

The Effects of Pregnancy on Bone Mechanics

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Background

- Pregnancy affects the body
 - Hormonal changes (PRL, PTH, progesterone, estrogen)
 - Developing fetus
- Affects many different organ systems
 - Example: Bone

Objective

The objective of this investigation is to determine if there are any changes in the mechanical and material properties of the femur during pregnancy in rats at gestation day 18 of 23.

Study Design

- 39 rats
 - 15 control rats
 - 24 pregnant rats 18 days into pregnancy
- Biomechanical Testing (Three-point bend)
- Material Testing (Spherical Micro-indentation)

Methods

- Soft tissues removed from femur
- Hydrated for 24 hours
- Loaded into Instron for three-point bend testing to failure

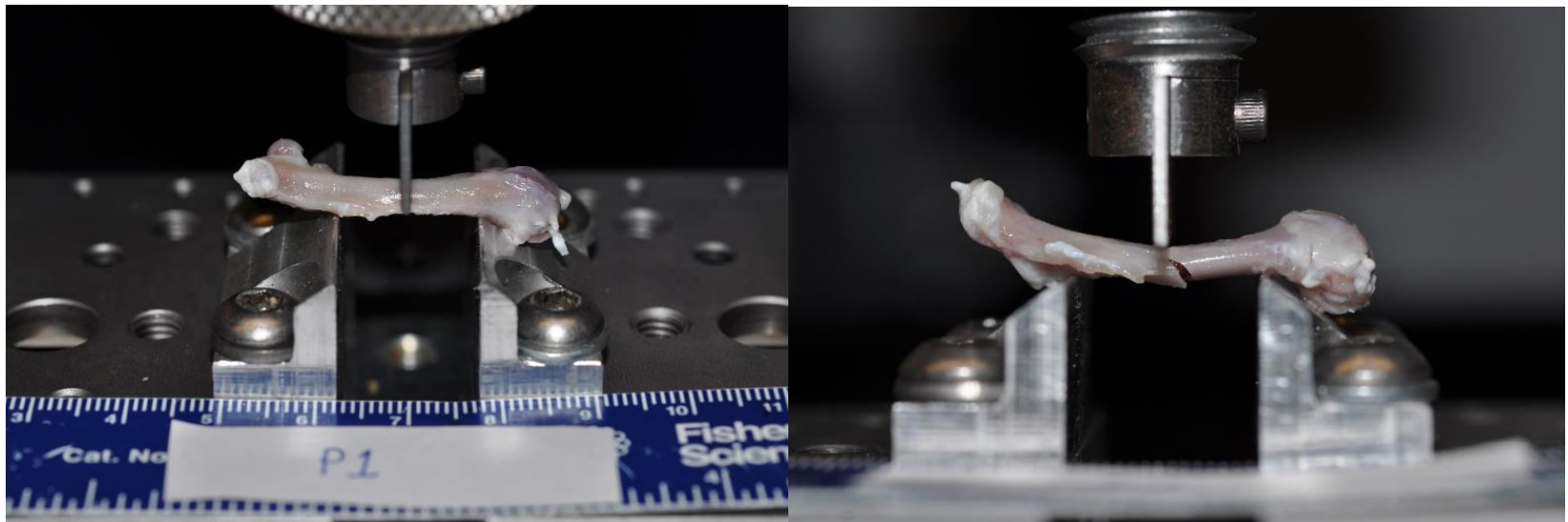


Figure 1: Three-Point bend testing set-up. Left: Femur before testing. Right: Femur after testing to failure



Methods

- Force-displacement data analyzed with MATLAB
 - Properties obtained were linear stiffness, maximum load, failure load, and energy to failure

