Anterior cruciate ligament reconstruction associated with brain activity differences during unilateral lower extremity motor imagery: A Pilot Study.

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Anterior cruciate ligament (ACL) tears are a prevalent injury, particularly in youth competitive sports. Post ACL reconstruction (ACL-R) surgery and rehabilitation, a significant patient population never returns to full functionality[1]. The contralateral leg is also seen to double its risk of ACL injury[2]. It is now thought that ACL-R affects multiple physiological factors, such as mechanical, anatomical, hormonal, etc., suggesting that rehabilitation needs a broader focus than just the involved limb. Recent research has indicated that ACL-R is associated with altered neurological factors [3-6]. It is speculated that these neurological adaptions affect motor processes[5,6]. However, it is unclear if these adaptions influence the feedforward and feedback mechanisms of motor control. In order to address this, a study was conducted to determine if ACL-R is associated with a neuroplastic alteration in feedforward motor control. A control group of healthy, active participants with no previous ACL-R (n (sample size)=3, age=24.5±0.71 years, height=1.74±0.05m, weight=74.16±18.28kg) and a group of participants with a left ACL-R (n=3, age=22.5±4.95 years, height=1.79±0.09m, weight=87.32±24.06kg, 52±31 months post-surgery) were locally recruited. The subjects performed a kinesthetic motor imagery (MI) task which served as a model indicator of feedforward motor control. What the MI task subjects were asked to perform consisted of remaining motionless while mentally performing unilateral left (involved) 45° knee extension/flexion at a rate of 1.2 Hz. This was done for 30 seconds at a time in four blocks, with 30 second of rest in between. Functional magnetic resonance imaging (fMRI) was performed for analysis of brain activation during the task. The two groups were compared using a mixed-effects general linear model with a cluster-forming threshold of $z>3.1$. Results revealed that, in comparison to the control group, the ACL-R group had increased activity within the ipsilateral inferior temporal sulcus (voxels:88; $p<0.001$, z-max:4.32, MNI coordinate voxel: -52,-4,-18), and contralateral insula (voxels:77; $p<0.001$, z-max:5.86, MNI coordinate voxel:34,2,18), dorsolateral prefrontal cortex (voxels:43; $p<0.03$, z-max:5.02, MNI coordinate voxel:38,36,14), and visual cortex (voxels:42; $p<0.03$, z-max:4.45, MNI coordinate voxel:10,-94,16). The described brain activity areas occurred relative to the side of injury (i.e. contralateral is right side of the brain, since side of injury is left). Furthermore, decreased activation in the basal ganglia (voxels: 230; p<0.001, z-max:5.44, MNI coordinate voxel:12,-24,-8) was recorded. These results indicate that ACL-R is associated with potential alterations in motor planning, as the analysis showed significant neurological changes in individuals who underwent ACL-R in comparison to healthy individuals. Specifically, ACL-R may lead to increasing executive function and visual-motor activity to engage in motor imagery. This predicted neuroplasticity may create more reliance on a different area of the brain than before ACL-R, contributing to the high rates of reinjury post ACL-R. Future research should focus on understanding what neural networks are associated with, the observed neuroplastic adaptations within this ACL-R population, and developing therapeutic interventions to restore neural sensorimotor planning activity in hopes of bettering the recovery of ACL-R.

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