Modeling the Impact of Long-term Exoskeleton Use on Achilles Tendon Remodeling

Jordyn N. Schroeder (jschroeder9@gatech.edu), Gregory S. Sawicki
Georgia Institute of Technology Woodruff School of Mechanical Engineering

Motivation
- Little is known about the long-term effects of human augmentation devices on the musculoskeletal system
- Decreased tendon stiffness may lead to less efficient concentric contractions\(^1\) and too much or too little stiffness may increase injury risk\(^2\)
- Tendons typically remodel after 14 weeks\(^3\) but the nuances of remodeling are unclear
- Modeling provides insight to parameter optimization and can be supplemented by longitudinal human studies

Approach
- Implemented a longitudinal model for hopping with a passive ankle exoskeleton
- Swept exoskeleton stiffness (with corresponding muscle stimulation to maintain mechanical power output\(^4\)) and proportion of exoskeleton locomotion for a set number of cycles
- Estimated the shift in the mechanical remodeling due to cycles as a proportion of nominal using a sigmoid function

Results and Implications
- Nominal Cycles (Fig. 3)
  - Most conditions result in tissue homeostasis
  - Stiffer exoskeletons worn more frequently decrease tendon stiffness

Future Directions
- Incorporate metabolic cost as an indicator for total daily cycles
- Longitudinal human trials to improve accuracy of tendon remodeling predictions and cyclic sensitivity

Fig. 1 – Model Block Diagram

Fig. 2 – Cyclic Sensitivity and Impact on Mechanical Remodeling Graph

Fig. 3 – \(\Delta K_t\): Nominal Cycles

Fig. 4 – \(\Delta K_t\): 2X Nominal Cycles

References