Introduction: The prevention and treatment of Pressure Ulcers (PU) remains a major challenge in healthcare. PU have been shown to develop in regions where mechanical loading induces large strains in the soft tissue, usually over bony prominences in regions such as the heel. Finite element (FE) models have previously been used to investigate the mechanical response of the heel tissue, but there are notable inconsistencies in the research (Keenan et al., 2022). One source for model variability is the many approaches to integrating material properties. In this study, we used a previously reported MRI-derived patient-specific FE model of the lower leg (Keenan & Rohan 2022) and evaluated the impact of using personalized material properties as opposed to average literature-based values on the simulated displacement and strain in the heel, and we compared these results to experimental measurements.

Methods: Ultrasound images of the heel contact region in unloaded and loaded configurations for one healthy subject were collected to evaluate the tissue displacement and strain using digital image correlation, along with the measured shear modulus using shear wave elastography (SWE) (Figure 1A). A previously reported MRI-derived FE model of the same subject's lower leg (Keenan & Rohan 2022) was adapted to fit the experimental configuration in terms of bone alignment (Figure 1B). Multiple simulations were computed with different material properties: values retrieved from literature were tested, along with the experimental shear modulus (Figure 1C). The simulation results were then compared to the experimental data calculated.

Results: The model displays differences for the displacement and strain of the tissue depending on the integrated material properties. While the overall behavior of the strain field resembled that of the experimental results, the magnitude of the simulated strain varied, and the location of the strain in the heel also changed depending on the properties (Figure 2).

Conclusions: This study illustrates the need to better characterize the material properties of the heel soft tissues for a model to accurately simulate a patient's biomechanical response. Current techniques, such as shear wave elastography, could be adapted to achieve personalized parameters capable of producing results that approach the experimental response measured.

Figures:

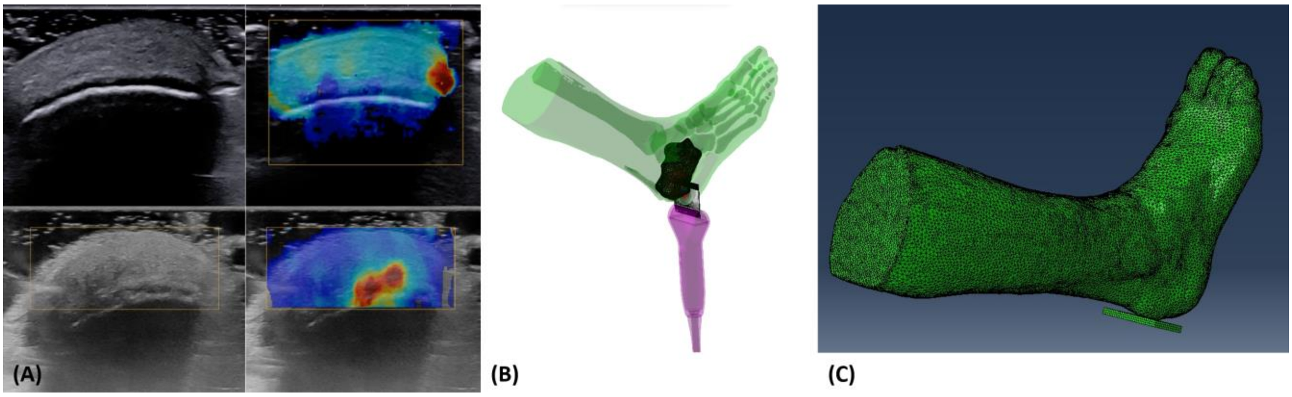

Figure 1: Experimental and simulated heel tissue response. (A) Ultrasound images of heel tissue, including SWE. (B) FE model configuration and ultrasound data alignment. (C) Simulation generated from FE model with adapted material properties.

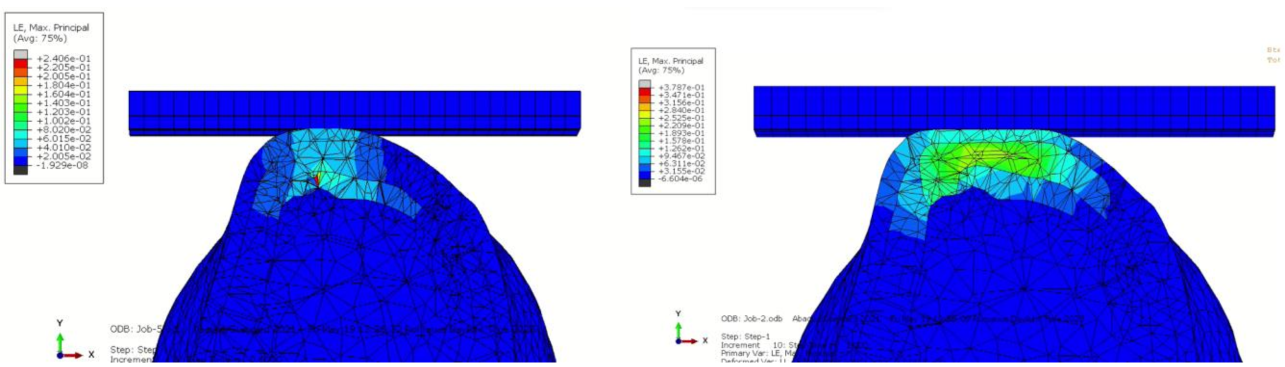

Figure 2: Strain field of simulated heel soft tissue response with different literature-based values integrated in the model.

References:

Keenan, B. E., Evans, S. L., Oomens, C. W. J. (2022). A review of foot finite element modelling for pressure ulcer prevention in bedrest: Current perspectives and future recommendations. *Journal of Tissue Viability*, *31*(1), 73–83. https://doi.org/10.1016/j.jtv.2021.06.004

Keenan, B. E., Rohan, P.Y. (2022, April). A mixed numerical-experimental approach to evaluate the internal soft tissue response of the heel. *Colloquium 627 Current challenges in soft tissue mechanics*, Euromech Mechanics Society, Frankfurt, Germany.