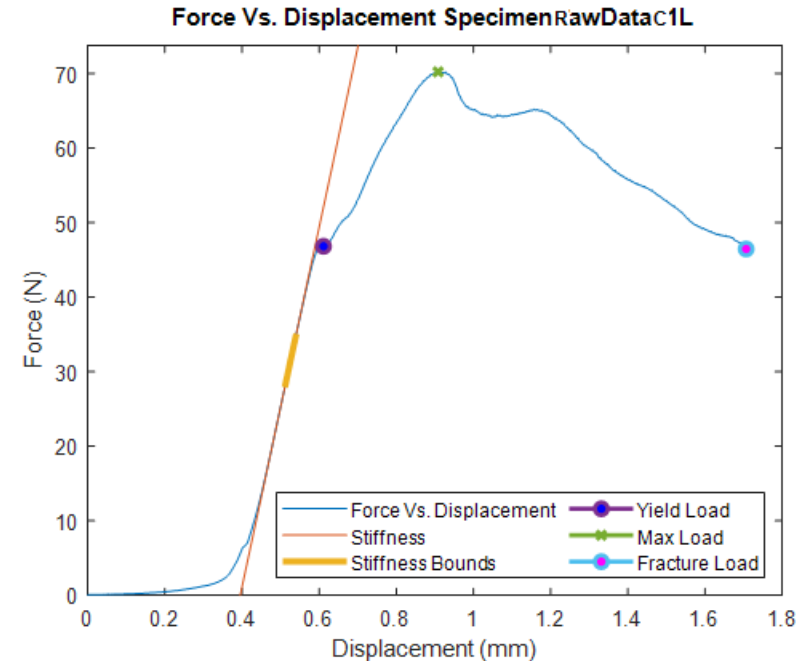


Figure 3: MATLAB was used to fit force-displacement curve in order to obtain properties such as linear stiffness, yield load, max load, and fracture load.

Methods

- Broken femurs are embedded in Epoxy
- Puck is cut and polished

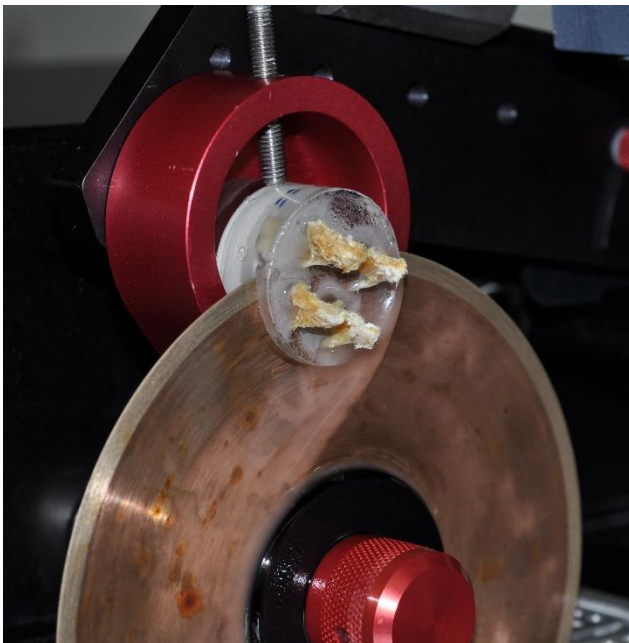


Figure 4: Cutting a puck after embedding samples



Figure 5: Final prepared sample after polishing

Methods

- 4-5 indentations per bone
- 30 second hold after reaching target depth
- MATLAB curve fit of force-displacement data for properties
 - instantaneous shear modulus, relaxed shear modulus, and modulus ratio.



Figure 6: Spherical Indentation Test on sample

Results:

