



Rehabilitation  
Engineering &  
Applied  
Research

# Tissue Deformation in the Seated Buttocks *Model*

Sharon Sonenblum, John Cathcart,  
John Winder, Stephen Sprigle

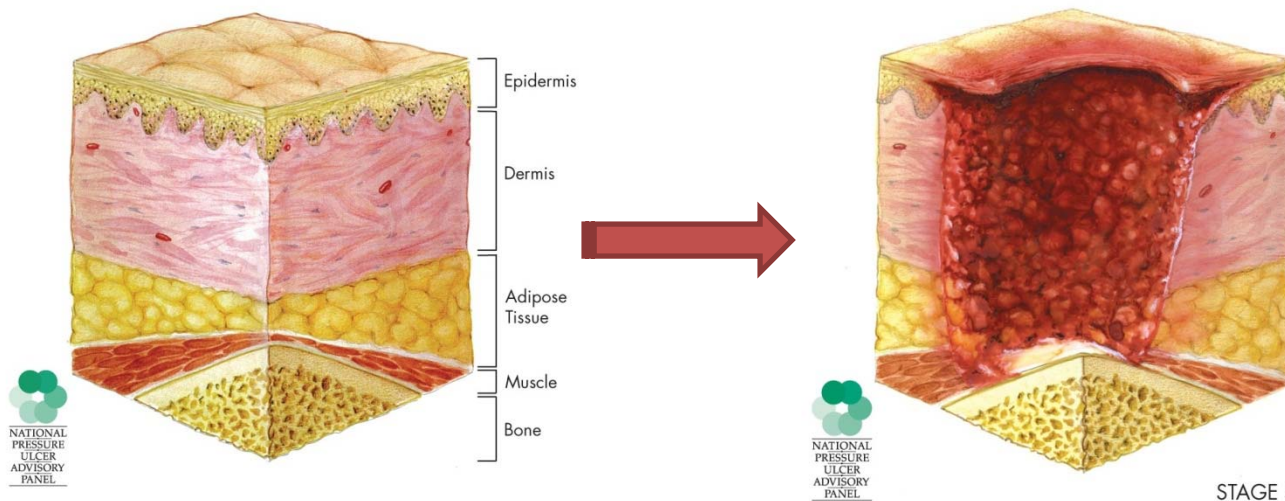


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# Background: Pressure Ulcers

- 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.



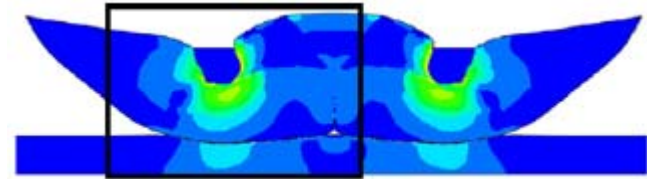
STAGE 4

# 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



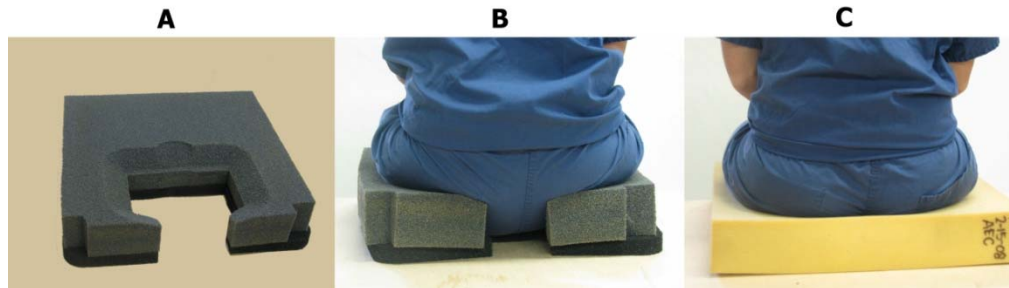
*Elsner, J. J. and A. Gefen (2008). J Biomech 41(16): 3322-3331.*

