THE BIOMECHANICS OF KICKING A FOOTBALL
Background/History

- Kicking features proximal to distal acceleration, much like throwing
- Similar to cracking a whip

“Straight-On” vs. “Soccer-Style”
- Origins
- Advantages/Disadvantages
6 Stages of the Kicking Motion

- Approach
- Swing-Limb Loading
- Plant
- Hip Flexion and Knee Extension
- Contact
- Follow Through
Approach
Approach

- 45° angle of approach produces maximum peak ball velocity

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<thead>
<tr>
<th>Body part</th>
<th>Action</th>
<th>Muscles</th>
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<tbody>
<tr>
<td>Trunk</td>
<td>Stabilisation</td>
<td>Abdominals, psoas major, erector spinae and spinal postural muscles</td>
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<tr>
<td>Right hip</td>
<td>Internal rotation/hip</td>
<td>Tensor fascia lata, rectus femoris, psoas, iliacus, sartorius and adductor group</td>
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<td>Left shoulder</td>
<td>Horizontal adduction</td>
<td>Anterior deltoid, biceps brachii, pectoralis major</td>
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Swing-Limb Loading
Swing-Limb Loading

- Lower leg is cocked back to prepare for upcoming downward swing
- Knee extensor muscles are key as the knee flexes and stores elastic energy
Plant
Plant

- Force and orientation of plant foot are crucial
- Plant should be about a foot’s length away from the ball and directionally facing the target
- Incorrect placement of the plant foot will drastically affect both distance and direction of kick
Hip Flexion and Knee Extension
Hip Flexion and Knee Extension

- From its loaded position, the thigh quickly swings forward as the lower leg drives downward towards the ball.
- Knee extensors help propel leg forward, releasing built up elastic energy.

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Contact
Contact

- Knee is extended, ankle is plantarflexed
- Hamstrings act in eccentric contraction to slow down the lower leg
- Kinetic energy transferred from moving leg to stationary football
Follow Through
Follow Through

- Longer time of contact improves transfer of momentum, increases ball speed
- Proper follow through should improve both distance and accuracy, as well as help prevent injury
- Skipping through the kick provides power and helps the kicker stay aligned with the target
A Closer Look
Deformation of the ball upon contact

Ball deforms 10.39% during contact!
Velocity Patterns Pre-Kick

- Foot velocity hits a local maximum during the swing-limb loading phase as the lower leg is cocked back.
- Knee velocity is increasing here at the onset of hip flexion and knee extension.
- Knee velocity hits a maximum early in the hip flexion and knee extension phase as the thigh is pulled forward.
- Foot velocity drops to a local minimum before…
- Foot velocity increases rapidly as the lower leg is driven downward toward the ball, peaking just before contact is made.
- Knee velocity decreases as the lower leg makes its descent and knee extension is made.
Force & Impulse

- Newton’s Second Law:
  - \( F = ma \)
  - *Assume* average male leg weighs 20% of total body mass*
    - \( M = 39 \) lbs
    - Per LoggerPro, acceleration prior to contact was 25.570 m/s\(^2\)
    - \( F = 455.5 \) N

- Impulse = Force × time
  - *Assume* foot is in contact with ball for .008 second **
    - Impulse = 3.644 N·s

*http://espn.go.com/video/clip?id=5762361
Further Questions

- How much force is generated by the plant foot impact and how does this affect kick velocity?
- Compare Straight-On and Soccer-Style approaches and the forces/velocities associated with each.
- How are the forces and velocities different when one attempts field goals of different distances? Do mechanics noticeably change past a certain distance?
References

- http://www.sportsinjurybulletin.com/archive/biomechanics-soccer.htm#ref