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Audrey RC Elias DPT
University of Montana - Missoula, audrey.elias@umontana.edu

Ryan L. Mizner PT, PhD
University of Montana - Missoula, ryan.mizner@umontana.edu

Neuromuscular Patterning Of The Thigh Muscles Following Anterior Cruciate Ligament Reconstruction Varies With Mechanism Of Injury

A.R.C. Elias, R.L. Mizner

At least 70% of the approximately 200,000 anterior cruciate ligament (ACL) injuries in the United States each year occur during non-contact movements, rather than in collisions with other players, and most frequently while landing from a jump on a single leg. Even following surgery, ACL injuries can be devastating to an athlete, with high rates of re-injury and early onset osteoarthritis. The ACL is one of the primary stabilizers of the knee joint, preventing the lower leg from slipping forward from underneath the thigh. The muscles surrounding the knee joint also provide support, particularly the hamstrings in the posterior thigh and the quadriceps in the anterior thigh. By coordinating the movement of the joint, these muscles can mitigate the strain on the ACL. Indeed, there is a subset of injured athletes (copers) who are able to return to sport without knee instability and without surgery, fully compensating for the loss of the ACL via muscular action. Compared with copers, ACL-injured athletes who require surgery to prevent repeated episodes of knee instability exhibit excessive contraction of the hamstrings with the quadriceps (co-contraction) during landings. As a result, co-contraction is thought to influence knee stability and increase non-contact injury risk, though epidemiological evidence is thin and mixed. Given the relative rarity of ACL injury, we can presume that athletes injured through a contact mechanism of injury (MoI) (e.g. being hit by another player) would otherwise be at low risk for a non-contact ACL injury. If muscle recruitment patterns do influence knee stability and injury risk, we would therefore expect differences in co-contraction depending on the athlete's ACL MoI.

PURPOSE: To determine whether co-contraction of the hamstrings with the quadriceps is increased in athletes with a non-contact MoI during a single leg landing task.

METHODS: Thirty-two physically active athletes with unilateral ACL reconstruction (24 non-contact, 8 contact injuries) participated in a one-time session analyzing single leg landing of both limbs off a 20 cm platform using a 3-D motion analysis system. The degrees of knee bending and amount of impact force (vertical ground reaction force – VGRF) served as measures of performance, with greater knee bending (in degrees) and lower VGRF (in body weights – BW) preferred. Quadriceps and hamstring recruitment were analyzed using surface electromyography (sEMG) and normalized to maximal voluntary isometric contraction. Instantaneous hamstring/quadriceps co-contraction was integrated over the weight acceptance phase of landing to generate a co-contraction index (CoI). The mean CoI was compared between groups (contact v. non-contact) using a one-sided independent *t*-test. Due to low sample sizes, we verified the results using a bootstrapped 95% confidence interval (CI) of the difference in means with 10000 iterations.

RESULTS: There was no significant difference in knee bending (p=0.84; -14.66–4.32 CI) or VGRF (p=0.32; -0.23–0.42 CI) between groups. The involved limb bent an average of 58.7° (SD=14.9°) with average VGRF of 3.4 BW (SD=0.4) in the contact group, and 62.6° (SD=10.5°) with 3.5 BW (SD=0.4) in the non-contact. The uninvolved limb bent 60.4° (SD=12.7°) with 3.5 BW VGRF (SD=0.5) and 55.0° (SD=11.3°) with 3.6 BW (SD=0.5) respectively. However, athletes with a non-contact MoI utilized significantly greater co-contraction in landing than those with a contact MoI in both the involved limb (p=0.008, 3.67-21.72 CI), and uninvolved limb (p=0.027, 1.06-13.25 CI). The involved limb displayed an average CoI of 22.46 (SD=7.47) in the contact group, but 34.58 (SD=19.56) in the non-contact. The uninvolved limb CoI averaged 18.39 (SD=4.60) and 24.71 (SD=13.22) respectively.

DISCUSSION: Though similar in knee joint motion and limb loading during landing, athletes who sustain non-contact injuries utilize very different muscle recruitment patterns than those injured by contact, despite surgical restoration of the stabilizing ACL. Differences in muscle recruitment between athletes are thus essentially invisible to medical professionals and coaches, but may have negative sequelae. Co-contraction of the hamstrings with the quadriceps increases compression through the knee joint, contributing to the high prevalence of early onset osteoarthritis after surgery. Additionally, the motor patterning of athletes with a non-contact MoI places them at higher risk for an additional ACL injury in their limb with implications for return to sport and play clinical decision making. The bilateral presentation of increased co-contraction in athletes injured by a non-contact MoI suggests the pattern was present prior to injury, and that the source of the motor patterning lies within the central nervous system. Fortunately, a centrally mediated impairment in motor coordination may respond well to specific retraining. These data underscore

the importance of prioritizing retraining efforts during rehabilitation in those athletes with a non-contact injury.