# Objective

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

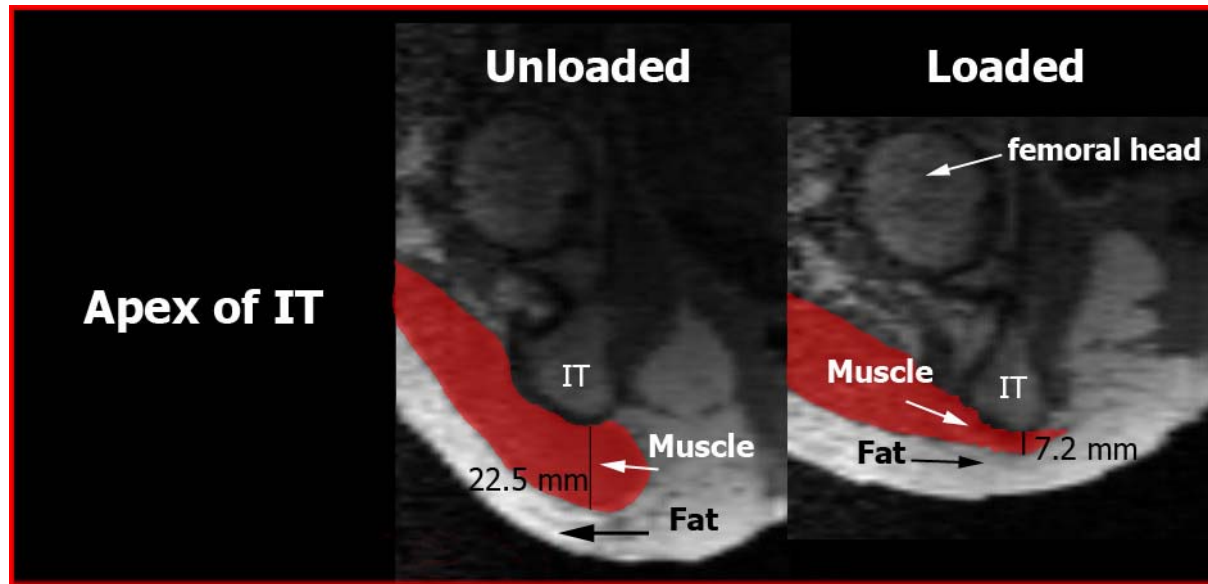
# Methods

- 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

