Persistent quadriceps activation failure reduces in ACL reconstructed patients submitted to strength training based on force steadiness and visual feedback

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Background: Quadriceps activation failure after anterior cruciate ligament reconstruction (ACLr) is related to the inhibition of alpha-motor units and results in muscle weakness. The quadriceps activation failure limits the rehabilitation outcomes, especially strength gains that are essential to the return to sport and to minimize the risk for the onset of knee osteoarthritis. Exercises involving force steadiness could reduce the variability of motor unit discharge rate and contribute to the force enhancement. On the other hand, force steadiness during isometric contractions involves controlling the fluctuations in the force signals, which might be enhanced by visual feedback. Therefore, the combination of force steadiness and visual feedback could have potential benefits for patients with persistent quadriceps activation failure.

Objectives: To determine the effect of strength training with force steadiness and visual feedback on knee extension torque, knee stability, and knee pain in patients with persistent quadriceps activation failure after ACLr.

Methods: Twenty-five patients (43.7±12.2 years-old, 69.8±10.8 kg, and 1.69±0.09 m, 10 men) with persistent quadriceps activation failure after ACLr non-responders to a conventional rehabilitation protocol were included in this case series. All protocols were approved by the local institutional ethics board. Persistent quadriceps activation failure was diagnosed based on the clinical history, temporal diphase with physical therapy protocol, non-gain of quadriceps strength after around 20 sessions of physiotherapy in the 9th month of rehabilitation, quadriceps weakness in the clinical examination, and abnormal isokinetic assessment (peak extensor torque<100 Nm, asymmetry in peak extensor torque>50%, or asymmetry in peak torque>70 Nm). All patients were submitted to an ACLr surgery performed by the same surgeon with semitendinosus-gracilis autograft. The intervention considered three sessions/week and lasted until 20 sessions or auto-perception of functional knee stability. The intervention and torque measurements were performed with an isokinetic device. A warmed up for 10 minutes on a cycle ergometer without load (60 rpm) was performed. After, they performed knee extension following a trapezoid curve feedback. Due to strength unbalances between ACLr and non-ACLr limbs, we used five series of 8 and 5 repetitions, respectively. The training was performed at a workload between 60% and 70%. Knee extension peak torque was determined at baseline and after training protocol. Proportions of responders and non-responders were extracted considering a threshold of 25.02 Nm. Knee pain (any painful feeling at the knee developed between the last and new session) and stability (same knee stiff sensation when they had not suffered the ACL injury) were also assessed as a binary proportion. A mixed ANOVA with 2 factors [time (before and after intervention), and limb (ACLr and non-ACLr limb)] was performed to compare the knee extension peak torque. To compare the proportion of intervention responders, knee stability, and pain before and after intervention the 2-tailed McNemar test was performed.

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Results: Training improved knee extension peak torque in the ACLr limb (98.2±47.2 to 155.2±78.9, Δ=57.0 Nm, p=0.031) and the non-ACLr (169.6±86.9 to 209.5±101.8, Δ=39.9 Nm, p=0.178). At baseline, lower torque was found in the ACLr limb (169.6±86.9 vs. 98.2±47.2, Δ=71.4, p=0.003) and remain different after training protocol (209.5±101.8 vs. 155.2±78.9, Δ= 54.3, p=0.026). Most of the patients (84%) increased knee extension peak torque (p<0.001), 72% increased self-reported knee stability (p<0.001), and 52% decreased knee pain (p<0.001).

Conclusion: Strength training with force steadiness and visual feedback was an effective intervention to improve knee extensor torque in ACLr patients with persistent quadriceps activation failure identified 9 months after an autograft ACL surgery. We found that 21 out of 25 patients were able to respond positively to the intervention. The intervention also improved the self-report of stability and pain. Although the difference in torque between limbs suggests that the asymmetries persisted after the intervention. This intervention might be the first rehabilitation stage in persistent quadriceps activation failure. The next rehabilitation stage to normalize the inter-limb strength needs to be explored.