HAMSTRING CO-CONTRACTION DOES NOT NECESSARILY REDUCE ACL LOADING

[1] Bing Yu, [2] William E. Garrett
[1] Center for Human Movement Science, Division of Physical Therapy, The University of North Carolina at Chapel Hill, Chapel Hill, NC, USA; [2] Sports Medicine Center, Duke University; email: byu@med.unc.edu

INTRODUCTION

One of the risk factors of sustaining non-contact anterior cruciate ligament (ACL) injury proposed in literature is the strong quadriceps muscle contraction at a small knee flexion angle. Previous studies with cadaver testing show hamstring co-contraction significantly reduces ACL loading, and suggest that training for hamstring co-contraction assist in reducing the risk of sustaining non-contact ACL injuries. The results of reduced ACL loading with hamstring co-contraction, however, were obtained with reduced knee joint resultant extension moment. The purpose of this study was to investigate the effects of hamstring co-contraction on ACL loading in a stop-jump task using a computer simulation method with in-vivo lower extremity kinematic and kinetic data.

METHODS

Twenty healthy recreational athletes (10 males and 10 females) with no known history of knee injuries or disorders were recruited to collect radiographic data of the knee. Side-view roentgenographic films of the knee were obtained for each subject at 0°, 15°, 30°, 45°, 60°, 75° and 90° knee flexion bearing 50% of the total body weight. Patella tendon-tibia shaft angles (PTTS) and actual knee flexion angles were measured from the roentgenographic films. Multiple regression analyses with dummy variables were performed to express the PTTS as a function of knee flexion angle and gender. Quadriceps and hamstring muscle moment arms and ACL elevation angles from the literature were also expressed as functions of knee flexion angle using regression analyses.

Sixty healthy recreational athletes (30 males and 30 females) without known history of knee injuries or disorders were recruited for kinematic and kinetic data collection. Three-dimensional (3D) kinematics and kinetics of the lower extremities were collected for each subject in a stop-jump task. Knee joint angles and joint resultants were estimated. Multiple regression analyses with dummy variables were performed to express each of the peak knee joint resultant extension moment and peak proximal tibia anterior shear force during landing of the stop-jump task as a function of the peak posterior and vertical ground reaction forces.

A biomechanical model of the knee was developed with the PTTS, quadriceps and hamstring moment arms, and ACL elevation angle as functions of knee flexion angle, and peak knee extension moment and proximal tibia anterior shear force as functions of peak posterior and vertical ground reaction forces. The hamstring tendon was considered as parallel to the femur. Peak posterior and vertical ground reaction forces and knee flexion angle at peak posterior ground reaction force were varied based on the variations of corresponding in-vivo data. Quadriceps and hamstring muscle forces were varied to satisfy the peak knee extension moment estimated from the peak ground reaction forces. ACL loading were estimated from the peak proximal tibia anterior shear force, quadriceps and hamstring muscle forces, and ACL elevation angle.

RESULTS AND DISCUSSION

ACL loading increased as the hamstring co-contraction increased when the knee flexion angle is smaller than 15 degrees for males and 20 degrees for females (Figures 1 and 2). Hamstring co-contraction effectively reduced ACL loading when the knee flexion angle is greater than 15 degrees for males and 20 degrees for females (Figures 1 and 2).

Knee flexion angle significantly affects the relationship between ACL loading and hamstring co-contraction. Quadriceps force has to be increased to satisfy the given knee extension moment due to external loading when hamstring co-contraction increases. The anterior shear force applied on the tibia by the quadriceps increases while the posterior shear force applied on the tibia by the hamstring decreases as the knee flexion angle decreases. The gender difference in the relationship between ACL loading and hamstring co-contraction is mainly due to the gender difference in PTTS.

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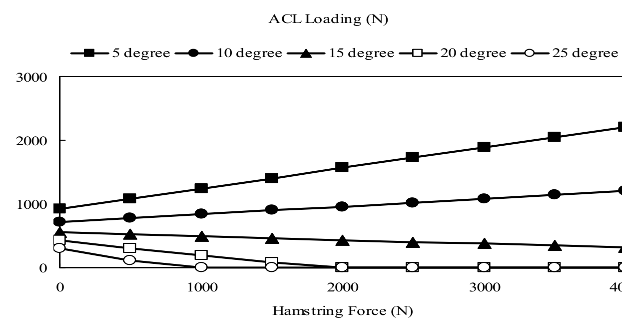

Figure 1. ACL loading as a function of hamstring force and knee flexion angle for male subjects.

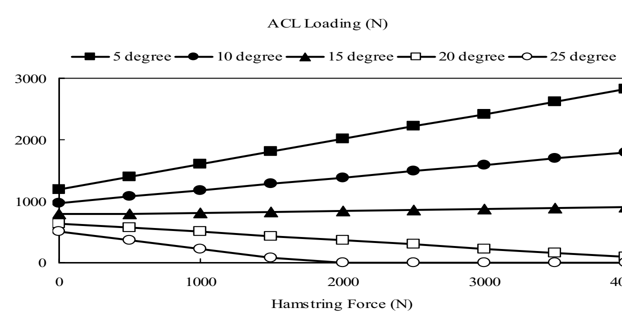

Figure 2. ACL loading as a function of hamstring force and knee flexion angle for female subjects.