Rig for imaging knee during walking gait in standing MRI or Biplanar Flouroscopy

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Introduction: The knee is a commonly injured joint in recreational activities. The most common structures that are damaged are the ligaments, particularly the anterior cruciate ligaments. While most people think of the knee as a hinge joint, in reality the knee is a complex structure that is held together by ligaments that restrict its motion to the familiar flexion extension motion. Ligament injuries are caused by loading these elastic mechanical structures to failure, and once injured can substantially reduce knee stability and lead to long-term damage to the cartilage.

While failure of the ligaments are the cause of injury, the ligaments themselves also undergo constant cyclic loading during locomotion tasks such as walking and running. As these cyclic loads can also weaken mechanical structures over time, it is important to understand what type of cyclic loads are applied to the ligaments during everyday activities.

Unfortunately, it is impossible to instrument the ligaments directly without invasive surgical techniques. However, we can use medical imaging techniques to estimate the ligament strains during locomotion tasks. While Magnetic Resonance Imaging and X-ray scans are common for measuring internal structures, there are typically two major flaws. First, many imaging modalities (most MRIs in fact) are designed to be operated with participants lying down. While participants can mimic the motion of walking or locomoting while lying down, there are no ground reaction forces from the leg supporting the weight of the upper body. In standing, this has been shown to drastically affect the relative positions of the bones and the strain on the ligaments, and thus would not be an accurate depiction of ligament strains in walking either. Second, many imaging modalities are designed to take single static images. While this is great for identifying tumors or broken bones, it is not ideal for tracking structures in a moving body.

Brief Project Description: UBC is unique in that it has imaging modalities that deal with both of these limitations. The standing MRI and high speed biplanar fluoroscopy systems located at Vancouver General Hospital (and elsewhere within British Columbia) have the ability to provide us with unique imaging data of the knee while walking. However, there is one final hurdle that must first be addressed. To capture these images, the capture volume is kept relatively small and thus the knee is prone to exiting the capture volume during gait. To alleviate this and take advantage of our unique imaging capabilities, we are looking for a capstone team to help us design a walking rig that is compatible with imaging modalities (particularly MRI) and can keep the knee in a relatively small capture volume during walking. This is akin to how a treadmill keeps the torso stationary while walking, but even in treadmill walking, the knee undergoes substantial movement.

Expected Outcomes: We are expecting a CAD design for this rig that can also be tunable to account for different subject gaits (stride lengths) and anatomy (participant heights). The design should be able to mimic both the kinematics and kinetics of walking gait while reducing the movement of the knee such that it can remain within the limited capture window of our current imaging technologies.

Resources Available from Customer: We are able to meet with students monthly to answer any questions and provide design feedback. We also have access to sample gaits from motion capture analyses and can help students analyze this data to mimic gaits.