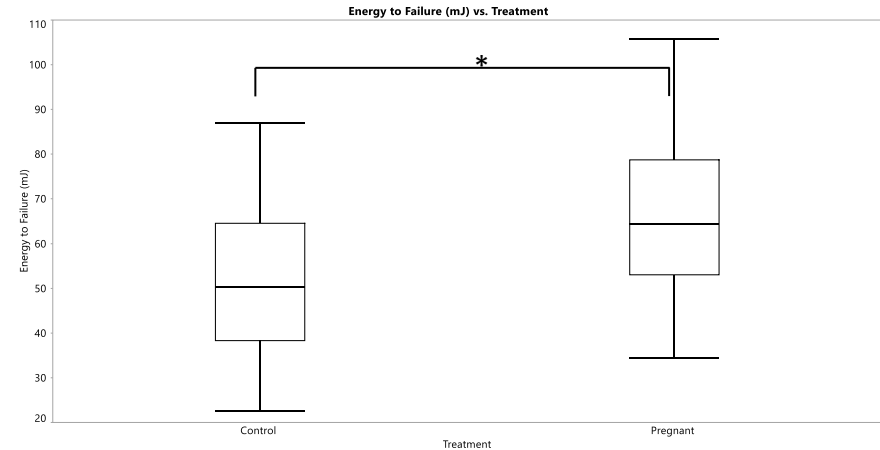
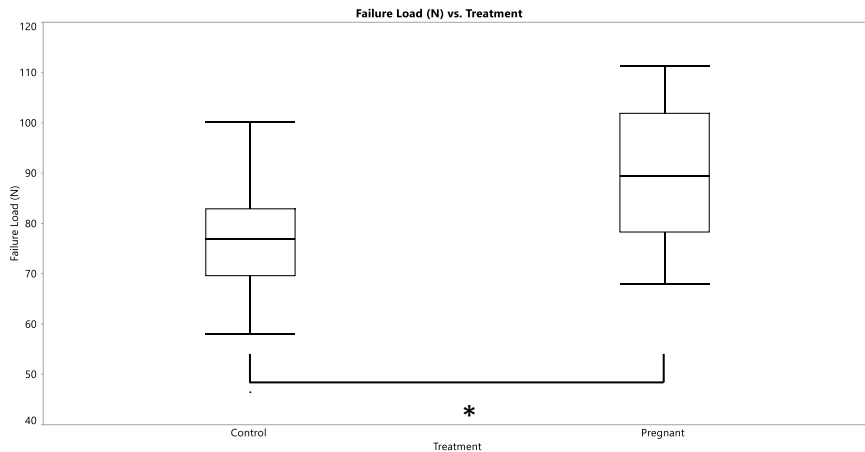
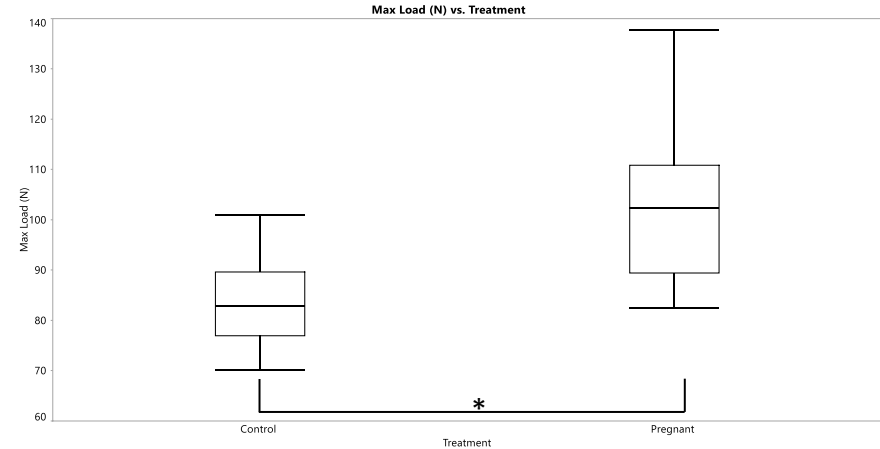
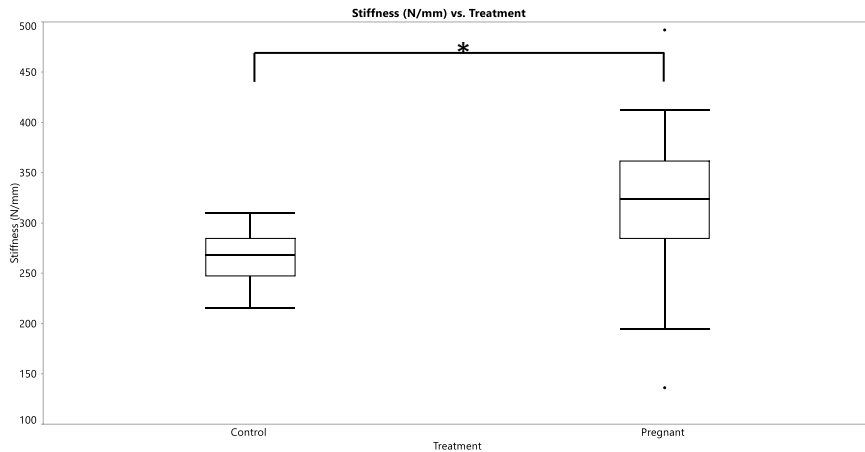


Figure 7: Box and Whisker Plots for the each of biomechanical properties
Top Left: Linear Stiffness. **Top Right:** Maximum Load. **Bottom Left:** Failure Load. **Bottom Right:** Energy to Failure

Results:

