CENTER FOR RESEARCH IN HUMAN MOVEMENT VARIABILITY

INFLUENCE OF HIP ABDUCTOR FATIGUE ON ACL LOADING DURING SINGLE-LEG LANDING

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INTRODUCTION

According to recent studies, weakness of hip abductors may contribute to greater hip adduction or internal rotation during dynamic activities such as landing or jumping [1]. These abnormal hip joint mechanics may lead to knee valgus collapse and it is considered the most common mechanism for ACL injury. Conversely, only a weak association was reported between hip abductor weakness or fatigue and knee joint mechanics.

To understand the cause and effect relationship between hip abductor weakness and ACL loading during single-leg landing, we need an experimental study. However, an internal force such as ACL loading cannot be easily studied in vivo during movements. Computer models of the musculoskeletal system offer a promising means to estimate ACL loading.

The purpose of this study was to identify the effects of hip abductor fatigue on ACL loading during single-leg landing. We hypothesized that hip induced hip abductor weakness through fatigue protocol would alter lower extremity kinematics, and would increase ACL loading during single-leg landing.

METHODS

Human experiment

10 healthy adults participated in this study (5 females, age 26.6 ± 1.35 years; height 1.75 ± 0.7 m, mass = 71.1 ± 14.1 kg). Three dimensional marker position data were collected at 200Hz by using a 3D motion capture system while the participants were performing single-leg landings from a height of 45 cm onto a force platform. Each participant performed single-leg landings in pre and post hip abductor fatigue conditions until they had 3 successful trials of single-leg landings for each condition. The fatigue protocol included 3 sets of side-lying hip abduction to induce hip abductor weakness.

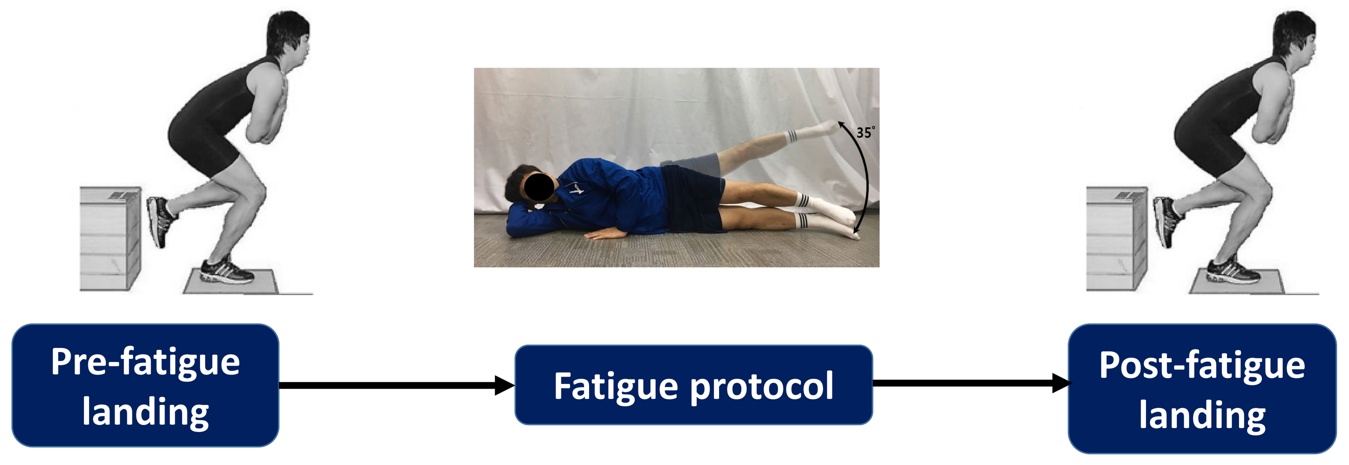

Figure 1. Human experimental protocol

Musculoskeletal model

Ten 31 degree-of-freedom (DOF), 92 muscle-tendon actuated subject-specific models were developed in OpenSim [2,3]. The knee joint of the model has 5 DOF that include all three planes of rotation, sagittal and transverse plane translation. The model includes an ACL from previous study [4] and it is scaled to each participant. ACL loading was calculated from initial contact (IC) to maximum knee flexion (MKF) using change in ACL length. Linear elastic stiffness was 240 N/mm based on the cadaveric study [5].

