ARE INTERNAL-EXTERNAL ROTATIONAL MOMENTS IN ACL DEFICIENT SUBJECTS DIFFERENT THAN THOSE IN HEALTHY SUBJECTS?

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INTRODUCTION
Impairment of the anterior cruciate ligament (ACL) is a common injury causing rotational instability of the knee joint. Evaluating how patients respond in the absence of an ACL can help identify compensation strategies and potential patient response to rehabilitation efforts. However, it is difficult to directly evaluate ACL-deficient patients in internal and external rotations due to the risk of further injury. We developed a technique using standing target matching that is able to actively test subjects in internal and external rotations [1]. The aim of this study was to evaluate the standing target matching task’s ability to challenge ACL-deficient patients in internal and external rotational moments and we hypothesized ACL injured subjects would exhibit larger external rotation moments during knee extension when compared to healthy subjects.

METHODS
Ten subjects participated in this study; four (2 males, 2 females) had no history of knee injury and six (3 males, 3 females) sustained complete isolated ACL rupture within 6 months prior to testing. All subjects were regular participants (> 50 hrs/year) in level I and II sports requiring running and cutting.

Subjects stood barefoot approximately hip-width apart on two force plates, a separate force plate for each foot (OR-6, AMTI, Watertown, MA, USA). One foot was selected at random to control a cursor and was coined the mobilizer. The limb not controlling the cursor but still maintaining stability for the subject was coined the stabilizer. Anterior/Posterior and Medial/Lateral shear forces controlled the cursor’s movement in the anterior-posterior-medial-lateral plane respectively. Internal/External rotation moments controlled a needle on the cursor which rotated counterclockwise for internal rotation and clockwise for external rotation. A projector was used to display the cursor on a screen in front of the subject to provide visual feedback of the subject’s shear and rotational forces/moments. The standing target matching task required subjects to position the cursor, described earlier, on a target consisting of two concentric circles (Figure 1) using the mobilizing limb while kinematic and force plate measurements were taken from the stabilizing limb (the limb of interest in this study). Targets appeared one at a time on the screen at one of eighteen positions around a circle (located at 20° increments in the anterior-posterior-medial-lateral plane). Subjects were required to hold the cursor within the narrow target for 500 ms before the trial was considered successful. 72 targets were matched bilaterally (both feet performed the mobilizer task). A force of 30% of maximum anterior or posterior shear of the mobilizing limb, whichever was greater (collected prior to trials) was required to move the cursor.

Figure 1: Depiction of the cursor used in standing target matching and successfully positioned cursor within target.
cursor to each target. Additionally, the mobilizing limb was required to minimize internal/external rotations loads by maintaining the needle in a narrow region of the cursor corresponding to 30% of maximum internal/external rotation. Lastly, subjects received no visual feedback of stabilizing limb.

Ground reaction force (GRF) data was collected via two force plates at 1000 Hz. Motion capture data was collected at 50 Hz via an 8 camera system (Qualysis Motion Capture System, Gothenburg, Sweden). Retro-reflective markers were placed on the subjects anatomical landmarks. Additionally markers adhered to rigid shells were placed on the thighs and shanks of subjects to aid in tracking motion of the lower limbs. Transverse knee moment for both limbs was calculated in Visual 3D using both GRF and kinematic data collected during the 500 ms period the cursor was located in the target.

**RESULTS AND DISCUSSION**

External rotation, denoted as the negative transverse knee moment, of the stabilizing limb during knee extension was observed to be higher in ACL-d subjects when compared to healthy subjects (Figure 2), supporting our hypothesis. There were no differences in rotation moments during knee flexion between healthy and ACL-deficient subjects.

Being that the ACL restricts anterior tibial translation and internal rotation [2], measuring changes in external rotation for the stabilizing limb can provide insight to the effectiveness of this task to challenge the ACL-d subjects. For the targets 0° to 180°, the subjects are moving in the forward direction corresponding to knee extension. Near full extension (i.e., target position = 90°) the ACL acts as a major restraint to internal rotation [3]. In the absence of this restraint muscles surrounding the knee joint must produce a larger external rotation moment. Specifically, the ACL deficient subjects are acting to limit internal rotation of the tibia. At target positions corresponding to knee extension the ACL-d subjects maintain an internally rotated tibia confirming the external rotation moment is acting to limit internal rotation of the tibia. In this manner the standing target matching task is requiring subjects to maintain rotational stability in the absence of the ACL.

**CONCLUSIONS**

We believe that the standing target matching protocol is effectively challenging ACL deficient subjects in internal and external rotations in a safe and controlled manner. The ACL deficient limb is exhibiting higher external rotation moments during knee extension as a preventative measure in the absence of the passive restraint provided by the ACL. Future studies using this task can be used to understand stabilization strategies in both ACL deficient and ACL reconstructed populations.

**REFERENCES**


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