REAL WORLD GAIT ASSESSMENT IN PEOPLE BEFORE ACL SURGERY USING IMU AND STATISTICAL PARAMETRIC MAPPING

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Introduction

Anterior Cruciate Ligament (ACL) rupture is a common injury among young and active people that can lead to lower quality of life, strength, and movement asymmetries. These asymmetries expose individuals to reinjury risk and negatively impact the knee joint health in the long term [1]. While many have looked at asymmetries during demanding tasks such as jumping and stair ambulation, walking at a faster speed is a simple task suitable for assessment in the early phase after injury. Recently, Inertial Measurement Units (IMUs) have been used to evaluate movement in real-world conditions, not limiting assessment to a closed motion laboratory assessment [2].

The most common way to assess gait kinematics is by analyzing discrete points, such as local minima and maxima of the joint angles during the gait cycle. Another analysis method utilizes Statistical Parametric Mapping (SPM) over the full cycle, therefore not reducing the data to a single point in time [3]. Therefore, we aimed to use an IMU system to measure gait at three different speeds in real-world conditions and analyze the lower limb angles during the complete gait cycle.

Methods

A total of 24 recreational athletes before ACL reconstruction (ACLR) signed an informed consent and were recruited for this study. Using an XSENS IMU system lower limb model, comprised of 7 IMUs, each participant walked along 20 meters corridor in a hospital at three self-selected speeds: slow, comfortable, and fast. Each speed consisted of three trials (60 meters in total for each speed). Hip, knee, and ankle angles were averaged over the gait cycle for the injured and non-injured limbs. Next, SPM, a two-tailed, paired t-test comparison between the limbs was made. Discreet point analysis of local maxima and local minima was done using a two-tailed, paired t-test. All statistical tests were conducted using Python 3.7 with an alpha value of 0.05.

Results

The mean knee flexion angle of the injured leg during fast walking was higher than the angle of the non-injured at 32-47% and 92-94% percent of the gait cycle, as seen by a two supra-threshold cluster exceeding the critical threshold of t=3.1. The mean hip extension angle was lower than the angle of the non-injured at 32-47% of the gait cycle, as seen by a single supra-threshold cluster exceeding the critical threshold of t=3.1 (Figure 1).

The probability that the supra-threshold clusters of this size would be repeated random sampling was p=0.004.In comfortable and slow speeds, only the knee angle differed between limbs.

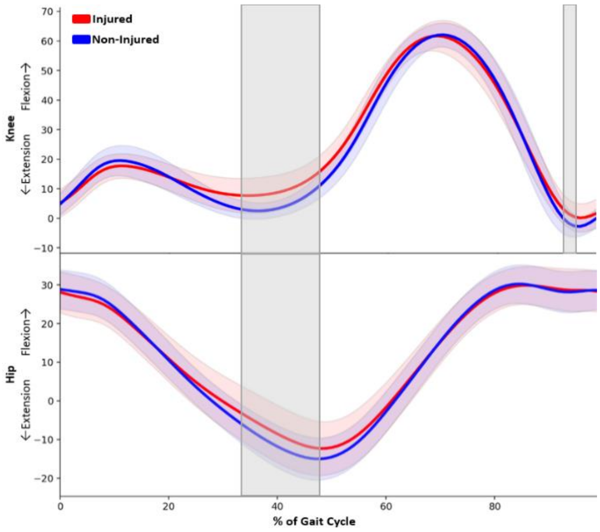

Figure 1: Knee and hip sagittal plane kinematics of the injured and non-injured legs at a fast speed, plotted on the normalized gait cycle. Mean± SD represented by solid lines and shaded areas, respectively. Areas with significant differences are indicated by grey bars.

Discrete point analysis found a statistically significant difference in the knee local minima angle at normal (2.4°, p<.05) and fast (2.8°, p<.05) walking speeds. Additionally, a statistically significant difference was found for the local hip minima angle at the fast speed only (2.1°, p<.05). No differences were found for the ankle joint (p>.05).

Discussion

At fast walking speeds, people waiting for ACLR surgery presented with lower knee flexion and hip extension in their injured knee during terminal stance and lower knee flexion at terminal swing, compared to their contralateral knees.

Analyzing only discreet points would miss these asymmetries and could lead to a less optimal rehabilitation plan.

Therefore, this research supports assessment at different walking speeds and the use of SPM analysis to achieve more accurate information regarding gait asymmetries during gait.

References

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