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ACHIEVING GREATNESS
Training for Whip in Baseball: Why Tendons Matter

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"Size matters not. Look at me. Judge me by my size do you?" - Yoda

The bamboo that bends is stronger than the oak that resists.
- Japanese proverb

RESILIANCE-DURABILITY

STRENGTH-PERFORMANCE
• Proximal-to-Distal Sequencing
  • Summation of speed principal: torques generated at each joint create rapid angular movements that accumulate kinetic energy

• Power:
  • Rate of doing work
  • Rate at which stored energy is converted to work
Is Muscle Enough

• Conservative model comparing average kinetic power by:
  
  – modeled internal rotator cuff muscle mass
    – 438-800 (W kg⁻¹) Exceeds max isotonic power production capacity for muscle by 3-7 fold
  – actual calculated power
    – 1,781 (W kg⁻¹)

• Other studies looking at the mechanical and energetic costs of running conclude that the muscle motor alone is not enough to explain the locomotor system

Roach et al. ‘13

Kubo et al. 1999; Lichwark & Wilson ‘05
What is Helping Transfer the Kinetic Energy
Elastic Energy

• Potential energy that is stored when a body is deformed
• Act as a power amplifier by releasing energy more quickly than it is stored
• Reduce metabolic costs of activity by recycling energy
Biological Springs

- Tendons
- Ligaments
- Capsules
- Fascia
- Connective tissue
- Muscle Sarcomere
Tendon Anatomy
Tendon is Viscoelastic

- Mechanical properties of liquid and elastic solid
- Time dependent properties
  - Rapid load = greater resistance to deformation
  - Longer duration = larger deformation
- Sensitive to hydration levels
- Sensitive to temperature
Tendon Stiffness

• Stiffness = force/change in length of MTC
  – Stiffer MTC requires greater force to produce given amount of stretch

• Compliance = exertion of less force to produce the given amount of stretch

• Stiffer tendons experience more forceful recoil
  \cite{Magnusson2008}

• More compliant tendons are less likely to be injured
  \cite{Magnusson2008}

• A certain level of compliance will enhance recoil
  \cite{Kubo1999}
• Stiffness of tendon is result of collagen and number of cross links

Modulus of Elasticity = Stress/Strain

Higher Modulus = Stiff
Lower Modulus = Compliant
Metabolically Active

• Highly responsive to mechanical loading
  – Changes in tendon material
  – Changes of tendon cross sectional area
• Just like muscle- tendons respond to intensity, duration, frequency, repetitions, sets, load, velocity
• Regeneration and adaptation rates of tendon are slower than muscle
• Degeneration and atrophy rates of tendon are faster than muscle

Kubo et al. 2010
Training Effects

• Increase Stiffness
  – Plyometric training Fouré et al. 2010
  – High Magnitude Loading (muscle contraction intensity) Bohm et al. 2015
  – Inactivity

• Increase Compliance
  – Slow low intensity rhythmic movements Mahieu et al. 2007
Injury and Tendons

- Pain in the tendon will lead to............
  - Increased cortical inhibition
    - Decrease in primary muscle strength
  - Greater corticospinal excitability
    - Compensation of other muscles
  - These changes are also seen in the unaffected side
    - Can’t drive leg as hard, won’t land as hard
  - These adaptations may linger after pain is gone

Rio et al. (2015)
SO WHAT?

• Relievers after a bunch up downs
• Starters
• Bench guys
• Hamstring exercises when break camp
• Oblique's
• Anterior shoulder rotators vs posterior cuff
• MRE’s
• Static vs dynamic stretching
Coaching

• Don’t win the battle, win the war
• Carrot vs the stick
• Less is more
• Know your injury trends
• Have a relationship with athletic trainer(s)
• Don’t just screen/test, to screen/test
• Measure CKCDF
References

• Kjaer et al. (2004). Role of extracellular matrix in adaptation of tendon and skeletal muscle to mechanical loading. Physiol Rev, 84, 649-698.
References Cont.