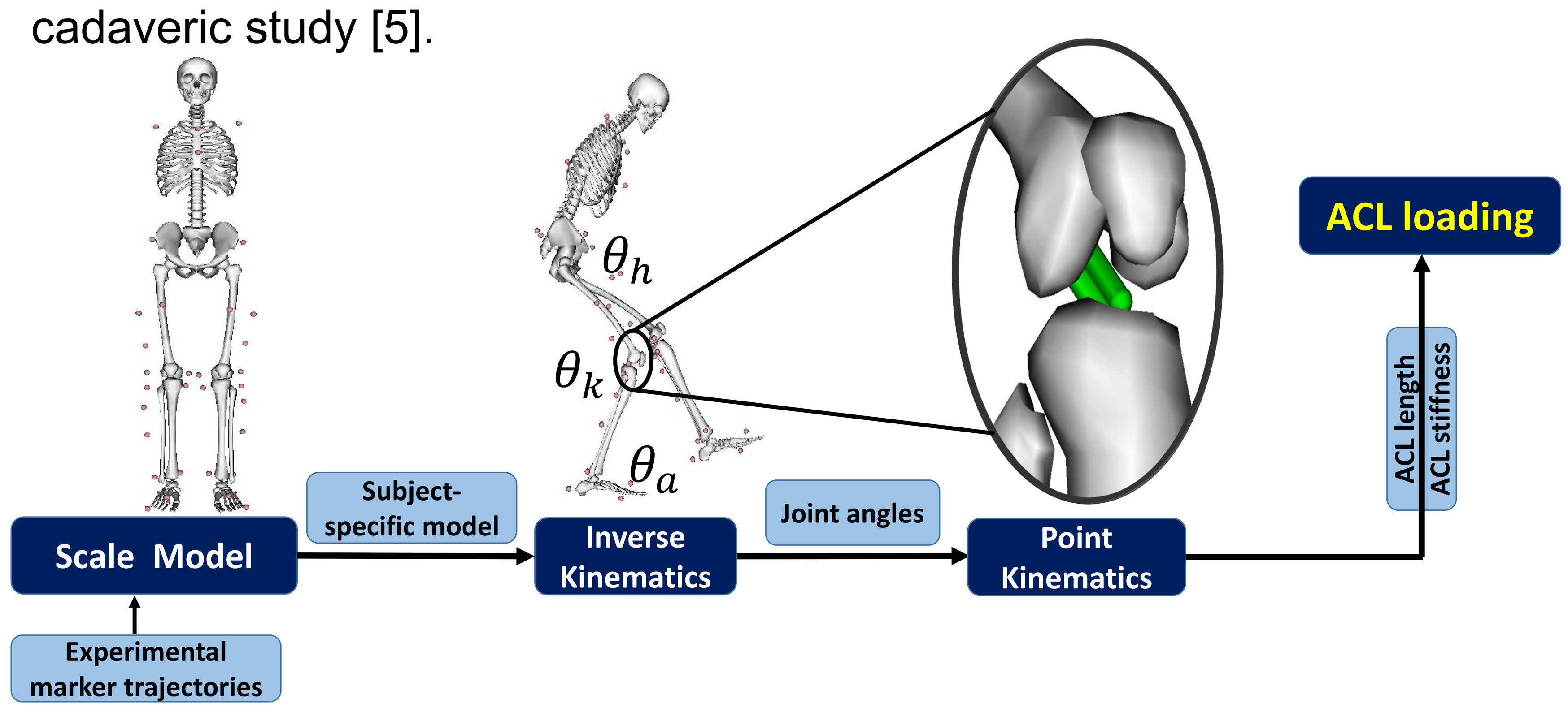

Figure 2. Schematic depiction of the musculoskeletal modeling workflow

RESULTS

Median frequency of EMG activity of gluteus medius was decreased after hip abductor fatigue. No differences between conditions were found in peak ACL loading, knee flexion, knee abduction, and knee internal rotation angle (Table 1). The mean peak ACL loading (12.52 N/kg) was well aligned with a previous study [5] in a low-risk group (13.04 N/kg).

