The Effect of Unstable Shoes on Knee Joint Contact Force

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Introduction

• Unstable shoes have gained recent popularity
• Claims for the efficacy of the shoe include:
  – Increased muscle tone
  – Improved posture
  – Reduce pressure on feet
  – Potential benefit for diseased populations such as knee osteoarthritis (OA)
Introduction

• Previously, our lab has done gait analyses on two different unstable shoes.
Purpose and Hypothesis

• Determine the knee joint contact forces in healthy individuals while walking with an unstable shoe compared to a control shoe
• Hypothesis: Wearing the unstable shoe will decrease the vertical knee joint contact force
Experimental Design

**Experimental Data**
- Walk across force plate in control and test shoes
- 3D Motion Capture
- EMG

**Visual 3D**
- Process data
- Perform inverse dynamics
- Export motion trials to OpenSim

**OpenSim**
- Scale V3D model to OpenSim model
- Perform RRA
- Perform CMC
- Calc JRF
Methods: Data Collection

• 14 healthy men
  – Age: 45.4 ± 8.4 yrs
  – Height: 1.82 ± 0.07 m
  – Weight: 83.2 ± 13.5 kg

• Walked at 1.3 m/s across a force plate
  – In control and test shoes

• 3D motion capture with reflective markers
  – Bilateral marker set
Methods: OpenSim Processing

- Exported walking to use in OpenSim
- Scaled V3D model to OpenSim model
- Performed residual reduction analysis (RRA)
- Performed computed muscle control (CMC)
- Performed JRF calculation
Results: Knee Contact Force

Why is the 2nd peak larger?
Results
Residuals (Force FY)

Time (s)
Results: KCF Comparisons (Single trial)

Single Support

Stance

~ 0.6 BW
Results: Left Knee Contact Force
**Fig. 5.** Tibial forces were recorded over 6 representative steps with and without shoes. The heel transients were higher when shoes were worn, and the stance phase peaks appeared more rounded. However, no significant differences in mean or peak tibial forces could be detected.
Discussion: Richards and Higginson (2010)

- Used OpenSim methods similar to this study
- Participants between the ages of 40 and 85
- Walked at a self selected pace (healthy 1.3 m/s; moderate 1.2 m/s)
Sasaki and Neptune 2010

- Walking speed of 1.2 m/s
- Used simulated annealing to minimize cost function
- Their model had less muscles than the OpenSim model

Fig. 4. Axial knee joint contact force over the gait cycle. The model’s body weight was 737 N. The vertical line indicates toe-off.
Results: Muscle activity comparison

CMC

EMG

Sasaki 2010

Gastrocnemius

Rectus Femoris

Biceps Femoris

Tibialis Anterior

EMG CMC
Conclusion (If these results are accurate)

• 1st peak knee contact force decreased by 0.5 – 1 BW by wearing unstable shoes
  – Possible benefit for OA
• 3 force plates needed for walking
  – Need GRF in double support
• KCF much greater than JRF calculated by inverse dynamics
• Large residuals ≠ large KCF
• Future research
  – Other activities: Stair walking, cycling, elliptical machine
  – Incorporate contact surfaces to determine loads on medial and lateral compartments
References

