early fatigue
Kinetic Chain Assessment

- Functional Assessment
  - Pelvic Rotation Test
    - Titleist Performance Institute
    - Disassociation test
Kinetic Chain Assessment

- Isolated Assessments
  - Trunk ROM
    - Rotation
  - Hip ROM
    - $IR \& ER$
Acceleration

- Biomechanical Goal
  - Maximal acceleration and velocity of the forearm
- Kinematics
  - $90^\circ$ - $110^\circ$ glenohumeral abduction
  - $160^\circ$ - $180^\circ$ ER
  - Scapular plane ($30^\circ$ anterior to frontal)
  - Over $7000^\circ$ /sec at the shoulder
- Kinetics
  - Shoulder
    - Anterior force = $380$ N
    - Compression force = $660$ N
  - Elbow
    - Valgus torque = $64$ Nm
Common Abnormalities

• Decreased shoulder abduction
  • Commonly due to pain or fatigue
  • **Smaller angle = smaller moment arm**
• Decreased ER
  • Lack of humeral retroversion
  • Tight IR muscles
• Throwing out of scapular plane
  • Tight posterior shoulder
  • Striding off driveline (opening pelvis)
• Knee extension occurs after ball release
  • Sinking into stride leg
  • Short stride
Kinetic Chain Assessment

• Injury History
  • Current pain during pitching
  • Scapular assistance & reposition tests

• Isolated Assessment
  • Shoulder strength
    • IR & ER
Kinetic Chain Assessment

- Isolated Assessments
  - Shoulder IR ROM
  - Shoulder ER ROM
    - Supine
    - Sleeper (teres major)
    - 0° abduction (subscap)
    - Supine flexion (lats)
Follow-Through/Deceleration

- Biomechanical Goal
  - Absorb the large amount of energy that was created throughout the previous phases of throwing

- Kinetics
  - Compression force
    - 1090 N at shoulder
    - 900 N at elbow

- Recommended Technique
  - Incorporate motion at all joints of the body
  - Impulse momentum \( Ft = (m_2v_2 - m_1v_1) \)
  - Large follow-through step

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Common Abnormalities

- No follow-through step
  - Stuck in hip and knee flexion
  - Stops momentum of lower body
- Arm stiffness up after ball release
  - Uses ER muscles to absorb all energy in short range
- Limited stride hip IR
  - Have trouble hitting corners
- Limited IR less time to absorb energy
  - HR related to PCT
- Scapula forced at end range
  - Tight posterior shoulder
  - Increased HR
Kinetic Chain Assessment

- **Isolated Assessment**
  - Glenohumeral ROM
    - IR & Horizontal Adduction
    - HR (if possible)
  - Scapular Strength & Control
    - Scapular weight forward flexion
      - 5lbs & 20 reps
    - Posterior Shoulder Endurance Test
      - Hold prone Y position isometrically
      - Record length of time
  - Hip ROM
    - IR & ER
Conclusion

- Focus mainly on lower extremity mechanics
  - Most impactful to overall improvements
  - Use the dirt to help you!
- Use video to assess mechanics from front and side view
- Identify abnormalities
- Determine underlying cause of altered mechanics
- Use corrective exercise to address underlying cause
Best Pitching Mechanics!
Thank you!