PATELLAR LIGAMENT INSERTION ANGLE INFLUENCES QUADRICEPS USE DURING STAIR CLIMBING: EFFECT OF AN ANTERIOR CRUCIATE LIGAMENT DEFICIT

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INTRODUCTION

The patellar ligament transfers the force of quadriceps muscle contraction to the tibia, The orientation of the force transferred to the tibia is influenced by the patellar ligament insertion angle (PLIA), defined as the angle between the patellar ligament and the tibial shaft, since the PLIA determines how quadriceps force is decomposed into the anterior and superior directions. In individuals with an anterior cruciate ligament deficit (ACL-D), this anterior component of the force may cause anterior tibial translation. One of the explanations for why ACL-D individuals often reduce quadriceps force gait during walking is to prevent excessive anterior tibial translation [1]. Based on this explanation one would expect that anatomical variation in the PLIA would influence the tendency of patients to reduce quadriceps contraction. While it has been observed that ACL-D knees have a reduced PLIA relative to the contralateral knee or control knees [2], the relationship between this reduced PLIA and the reduction or avoidance of quadriceps usage has not been explored.

This study tested the hypothesis that in ACL-D knees, the peak external knee flexion moment during stair climbing would be negatively correlated to the PLIA, while in the contralateral or control limbs no such correlation would occur.

METHODS

Seventeen subjects were studied after giving IRB-approved informed consent – nine unilateral ACL deficients (age=40.1±12.7 years, 7 male, 2 female, average 178 months past injury) and eight controls with no history of musculoskeletal injury (age=34.3±9.9 years, 6 male, 2 female). Sagittal-plane magnetic resonance images (3DSPGR) were taken of each subject's knees in a fully extended, non-weight-bearing position. PLIA was defined as the angle in the sagittal plane between the patellar ligament and the tibial shaft, as described previously [2].

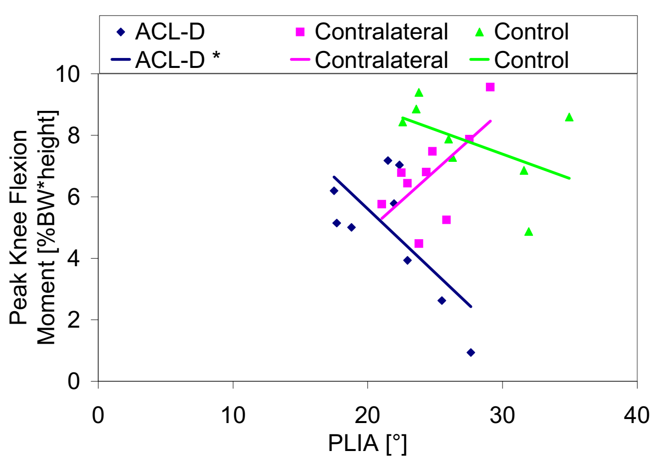

Figure 1: Peak external knee flexion moment vs. PLIA for ACL-deficient, contralateral, and control knees. * denotes slope significantly different from zero.

All subjects climbed a set of 21-cm steps while being recorded using an opto-electronic motion capture system with six markers on each lower limb. A force plate under the first step recorded the ground reaction force. A previously-described link model was used to estimate the net external forces and moments acting at the joints [3]. Three trials were captured for each leg, and the peak external knee flexion moments for the three trials were averaged together for subsequent analysis.

Linear regressions were performed to examine the strength of the correlations between the PLIA and the peak knee flexion moment, with a significance level of α=0.05.

RESULTS AND DISCUSSION

The significant negative (slope=-0.41, p=0.04, R^2=0.48) relationship between PLIA and knee flexion moment (Figure 1) for the ACL-D knees suggests that individuals with a smaller PLIA experience less of an anterior pull on the tibia when the knee extensors are active, and therefore they show less of a tendency to avoid using these muscles.

Although it fell short of statistical significance, the positive slope observed in the contralateral knees (slope=0.39, p=0.05, R^2=0.43) appears to be different from the control knees and deserves further study. For the control knees, no relationship was observed (p=0.19, R^2=0.26).

CONCLUSIONS

The results of this study indicate that differences in the orientation of the patellar ligament can influence the tendency of ACL-D patients to reduce quadriceps contraction. Moreover, this study may help to explain why some researchers have reported observing quadriceps avoidance [1] while others have not [4], since the PLIA variability between ACL-D subjects can be considered as a confounding factor in those earlier studies.

REFERENCES

1. Berchuck M, et al. *J Bone Joint Surg* **72-A**, 871-877, 1990.
2. Shin CS et al. *28th Meeting of ASB,* Portland, 167, 2004.
3. Andriacchi TP, et al. in *Basic Orthopaedic Biomechanics,* Lippincott-Raven, Philadelphia, 37-68, 1997.
4. Torry MR, et al. *Med Sci Sports Exerc* **36**, 1403-1412, 2004.

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