Internship proposition

Academic Year: 2025-2026
Acronym: ADIPOSE

Project title:
Ex vivo protocol for the mechanical and histological characterization of gluteal adipose tissue
Funding :
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Project description:

Project Overview and Hypothesis:

Pressure ulcers (PUs) are localized injuries resulting from sustained mechanical loading that leads to tissue breakdown. They predominantly affect individuals with limited mobility, such as elderly patients and people with spinal cord injuries, who are unable to reposition themselves. Despite growing awareness, their incidence remains unacceptably high: PU prevalence is reported at 12.1% in Belgium, 8.9% in France and 10.2% in the UK (Barrois et al., 2008; Vanderwee et al., 2007). As populations age and chronic diseases become more common, these figures are expected to rise.

While the economic and societal burden of PUs within traditional clinical settings is well-documented (Demarré et al., 2015; Padula and Delarmente, 2019), the **challenge of tissue breakdown due to sustained mechanical loading extends to the Assistive Technology industry where devices like exoskeletons, prostheses, and wheelchairs with suboptimal design and fit can lead to similar complications**. For instance, sub-optimally fitted orthosis/prosthesis can lead to pain and, potentially, to dermatologic problems such as contact dermatitis (Lyon et al., 2000) and keratosis (Ibbotson et al., 1994) and in serious cases, internal tissue strain and ischemia can lead to deep tissue injury (Bouten et al., 2003). Up to 50% of people with lower limb amputation, do not regularly use their prosthesis, primarily due to socket fitting problems causing socket discomfort and skin problems (Meulenbelt et al., 2009, 2007). Similarly, 85% of spinal cord injury (SCI) patients who rely on wheelchairs, will develop PU amounting to approximately 11,000 new cases each year.

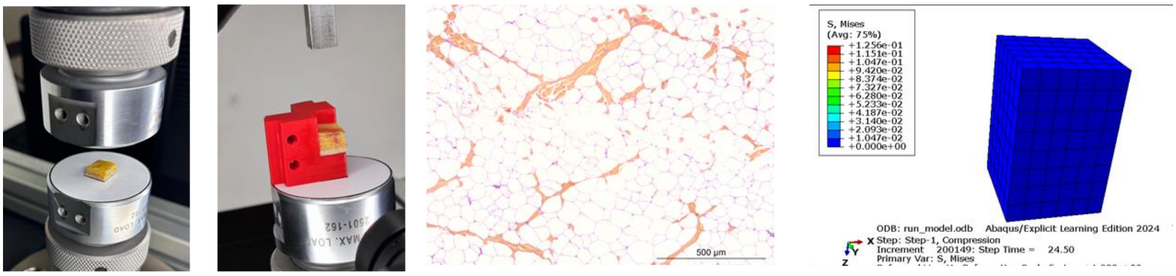
Classically, deep tissue injury (DTI) has been attributed to skeletal muscle breakdown beneath bony prominences. However, recent MRI studies (Call et al., 2017; Sonenblum et al., 2018, 2015) have shown that in many seated individuals, the gluteus maximus shifts laterally, **leaving adipose tissue as the primary load-bearing layer under the ischium**. This challenges muscle-centered PU theories and suggests that **adipose tissue may play a central role in DTI initiation**. Yet, quantitative mechanical data for human gluteal adipose tissue are virtually absent: previous work has focused on abdominal, breast, or perivascular fat, often from bariatric surgery or cadaveric donors, with heterogeneous testing conditions (uniaxial tension, compression, indentation, rheology). Only one prior study examined sheep gluteal adipose tissue (Gefen and Haberman, 2007).

Moreover, the structure–function relationship of gluteal adipose tissue remains unknown, and quantitative mechanical data for the human gluteal region are lacking. This gap is critical, since gluteal adipose tissue is a primary load-bearing structure during sitting, especially in individuals with limited or absent muscle under bony prominence.

The central hypothesis of this project is that the **structure–function relationship of gluteal adipose tissue** governs its ability to tolerate mechanical loading and plays a key role in deep tissue injury initiation.

Previous Work (MSc Maeva Lamant, 2025)

An *ex vivo* protocol was established last year (2025) for the mechanical and histological characterization of human gluteal adipose tissue (summarized in **figure 1** below). Methods developed: compression testing (confined/unconfined, two strain rates), stress–relaxation, mass loss analysis, and finite element calibration using a first-order Ogden model.



(a) (b) (c) (d)

Figure 1: Results from the 2025 internship (Maeva Lamant) (a) Mechanical testing setup for unconfined compression, (b) confined compression (well open) (c) histological section of gluteal adipose tissue, and (d) finite element simulation of compressive loading for identification of constitutive parameters using an inverse methodology.

Preliminary results showed that adipose tissue exhibited strong rate-dependent behavior, measurable fluid exudation (~3–5%), and regional stiffness differences (gluteal vs abdominal). This pioneering work provided the first quantitative results regarding the mechanical response of human gluteal adipose and demonstrated the feasibility of linking structure and function. However, shear deformation testing, larger sample cohorts, and advanced constitutive modeling remain unexplored.

Objectives of the Internship

Building directly upon Maeva Lamant's work, the new internship will pursue three main objectives:

1. Expand experimental testing protocols (Develop setup and protocol for shear tests to complement compression experiments. Establish protocole to image microstructure using **µCT imaging (to be validated against histological measurement).** Increase the number and diversity of tested samples (new donors). Improve testing conditions (physiological temperature, refined preconditioning cycles, boundary condition control)).

2. Strengthen biological and structural analysis (Quantify adipocyte morphology and septal fiber orientation from histological images. Investigate correlations between tissue microstructure and mechanical properties).

3. **Advance constitutive modeling** (Incorporating viscoelastic and/or poroelastic formulations into FE models. Calibrate models against both compression and shear tests. Assess whether microstructural parameters (e.g., adipocyte density) predict regional mechanical behavior.

Expected Outcomes

The internship is expected to deliver an expanded experimental dataset of gluteal adipose tissue properties, including both compression and shear responses. It will establish the first quantitative correlations between tissue microstructure and mechanical behavior, providing new insights into the structure–function relationship of human adipose tissue. In parallel, the project will yield an improved constitutive model, incorporating viscoelastic and/or poroelastic formulations, and calibrated against the new experimental results. Taken together, these outcomes will supply essential quantitative inputs for predictive biomechanical simulations of seated posture, ultimately enhancing pressure ulcer risk modeling and informing the design of safer seating systems and assistive technologies..

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