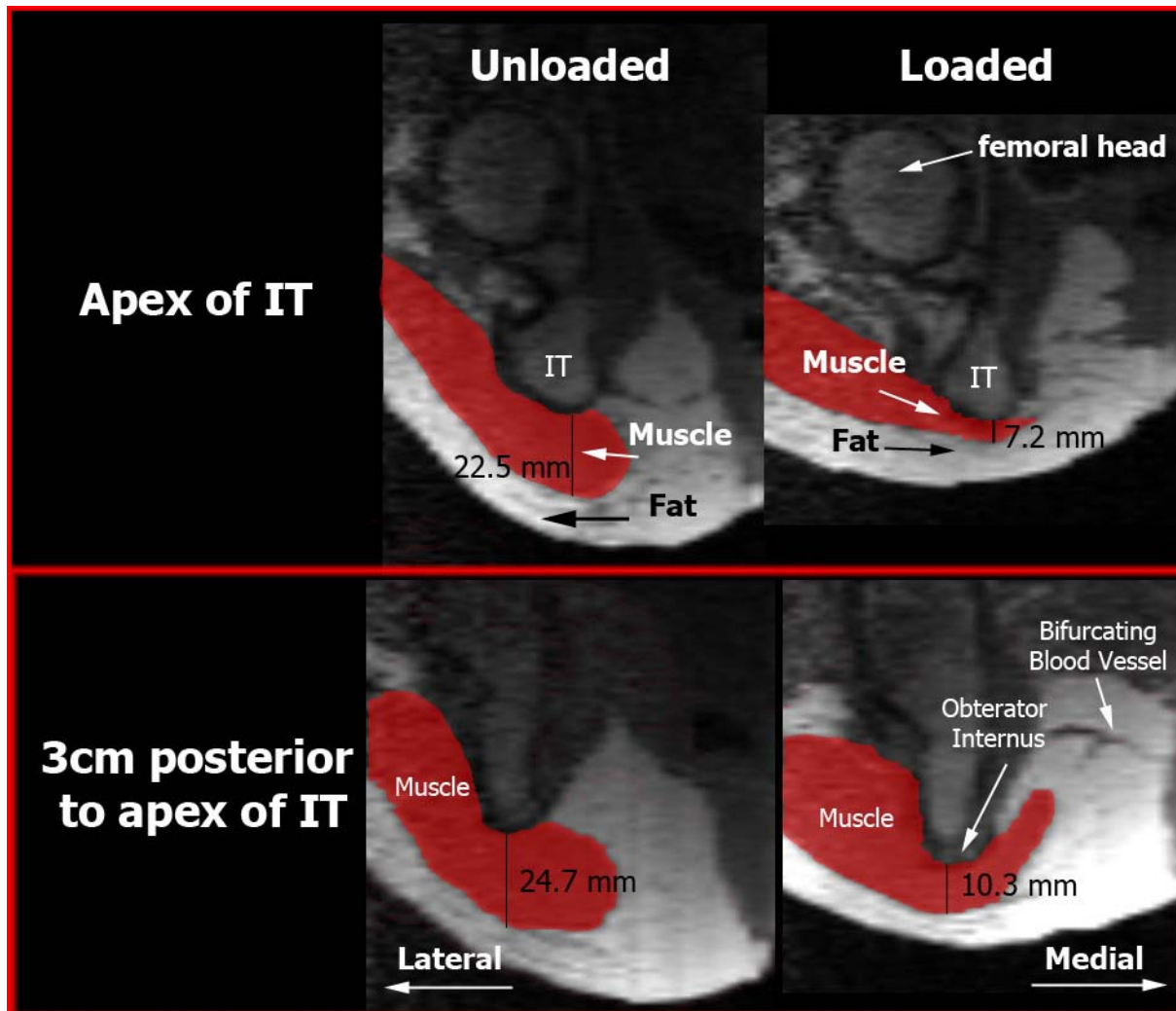
# MRI of the Seated Buttocks



*Right Side Only  
Coronal Plane*

# MRI of the Seated Buttocks

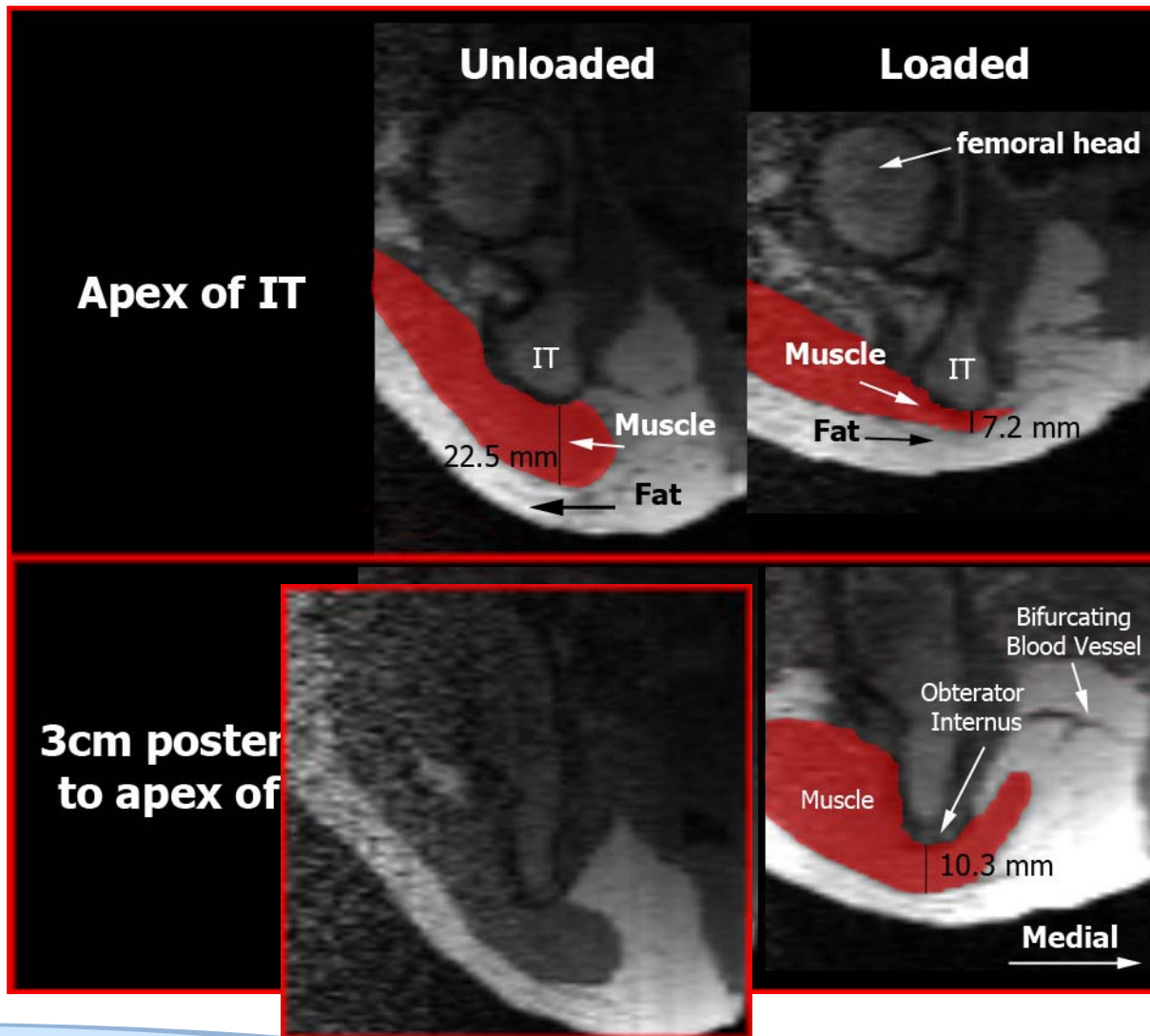
