Tissue Deformation in the Seated Buttocks Model

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Background: Pressure Ulcers

- Pressure ulcer
  - localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear.
Background: Tissue Deformation

- Primary cause of pressure ulcers
- Response to loading varies according to tissue properties
  - Tissue properties vary across individuals
What does strain look like inside the seated buttocks (FEM)?

- **Peak Strains**
  - Under the ischial tuberosity
  - 100-200% in the muscle
  - 50-90% in the fat

- **Finite element models to date**
  - Based on MRI in one coronal plane.
  - Bulk deformation within coronal plane are matched to the human
  - Assumes no anterior/posterior deformation
  - Estimate material properties

Objective

• To describe an able-bodied individual’s 3D buttocks response to sitting
  – How does tissue displace?
  – How does tissue distort (or change shape)?
Methods

• Healthy, female adult (32 years old, height 1.57 m, weight 49.9 kg)
• 0.6 Tesla resistive FONAR Upright MRI
  – Seated Unloaded
  – Seated Loaded

• T1-weighted Fast Spin Echo protocol
• 110 contiguous sagittal slices of 3mm thickness
• 350mm in-plane field of view
MRI of the Seated Buttocks

Right Side Only
Coronal Plane
MRI of the Seated Buttocks

Right Side Only
Coronal Plane

Apex of IT

22.5 mm

Muscle

Fat

IT

24.7 mm

Lateral

3 cm posterior to apex of IT

22.5 mm

Muscle

Fat

IT

24.7 mm

Medial

Bifurcating Blood Vessel

Obterator Internus

10.3 mm
MRI of the Seated Buttocks

Right Side Only
Coronal Plane

Apex of IT

Unloaded

Loaded

22.5 mm

7.2 mm

3 cm posterior to apex of IT

Bifurcating Blood Vessel

Obturator Internus

10.3 mm

Medial
MRI of the Seated Buttocks

Right Side Only
Coronal Plane

Apex of IT

Unloaded

Loaded

femoral head

Muscle

IT

Fat

22.5 mm

7.2 mm

Bifurcating Blood Vessel

Obturator Internus

Muscle

10.3 mm

Medial

3 cm posterior to apex of IT
MRI of the Seated Buttocks

Right Side Only
Coronal Plane
MRI of the Seated Buttocks

**Right Side Only**

**Coronal Plane**

**Apex of IT**

**Unloaded**

- IT
- Muscle
- Fat

**Loaded**

- IT
- Femoral head
- Muscle
- Fat

**3 cm pos to apex**

- Bifurcating Blood Vessel
- Obterator Internus
- Muscle

**Medial**

- 22.5 mm
- 7.2 mm
- 10.3 mm

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MRI of the Seated Buttocks
(Sagittal Plane)
3D Renderings of the ischium, ilium, proximal femur and muscles

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- bone (white)
- gluteus (red)
- hamstring (orange)
What about the models?

- Symmetric models with flatter sub-structures had deformations < 50%
- No opportunity for simulating muscle displacement
- Less sensitive to differences between cushions than the human buttocks
- Need to try different models
Discussion

• Muscular Deformation = displacement + distortion
  – posterior and lateral displacement of the gluteus
  – anterior displacement of the hamstrings
  – thinner in places, less flat muscle under load

• Comparison with finite element models
  – Incorrect assumption that all deformation is in the coronal plane
  – “No slip” characteristics might not allow for all of the displacement
Discussion: Who cares?

• **Deformation Resistance** - intrinsic characteristic of an individual’s soft tissues to withstand extrinsic applied forces

• **Shape Compliance** - ability of a cushion to support the buttocks with minimal buttocks deformation

• Improved cushion design

• Improved matching of individuals with cushions

• Other interventions based on Deformation Resistance
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