THE RELATIONSHIP BETWEEN KNEE PROPRIOCEPTION AND BALANCE IN ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTED INDIVIDUALS

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INTRODUCTION

The anterior cruciate ligament (ACL) of the knee is an important ligament that prevents anterior translation and medial rotation of the tibia relative to the femur. Non-contact ACL tears can occur via poor landing, planting, or cutting mechanics. Injury to this ligament causes changes in the somatosensory and proprioceptive capabilities of the joint [1,2]. Proprioception is the ability to sense the location of parts of the body in space without the use of visual assistance and is vital to maintaining neuromuscular control during movement. The loss of proprioception can result in neuromuscular deficits that may force the nervous system to increase dependence on visual feedback for motion [2]. Increased deficits in the ACL reconstructed (ACLR) leg increase the risk of re-injury [3]. These deficits may be displayed when moving into a complex athletic environment or restricting visual feedback. It is unknown how vision moderates the relationship between proprioception and postural control. The purpose of this study was to determine the relationship between proprioception and static balance in ACLR individuals under varying two visual conditions.

METHODS

2.1 Participants

Thirteen individuals who previously had an ACL reconstruction (6 males, 7 females; age = 25.5±1.37 years, height = 1.70±0.13 m, mass = 75.6±19.2 kg) participated in this study. Inclusion criteria were as follows: 18 to 39 years old, underwent an ACL tendon graft reconstruction, and currently physically active. Participants completed a Tegner activity [4] survey indicating their current levels of activity (Tegner score = 6.0±1.5). The mean time interval after reconstruction was 23±18 months.

2.2 Measurement of Proprioception

Proprioceptive capability was measured using a Biodex System 3 isokinetic dynamometer (Biodex Medical Systems, Shirley, NY). Active joint position sense (AJPS) and passive joint position sense (PJPS) were performed to determine proprioception. Both methods tested errors associated with movement into flexion and into extension to a knee position of 20º. For both sensing tests, participants were placed at 90º hip flexion, eyes were blindfolded and ears covered. The knee was placed in 45° of flexion and extended to 20º flexion, either by the dynamometer during PJPS, or by the subject during AJPS. The participant's knee was then moved by the dynamometer back to 45º of flexion, and the participant was instructed to mark when they returned to the 20° flexion position. During PJPS, the dynamometer moved at an angular velocity of 2°/s, and the leg was allowed to freely move during AJPS. The same procedure was repeated for both PJPS and AJPS, starting from an extended position (0° flexion) and moving into 20° of flexion. Error for proprioception tests was determined to be the absolute difference from 20º.

2.3 Single Limb Balance Measurement

Static single limb balance was performed on a tri-axial force platform (Bertec, Columbus, OH) collecting at 1500 Hz to measure center of pressure (CoP) excursion with eyes open and blindfolded. During testing, participants stood on the uninvolved limb first, and then repeated the task on the involved limb. Participants were instructed to maintain balance on the specified leg for 30 seconds. Processing of balance data was performed

through custom MATLAB scripts (MathWorks, Natick, MA) with all CoP data low-pass filtered at 100 Hz using a 4th order Butterworth filter. CoP excursion was calculated as the total path length of the CoP excursion during the first ten seconds of the balance task.

2.4 Statistical Analysis

Separate Pearson correlations were used to assess the relationship between proprioception and single limb postural control across different vision conditions with a significance level of $p<0.05$ *a priori*.

RESULTS AND DISCUSSION

There was a significant correlation between CoP excursion during eyes closed balance and AJPS into extension error in the involved limb ($r^2 = 0.34$, $p = 0.038$), meaning decreased single leg stability on the reconstructed limb was correlated with worse proprioceptive ability (**Figure 1**).

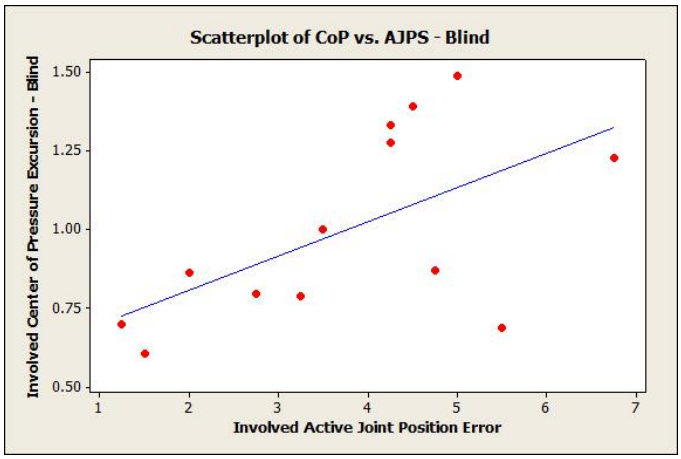

Figure 1: Scatter plot of CoP excursion and AJPS during blindfolded balance ($r^2=0.34$, $p=0.038$).

No significant correlations were found between proprioception and postural control in the involved limb for the eyes open condition. No significant correlations to joint proprioception were found in the uninvolved limb during the eyes open and blindfolded condition. Lee et al. observed that the threshold for detection of passive motion was strongly correlated with dynamic single leg balance after ACL injury [1]. Additionally, literature reviews have concluded that ACL injuries may cause neuroplastic changes and knee proprioception deficits [2, 5]. As AJPS error decreased in the involved limb, CoP excursion was greater during the eyes closed condition, indicating vision may moderate the relationship between proprioception and static single limb balance on knees with reconstructed ACL's. The moderate r^2 value for this relationship indicates that there may be additional factors that contribute to balance. Some factors may include core control, leg strength, and/or vestibular influence. Future research is needed to further explore what kind of influence, if any, such variables may have.

CONCLUSIONS

After ACL reconstruction, individuals may experience changes or deficits in proprioception and neuromuscular control. To maintain postural stability, ACLR individuals may depend more on vision with decreasing proprioceptive capabilities, but without visual restriction proprioception does not seem to play a role.

These findings suggest that active joint proprioception in ACL reconstructed limbs may be utilized in moderating involved single leg balance when vision is impaired. Improving proprioception under varying visual conditions may be an additional rehabilitation tool to aid in reducing the risk of re-injury.

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