*Right Side Only  
Coronal Plane*





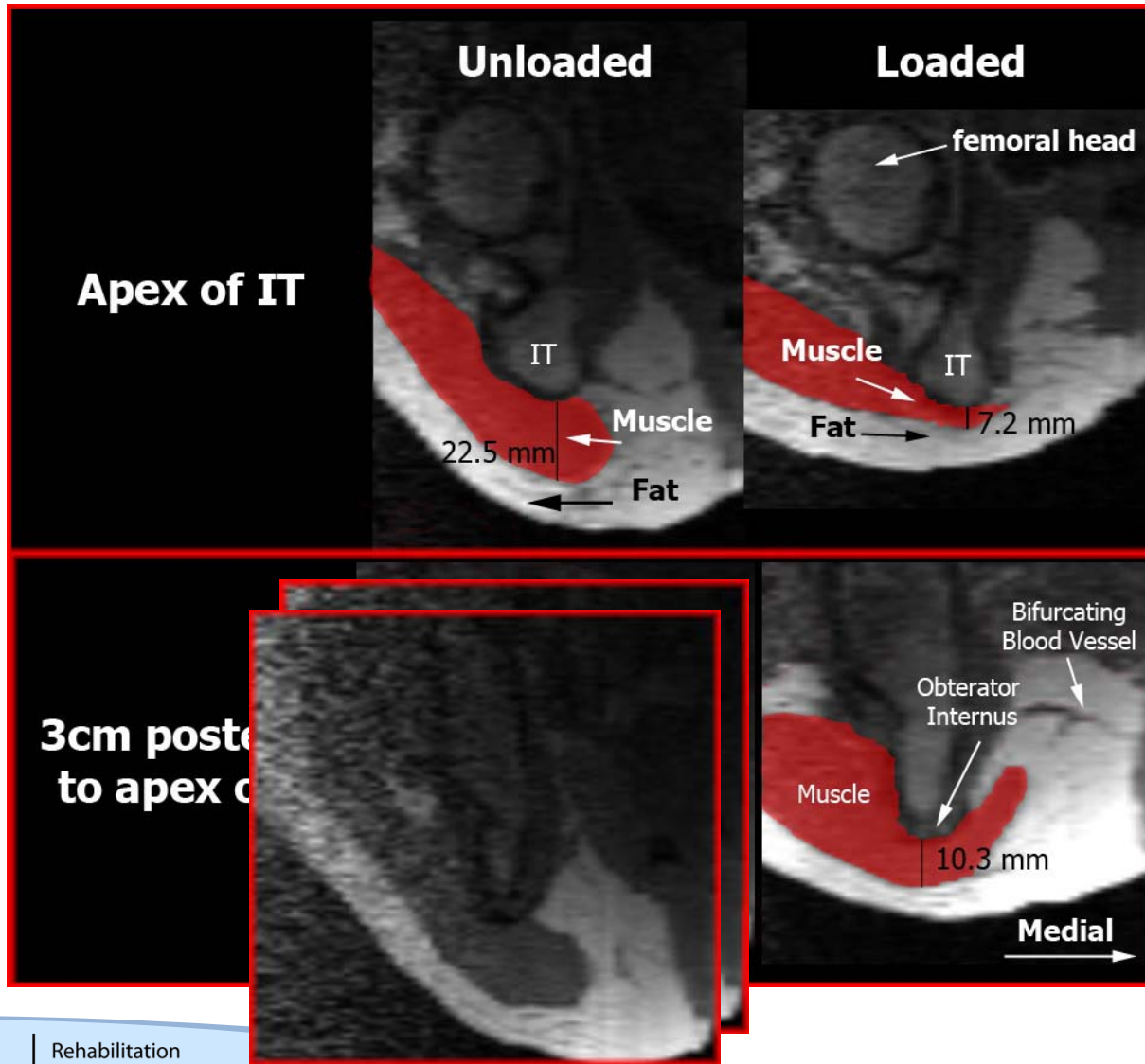
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*Right Side Only  
Coronal Plane*



