**2023 Multidisciplinary Research Program in Medicine Project:** PhysViz: Validation of a new telerehabilitation platform

**Hypothesis or Research Question(s):** Objective assessment of lower extremity muscle function is crucial to deliver evidence-informed injury rehabilitation. We have recently validated an affordable technology (PhysViz) for telerehabilitation applications and demonstrated that real-time load-monitoring during exercise is feasible. Next, we want to ascertain what levels of tendon strain result from the prescribed loads and whether these strains are reproducible with the PhysViz - appropriate strains are the cornerstone of tendon rehabilitation.

**PROJECT BACKGROUND & SUMMARY**

Outpatient rehabilitation of Achilles tendon injuries has changed little over the past few decades. The typical model of post-surgical outpatient care involves an in-clinic assessment of lower extremity function, followed by prescription of a home exercise program (HEP) with a number of in-person follow-up visits to monitor and progress the program. The HEP is designed to introduce controlled loading to the injured tissue, thereby stimulating healing and restoring tissue function.

This approach to outpatient rehabilitation presents significant challenges, such as unknown compliance, unknown load through injured tissue, lack of regular feedback to the patient, and reliance on subjective criteria for progressing. Perhaps most importantly, the actual dose of loading experienced by the injured tissue is unknown.

Telerehabilitation has rapidly emerged as an innovative approach to deliver care when in-person attendance is not possible. It also has the potential to address many of the challenges associated with a traditional outpatient HEP. This new area of research requires many disciplines to work together to develop appropriate telerehabilitation technologies for a wide variety of clinical scenarios, most notably physiotherapy, kinesiology and engineering. Hence, our project involves an interdisciplinary collaboration between the Department of physical therapy (specializing in rehabilitation science and clinical decision-making) and the School of Biomedical Engineering (specializing in biomedical engineering and software development).

In collaboration with engineers from the dept. Applied Sciences, Dr XXX’s lab has developed a low-cost prototype telerehabilitation system for home-use. Key features of the prototype include real-time load monitoring on the patient's phone, recording of all exercise sessions, and a web-portal for the clinician to remotely access these records and track patient progress. This telerehabilitation platform is the focus of lab member XXX’s (PEng, MPT-PhD student) PhD project. Mr XXX was the student advisor of a 2022 MRPM project which validated our telerehabilitation system prototype (PhysViz) to the laboratory gold standard (a Biodex dynamometer).

Our follow-up project addresses the pressing need to develop accurate distance-based strength assessment tools appropriate for clinical applications. Specifically, we aim to ascertain whether the prescribed loads (based on a percentage of maximum voluntary contraction) results in the same actual strain experienced by the Achilles tendon on both devices. This is important because tendons experience strain (extension) in response to an applied load (e.g. muscle force) and strain magnitude forms the cornerstone of tendon rehabilitation.

**METHODS** We aim to recruit 60 participants in total for this study, which will be split across 3 groups. Group 1: 20 patients with surgically managed Achilles tendon rupture and at least 12 weeks post-op and
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cleared to begin exercise, Group 2: 20 patients with Achilles midportion tendinopathy (VISA-A score between 50 and 80 and pain < 3/10 during maximal contraction), and Group 3: 20 participants with no tendon pathology.

Each participant will visit the CHHM lab once. After an orientation, they will have a short practice period consisting of several submaximal warm-ups, followed by several maximum voluntary contractions (MVC; Groups 2&3 only). For group 1, the contraction effort will be set at a level which corresponds to that currently prescribed by their treating surgeon or physiotherapist.

The exercise prescription will be 70% of MVC, 1 set of 15 repetitions, 3 second duration per repetition with a 1 second ramp up and down. The participant will then switch to the PhysViz condition after a 10-minute rest, and a second exercise set completed using the alternate equipment. During exercise in each condition, the load will be recorded; the data captured by the PhysViz is automatically uploaded to a cloud-based server where it can be accessed by the investigator via the PhysViz’s web-based clinician portal. In addition, tendon strain will be recorded with ultrasound, muscle activity will be recorded with EMG and joint kinematics will be recorded with motion capture equipment. Musculoskeletal simulations will be used to predict differences in the conditions.

The validation of this distance-based system is an essential step in developing a robust clinical tool which we anticipate could find widespread use.

**BENEFIT TO THE STUDENTS**

Interactions: The students will be joining a very interdisciplinary team, with the opportunities to interact with the whole research team behind this project. In addition to those mentioned above (physiotherapist, biomedical engineer, kinesiologist), the PhysViz development team, led by the PI and funded by a Michael Smith C2 grant, includes a patient partner, an industry software expert, an occupational therapist, a medical device regulatory specialist, and several clinicians. In addition to this team, the students will work alongside other members of the PIs lab who have regular lab meetings.

The projects to which they’ll be exposed are very diverse, everything from molecular events involved in tendon cell mechanotransduction to methods for generating clinical consensus. The collaborator’s lab specializes in making measurements of human motion in natural "out of laboratory" environments to study the biomechanics of musculoskeletal injuries and the neuromechanics of human motion perception. The students will be invited to regular lab meetings.

The experiments will take place at the Centre for Hip Health and Mobility where both PIs are based. They will naturally meet other students at regular Lunch and Learn as well as social events, engaged in a variety of interdisciplinary projects. The supervising PhD student is working in a very similar area and will be able to provide high quality support.

Skills: The students will be involved in carrying out participant recruitment activities, interacting with patients and healthy volunteers, data collection both in person and virtual, data processing and statistical analysis methods, presentation of results to fellow lab members and virtually to the Canadian Musculoskeletal Research Network summer conference, and contribute to writing a report suitable for publication. They will also come away with practical knowledge about how strength is assessed and how that information is used to prescribe exercise in both healthy and clinical populations.
Resources: In addition to the supervisory team outlined above, the students will benefit from the presence of a senior research associate in the lab (VCHRI funded). The PI's lab is well equipped via both NSERC and CIHR streams. The PhysViz has been developed so far using a mix of funds, both NSERC and Michael Smith as well as additional legacy funds from the PI's CFI. All the equipment required is in place at the Centre for Hip Health and Mobility or in Dr XXX's research lab there.