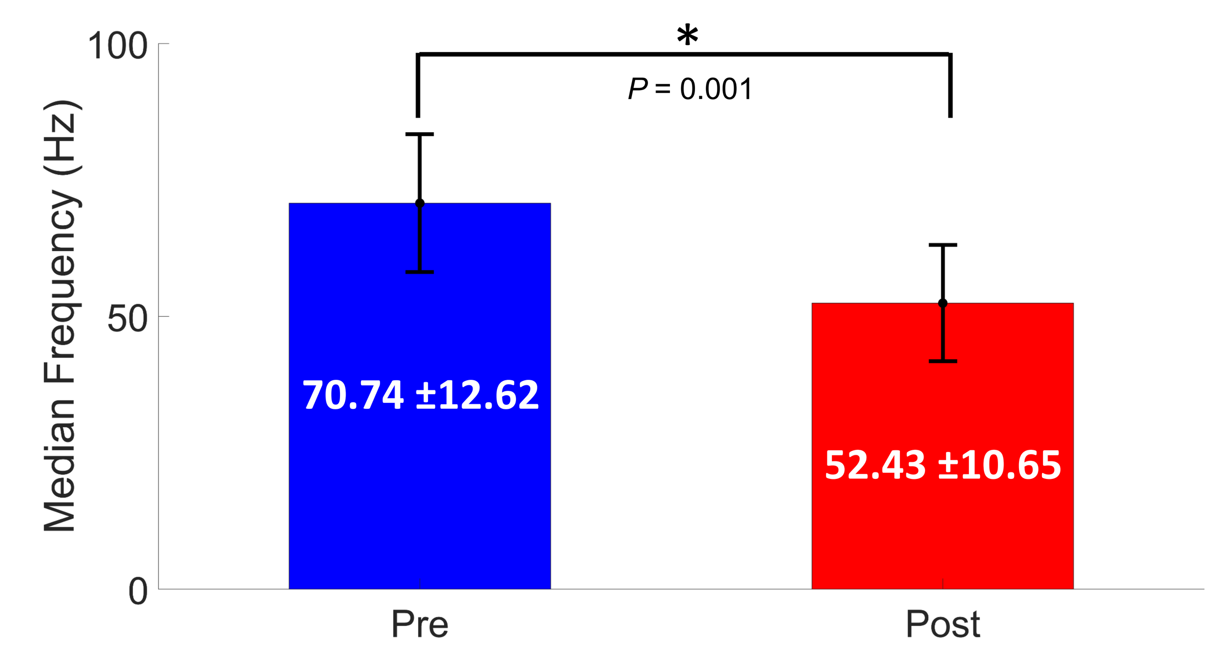

Figure 3. Average mean frequency prefatigue and postfatigue

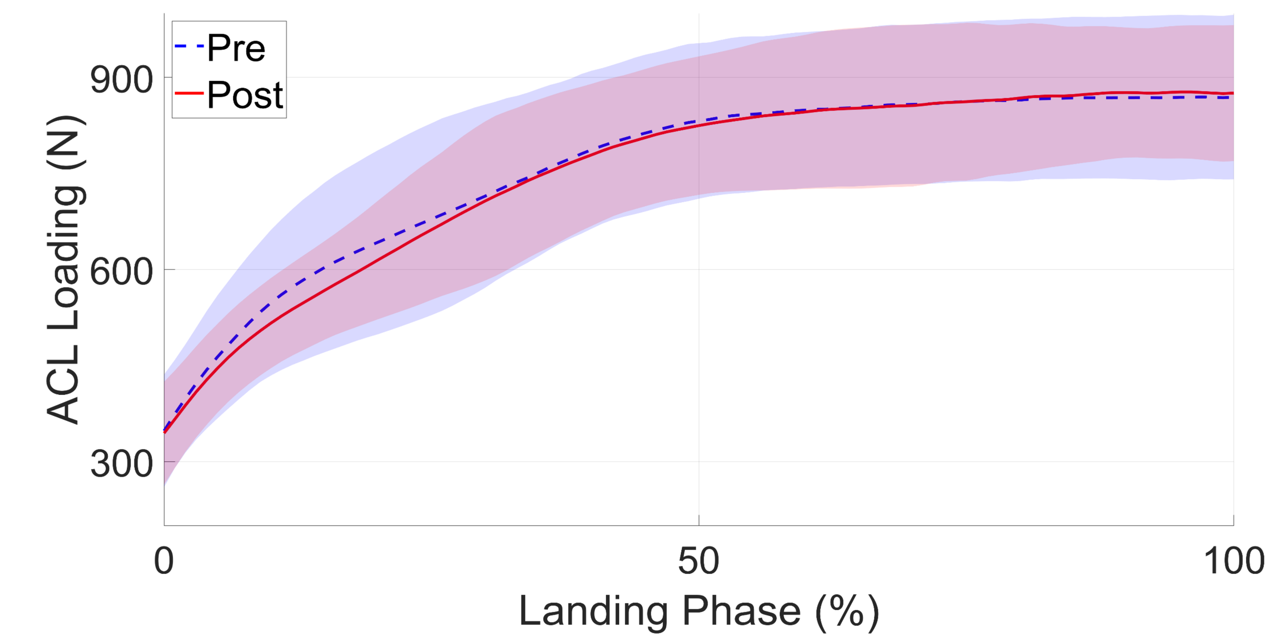

Figure 4. Mean and SD of time-normalized ACL loading

Table 1. Peak ACL loading and knee kinematics pre and postfatigue

Variable	Prefatigue Mean±SD	Postfatigue Mean±SD	P Value
ACL loading (N)	884.15± 124.8	896.40 ± 110.3	0.414
Knee Flexion	65.54 ± 7.68	66.74 ± 7.21	0.584
Knee Abduction	5.81 ± 6.18	5.87 ± 5.42	0.923
Knee IR	8.98 ± 6.93	8.15 ± 8.04	0.230

DISCUSSION

We only used successful trials, where subjects maintained balance without falling over or touching the ground with their non-dominant leg, which may mask the effect of hip abductor fatigue on ACL loading during single-leg landing. Comparing successful trials with unsuccessful trials may be necessary to identify the effect of hip abductor fatigue on ACL loading during single-leg landing. Future studies will focus on determining what extent weakness of hip abductors start to alter ACL loading during single-leg landings, and explore compensation in other joints during single-leg landings after hip abductor fatigue.

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ACKNOWLEDGMENTS

NIH P20 GM109090 and R15 HD094194

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