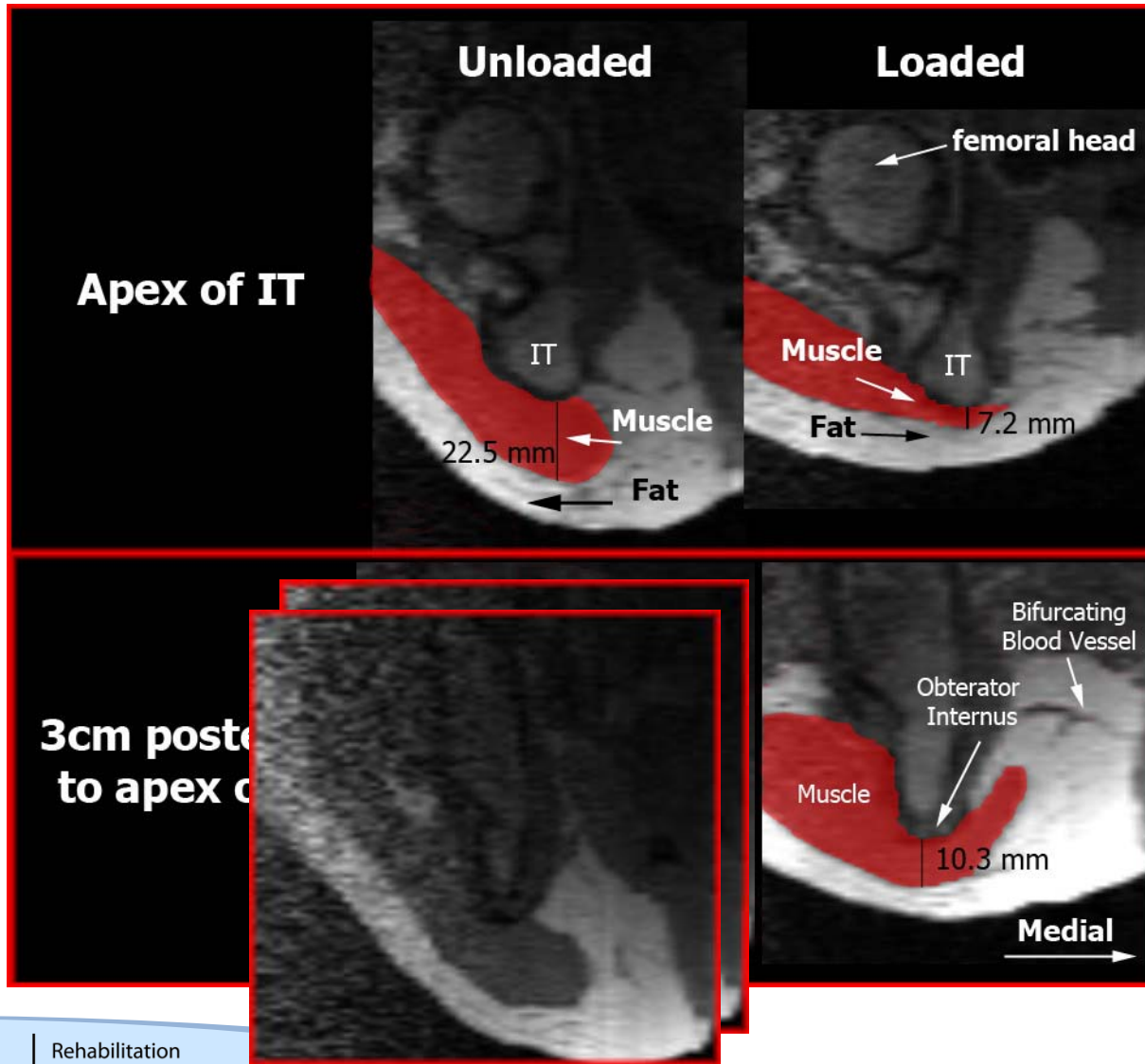
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