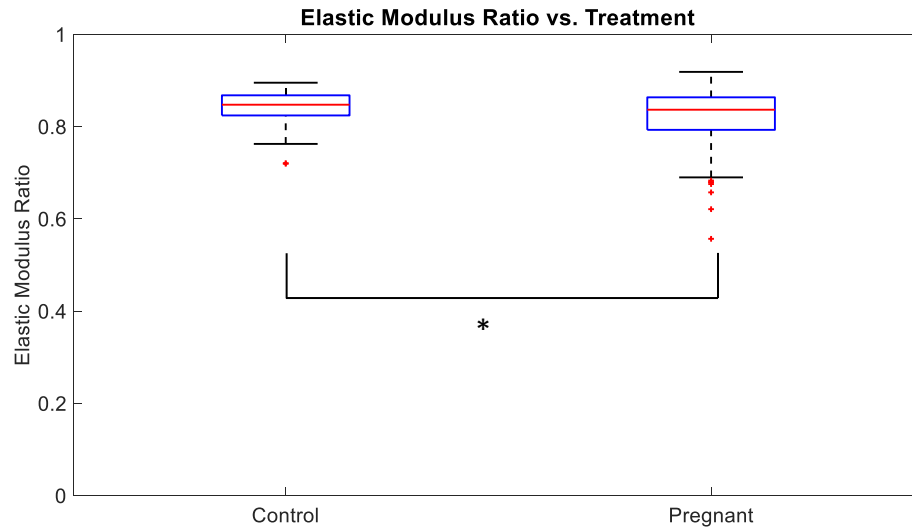
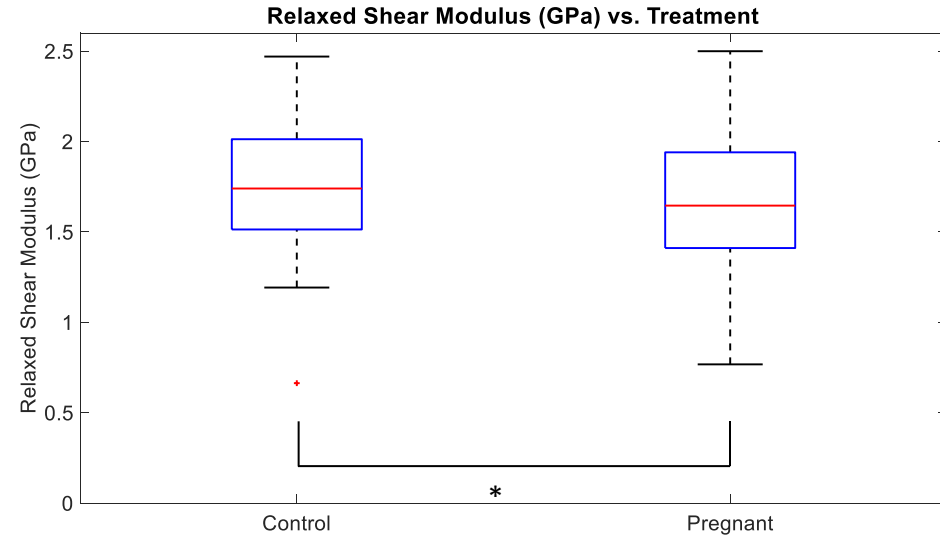
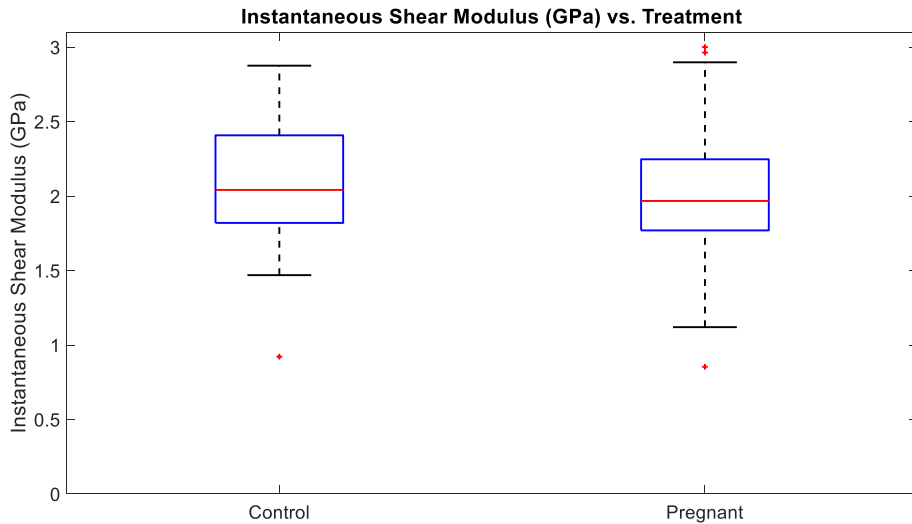


Figure 8: Box and Whisker Plots for the each of material properties
Top Left: Instantaneous Shear Modulus
Top Right: Relaxed Shear Modulus
Bottom: Modulus Ratio
 * Signifies statistical significance

Discussion

- All biomechanical properties increased
- Two material properties decreased
- Suspect that organic matrix (collagen) is affected
 - Studies have shown increased levels of progesterone and estrogen lead to ligament laxity [1, 2, 3]
- Changes in bone metabolism
 - Increase in PTH levels [4]
- Wolff's Law affects biomechanical properties
 - Pregnant rats heavier than controls
 - Did not get weights due to tissue sharing

Current and Future Work:

- Short term changes in bone material properties after pregnancy
- Histology
- Smaller scale material testing
- Compositional analyses
 - Finite element analysis

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References

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Questions?