

BIOMECHANICS OF THE LOWER LIMB DURING STAIR LOCOMOTION IN SUBJECTS WITH ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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INTRODUCTION

The anterior cruciate ligament (ACL) is one of the most commonly injured ligaments in the knee. Its injury would lead to the degradation of stability and/or mobility of the joint. To regain stability and restore function after ACL injury, surgical reconstruction is frequently considered and a proper rehabilitation program is crucial for the recovery of the function. The accelerated rehabilitation program, which emphasizes early full knee extension and weight bearing as well as closed kinetic chain (CKC) exercises, has been proven to have good results after a long-term follow-up [1]. Being one of the most frequently used CKC exercises and a frequent activity of daily living, studies on the three-dimensional dynamics of stair locomotion in ACL-injured patients were limited. Previous studies of stair activities in ACL patients focused on the mechanical changes at the knee joint [2,3]. However, stair locomotion is achieved through a complicated mechanical interaction among the lower limb joints in three dimensions. The present study aimed to provide a more complete account of the possible biomechanical changes among the lower limb joints.

METHODS

Ten ACLR subjects (28.3±8.5 years) and ten normal controls (21.4±1.7 years) were recruited in this study. Each subject performed stair ascent and descent on a three-step stair in a gait laboratory. A seven-camera motion analysis system (VICON 370, Oxford Metrics, U.K.) was used to measure the movement trajectories of each segment of the lower extremity. The ground reaction forces (GRF) were measured with a force platform (AMTI, Mass., U.S.A.), which served as the second step of the three-step stairs. Peak joint angles, peak joint moments and angular impulses of the lower limb joints in three dimensions during the stance phase of the stair activities were calculated and compared between groups using t-test and between affected and unaffected limbs using paired t-test. A significance level of 0.05 was used.

RESULTS AND DISCUSSION

Compared to the normal knees, significantly smaller peak moments and angular impulses of the extensors and internal rotators at the affected knees were found during both stair activities while larger peak moments and angular impulses of the adductors and peak abduction angles were needed at the unaffected knees. Larger hip extensor impulses and smaller hip external rotation angles and smaller peak ankle plantarflexor moments at the affected limb during stair ascent were found (Figure 1). During stair descent, larger hip internal rotation angles, and smaller peak hip abductor moments and ankle plantarflexor moments in the affected limb

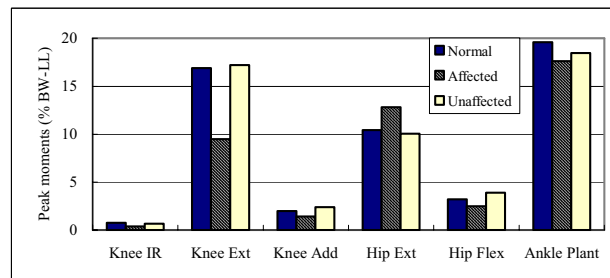


Figure 1: Peak joint moments during stair ascent.

were found while larger hip flexor impulses in the unaffected limb were required.

These results suggest that the ACLR knees had significant reduction in the mechanical loadings in the sagittal and transverse planes during both stair activities, possibly due to the need to protect the ACL graft as well as the deficit of the quadriceps strength, which may persist even at 24 months after reconstruction [4]. The compensations to these changes occurred mainly in the coronal components of the unaffected knees and at the hip joints, with different strategies for stair ascent and descent. The increased hip extensor impulses were used to compensate the reduced knee extensor impulses in the affected limb during stair ascent. During stair descent, the increased hip flexor impulses in the unaffected limb helped controlling the movements of the trunk.

CONCLUSIONS

Significant mechanical changes in the sagittal and transverse components at the ACLR knees were found during both stair activities and the compensations occurred mainly in the coronal components of the unaffected knees and also at both hip joints with different strategies for stair ascent and descent.

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