Human Motion Lab

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The Human Motion Lab continues to work closely with our clinical colleagues to address unmet clinical needs. Using custom sensors, motion capture, ultrasound imaging, and musculoskeletal modeling, we have established exciting new frameworks to continuously monitor structural and functional progress in patients who are treated in the Orthopaedic Surgery clinics at Penn Medicine. In the past year, we've been busy. Our group has collaborated with clinicians and scientists at Penn to identify governing factors following Achilles tendon injuries,[1–3] automate medical image analysis,[4] improve musculoskeletal simulations,[5] predict function following tendon injury,[6,7] discover predictors of ankle function,[8,9] and developed novel paragigms to monitor patioen biomechanics using low-cost sensors.[10–12]

The Human Motion Lab is focused on establishing itself as a leader in the field of Achilles tendon health. Using motion capture, ultrasonography imaging, and musculoskeletal modelling we are beginning to explain the biomechanical factors that explain functional outcomes in these patient cohorts. With strong collaborations around the Department of Orthopaedic Surgery, we are excited for the future of the Human Motion Lab.

Our group is developing new clinical paradigms for monitoring and guiding rehabilitation after Achilles tendon injuries. Working closely with Drs. O'Connor and Farber in the Foot and Ankle division, we have identified novel mechanisms that explain functional outcomes in patients after Achilles tendon ruptures. To improve the structural response of both muscle and tendon to these injuries, we have developed exciting new techniques to quantify Achilles tendon loading when patients begin to load their healing tendons.[12] This work is currently supported by the American Orthopaedic Foot and Ankle Society.

In addition to collaborating with orthopaedic surgeons, we also utilize musculoskeletal simulations and small animal models to experimentally determine the interplay between Achilles tendon injuries, muscle-tendon changes, and functional outcomes.[1,8] With support from the National Institutes of Health, we will work with Dr. Soslowsky to experimentally determine rehabilitation loads that stimulate muscle-tendon healing. By leveraging the strengths of the McKay Orthopaedic Research Laboratory, we expect to accelerate the translation of basic discovery to clinical care.

In addition to studying Achilles tendon health, we work closely with orthopaedic trainees to advance the educational mission of Penn Orthopaedics. This past year, we worked with Drs. Gandhi (PGY-5) and Serra López (PGY-2) to develop and deploy a wearable sensor to quantify thumb motion in patients with carpometacarpal joint arthritis. Our exciting preliminary results confirmed that quantifying functional outcomes can be part of routine clinic care.

We are excited to continue our clinically-focused work 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. **Baxter JR, Farber DC, Hast MW.** Plantarflexor fiber and tendon slack length are strong determinates of simulated single-leg heel raise height. J Biomech. 2019 Mar 27;86:27–33.
2. **Hullfish TJ, O'Connor KM, Baxter JR**. Gastrocnemius fascicles are shorter and more pennate throughout the first month following acute Achilles tendon rupture. PeerJ. 2019 Apr 23;7:e6788.
3. **Hullfish TJ, O'Connor KM, Baxter JR**. Medial gastrocnemius muscle remodeling correlates with reduced plantarflexor kinetics 14 weeks following Achilles tendon rupture. J Appl Physiol. 2019 Aug 8;127(4):1005–1011.
4. **Drazan JF, Hullfish TJ, Baxter JR**. An automatic fascicle tracking algorithm quantifying gastrocnemius architecture during maximal effort contractions. PeerJ. 2019 Jul 2;7:e7120.
5. **Hast MW, Hanson BG, Baxter JR**. Simulating contact using the elastic foundation algorithm in OpenSim. J Biomech. 2019 Jan 3;82:392–396.
6. **Bachner EM, Schmidt EC, Chin M, Namdari S, Baxter JR, Hast MW.** Parameterization of proximal humerus locking plate impingement with in vitro, in silico, and in vivo techniques. J Shoulder Elbow Surg [Internet]. 2019 Feb 13 [cited 2019 Feb 15];0(0). Available from: https://www.jshoulderelbow.org/article/S1058-2746(18)30892-9/abstract
7. **Schmidt EC, Hullfish TJ, O'Connor KM, Hast MW, Baxter JR.** Ultrasound Echogenicity is Associated with Achilles Tendon Fatigue Damage in a Cadaveric Loading Model. BioRxiv Prepr. 2019 Nov 21;849943.
8. **Baxter JR, Hast MW**. Plantarflexor metabolics are sensitive to resting ankle angle and optimal fiber length in computational simulations of gait. Gait Posture. 2019 Jan 1;67:194–200.
9. **Drazan JF, Hullfish TJ, Baxter JR**. Muscle structure governs joint function: linking natural variation in medial gastrocnemius structure with isokinetic plantar flexor function. Biol Open. 2019 Dec 15;8(12):bio048520.
10. **Hullfish TJ, Qu F, Stoeckl BD, Gebhard PM, Mauck RL, Baxter JR.** Measuring clinically relevant knee

motion with a self-calibrated wearable sensor. J Biomech. 2019 May 24;89:105–109. PMCID: PMC6249046

11. **Hullfish TJ, Baxter JR**. Novel instrumented insole algorithm accurately approximates plantar flexor loading. BioRxiv Prepr [Internet]. 2019 Dec 23 [cited 2020 Jan 2]; Available from: http://biorxiv.org/lookup/doi/10.1101/2019.12.20.885228
12. **Hullfish TJ, O'Connor KM, Baxter JR.** Instrumented immobilizing boot quantifies reduced Achilles tendon loading during gait. BioRxiv Prepr. Cold Spring Harbor Laboratory; 2020 Feb 27;2020.02.27.968495.