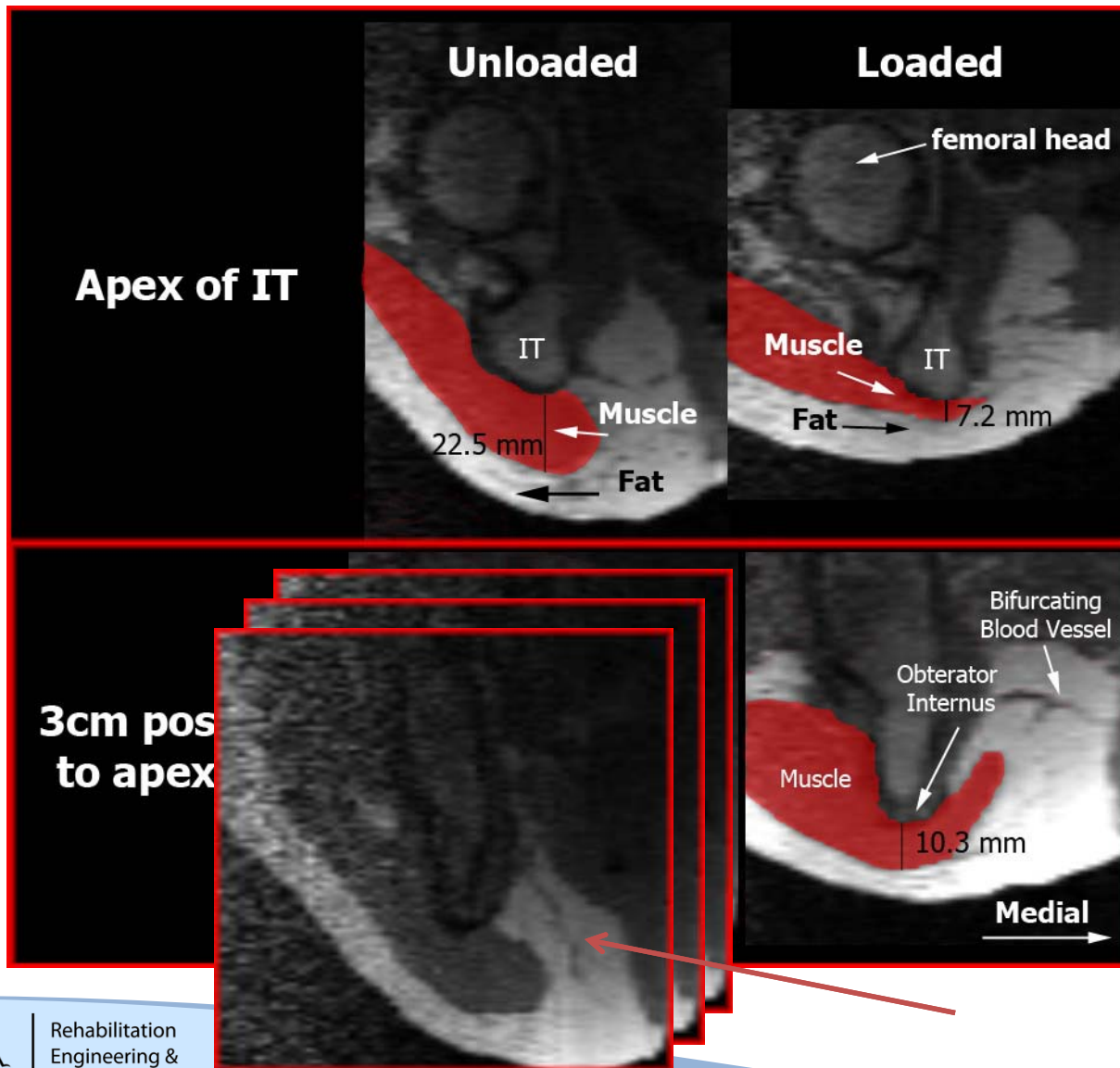
# MRI of the Seated Buttocks

