Human Motion Lab

Josh Baxter, PhD

The Human Motion Lab continues to work closely with our clinical colleagues to address unmet clinical needs. Our research focuses on Achilles tendon injuries using small animal experiments and observational patients studies. We use wearable sensors, motion capture, ultrasound imaging, and musculoskeletal modeling to establish and improve exciting new frameworks to continuously monitor structural and functional progress in patients who are treated in the Orthopaedic Surgery clinics at Penn Medicine. Despite the challenges of COVID-19 this past year, our lab has thrived. We were awarded 2 NIH grants, a PCMD pilot grant, and an American Orthopaedic Foot and Ankle Society (AOFAS) research grant. We also started new collaborations with researchers at the University of Delaware and Washington University in St. Louis.

We are excited to begin a new clinical research study on patients with Achilles tendinopathy that is supported by the National Institutes of Health (R01AR078898). This study will investigate the effects of tendon mechanical loading on tendon disease state, healing, and outcomes. Treating Achilles tendinopathy is challenging in part due to the wide range of disease severities and presentations seen in the clinic. To account for this variation, we are leveraging machine learning to identify patient subgroups to better guide treatment. Our recent study published in the journal Medicine & Science in Sports & Exercise ranked common rehabilitative exercises for patients with Achilles tendon pain. By continuously monitoring patients during daily living, we will capture the cumulative tendon loads they experience. This will provide a never-before-seen picture of how our daily activities of real-life impact—for better or worse—tendon health across a diverse group of patients.

In addition to growing our clinical research effort, we also are studying the effects of mechanical loading on Achilles tendon ruptures using a small animal model. Dr. Baxter received funding through the NIH (K01AR075877) and the PCMD (P30AR069619) to investigate how Achilles tendon ruptures stimulate muscle remodeling and tendon elongation. Then, he will determine how joint immobilization can most effectively be used to promote tendon healing and preserve muscle function. We are running a parallel clinical study supported by the AOFAS to characterize tendon loading biomechanics throughout healing in patients. We expect these studies will identify rehabilitative loading guidelines and ultrasound imaging benchmarks to inform personalized treatment.

Our group published 6 papers this past year. We have developed new techniques to monitor patient function outside of the traditional laboratory setting, which we expect will expand our reach and impact on musculoskeletal patient research. We also teamed up with researchers and the University of Delaware and Washington University in St. Louis to understand the varying implications of Achilles tendon ruptures on function. In this study, we found that although patients restore most of their functional strength during tasks like jumping, their ankles can operate through a reduced range of motion. These findings highlight the importance of rehabilitative care to restore plantar flexor function that will translate to improved return to activity outcomes.

We are excited to continue our clinically-relevant research to improve patient care, advance our fundamental understanding of musculoskeletal biomechanics, and educate the next generation of leaders in clinical care and research.

Recent Work

1. **Schmidt EC, Hullfish TJ, O'Connor KM, Hast MW, Baxter JR.** Ultrasound echogenicity is associated with fatigue-induced failure in a cadaveric Achilles tendon model. J Biomech [Internet]. 2020 May 22;105:109784. Available from: http://dx.doi.org/10.1016/j.jbiomech.2020.109784 PMID: 32278525
2. **Drazan JF, Hullfish TJ, Baxter JR.** Novel isodamping dynamometer accurately measures plantar flexor function. J Biomech [Internet]. 2020 Oct 9;111:110015. Available from: http://dx.doi.org/10.1016/j.jbiomech.2020.110015 PMID: 32891810
3. **Hullfish TJ, Baxter JR.** A simple instrumented insole algorithm to estimate plantar flexion moments. Gait Posture [Internet]. 2020 Jun;79:92–95. Available from: http://dx.doi.org/10.1016/j.gaitpost.2020.04.016 PMID: 32388057
4. **Hullfish TJ, O'Connor KM, Baxter JR.** Instrumented immobilizing boot paradigm quantifies reduced Achilles tendon loading during gait. J Biomech [Internet]. 2020 Aug 26;109:109925. Available from: http://dx.doi.org/10.1016/j.jbiomech.2020.109925 PMID: 32807329
5. **Baxter JR, Corrigan P, Hullfish TJ, O'Rourke P, Silbernagel KG.** Exercise Progression to Incrementally Load the Achilles Tendon. Med Sci Sports Exerc [Internet]. 2021 Jan;53(1):124–130. Available from: http://dx.doi.org/10.1249/MSS.0000000000002459 PMID: 32658037
6. **Zellers JA, Baxter JR, Gravare-Silbernagel K.** Functional ankle range of motion but not peak Achilles tendon force diminished with heel-rise and jumping tasks after Achilles tendon repair. Am. J. Sports Medicine. [Accepted—ahead of print].