*Right Side Only  
Coronal Plane*



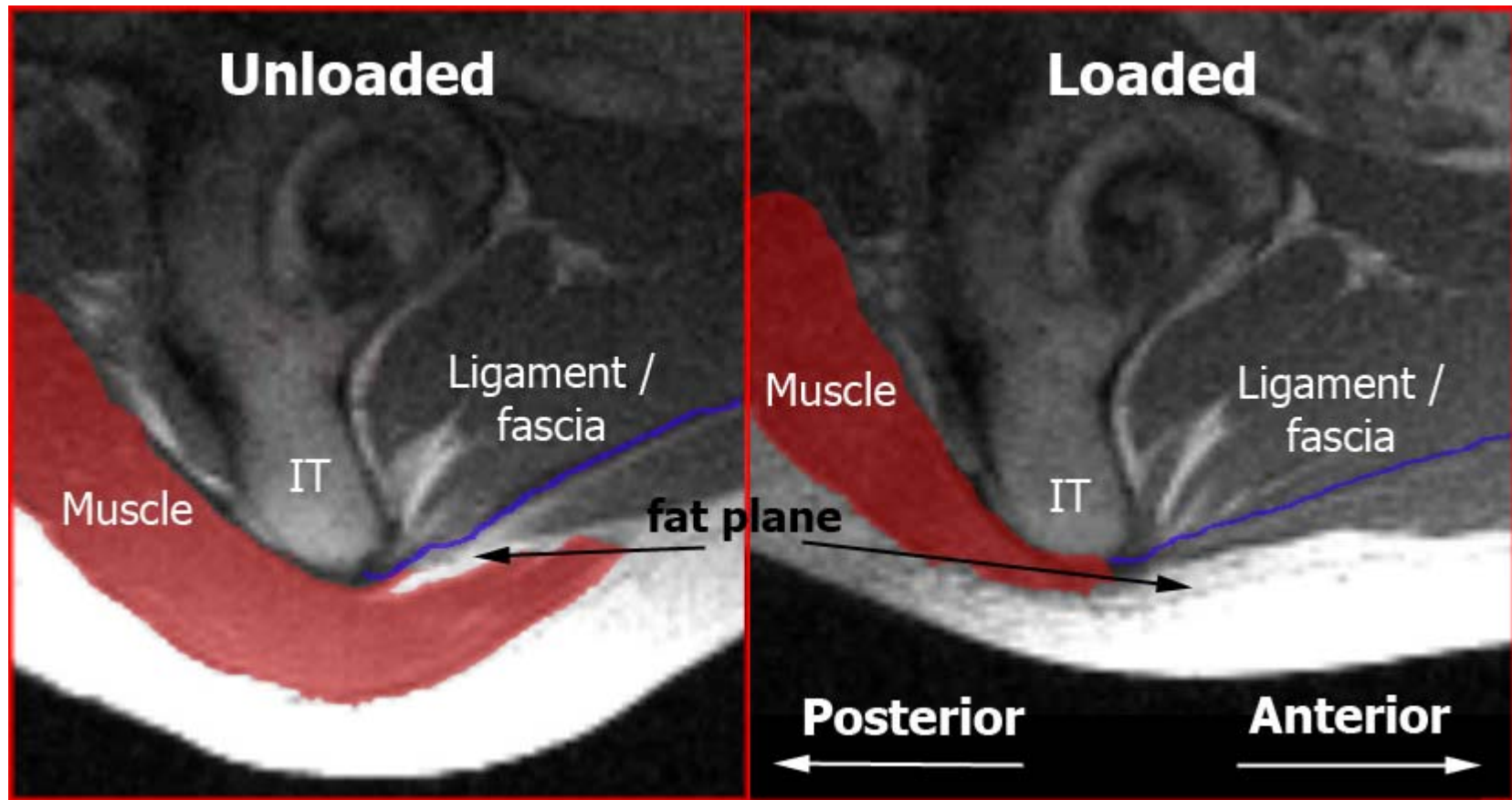
# MRI of the Seated Buttocks

*Right Side Only  
Coronal Plane*



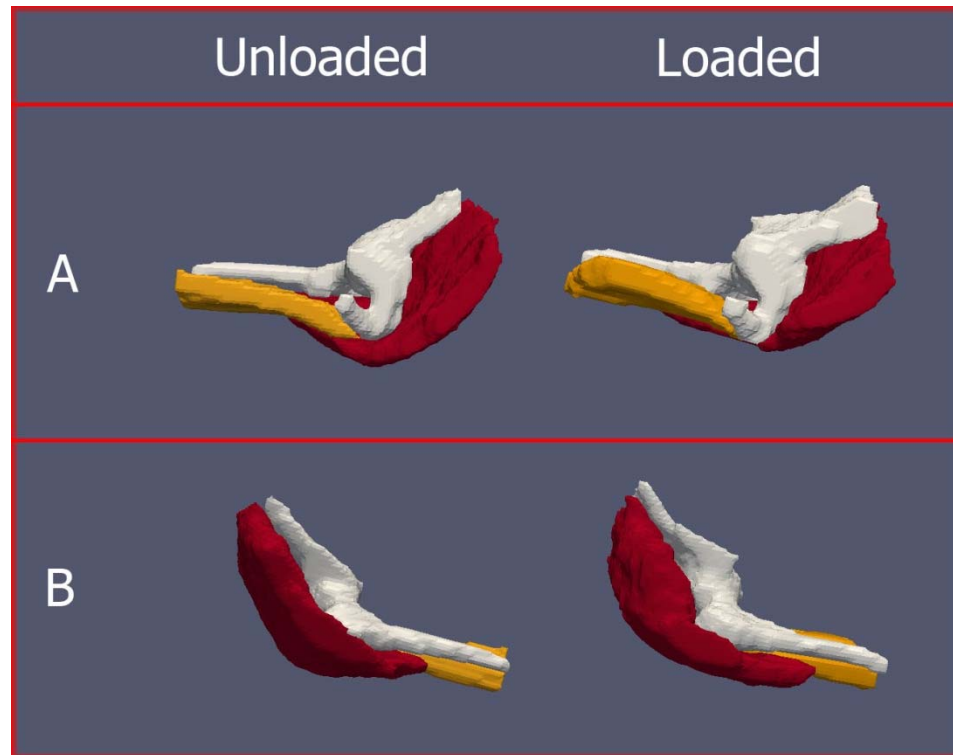
# MRI of the Seated Buttocks

## (Sagittal Plane)





# 3D Renderings of the ischium, ilium, proximal femur and muscles



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

# Thanks to

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