Fear of reinjury matters after ACL injury

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Abstract

Purpose: Fear of re-injury has been linked to functional joint instability after an anterior cruciate ligament injury. However, it is still unknown how fear and function are linked sequentially in patients with a knee sprain. Therefore, the purpose of this narrative review article was to provide a comprehensive summary of the interrelationships between neuromuscular control, cognition, and emotion, the neural mechanisms underlying cognitive and emotional regulation processes, and potential emotional regulatory training after knee ligamentous injury.

Methods: Previous research articles and more relevant research articles through a cited reference emphasizing fear of re-injury, cognition, emotion, neuromuscular control, and anterior cruciate ligament injury searched from PubMed databases were reviewed.

Results: Higher fear of re-injury in patients after an anterior cruciate ligament (ACL) injury may be associated with diminished neuromuscular control. As negative emotion requires better cognitive neural processing in the several brain’s regions that are also essential for maintaining dynamic joint stability, increased neural demands as a result of higher fear of re-injury can disrupt neuromuscular control and long-term pathological sequelae. Therefore, enhanced neural efficiency in cognitive control networks through executive function training may help ACL patients to regulate high fear of re-injury and dynamic restraint systems to maintain functional joint stability during intense physical activity.

Conclusions: As negative feelings can interfere with the cognitive processing for neuromuscular control, executive function training may improve affective control and muscle coordination. Understanding the interrelationships that exist between neuromuscular control, cognition and emotion help to not only develop better rehabilitation program, but also improve patient outcomes after an anterior cruciate ligament injury.

Key words: Anterior cruciate ligament rupture, Neuropasticity, Fear of re-injury and movement, Emotional regulation, Functional joint instability

Introduction

It has been suggested that some anterior cruciate ligament (ACL) patients who suffer long-term disabilities have altered muscular contraction patterns (Swank, Lephart, Swank, Stone, & Fu, 2004), and significantly greater fear of participating in intense physical activity (Gignac et al., 2015; Lee, Karim, & Chang, 2008). Moreover, ACL patients with relatively higher fear demonstrate lower knee function
during activities of daily living when compared to other ACL patients who have less fear of re-injury/movement (Ross, 2010). Furthermore, higher fear of re-injury has been suggested as one of reasons leading to long-term pathological sequelae such as a recurrent rupture (Ardem, Taylor, Feller, Whitehead, & Webster, 2013). According to Morrey et al. (Morrey, Stuart, Smith, & Wiese-Bjornstal, 1999), ACL patients show progressively improved emotional responses throughout the rehabilitation process. These patients express heightened arousal levels both immediately following the ACL injury and at clearance to physical activity participation, even after completion of an extensive rehabilitation program (Morrey et al., 1999). Given this fact, the direct correlation between reduced subjective knee function scores and augmented fear of re-injury/movement in ACL patients may suggest that negative feelings can alter dynamic muscle contraction mechanisms (Lentz et al., 2015). However, it is still unknown how fear and function are linked sequentially.

An ACL injury may change existing neural networks in the central nervous system (CNS), and therefore ACL patients have varying cortical adaptations in regions of the brain responsible for awareness of sensory inputs from multimodal sources. As a result, the CNS reorganization, which is referred to as neuroplasticity, may differ with respect to proprioceptive feedback and neuromuscular control among ACL patients (Kapreli & Athanasopoulous, 2006). This is critical as several regions of the brain that depend on this information for neuromuscular control and maintenance of dynamic joint stability are also associated with cognitive motor planning strategies (LeDoux & Damasio, 2013). Moreover, it has been suggested that several frontal cortical regions related to cognitive processing for voluntary movements are also highly associated with the regulation of emotion (LeDoux & Damasio, 2013). An unpleasant emotional state, such as fear, increases cortical activity in these frontal areas of the brain in order to regulate emotional responses, by projecting significant information to other brain regions responsible for sensorimotor control (Horn & Swanson, 2013; Morris & Dolan, 2004). It has been shown that unconscious “fight-or-flight” behaviors, in response to unanticipated events, will alter muscle contraction patterns necessary for joint stability (Okada, Hirakawa, Takada, & Kinoshita, 2001). This may indicate that emotional dysregulation resulting from negative emotional stimuli can interrupt a normal cascade of neurocognitive processes associated with the muscle coordination to protect joints (dynamic restraint) and maximize patients’ functional outcomes (Okada et al., 2001). However, the lack of understanding surrounding the CNS’s role has created a barrier to determining how negative feelings after an ACL injury is associated with diminished knee function in ACL patients. Therefore, the purpose of this article is to assess the interrelationships that exist between neuromuscular control, cognition and emotion, to identify the neural mechanisms underlying cognitive and emotional regulation processes, and to discuss potential emotional regulatory training after an ACL injury to lessen barriers to a patient’s full function.

**Cognition, Fear of re-injury/movement and Neuromuscular Control**

The cognitive management strategy for motor planning is a critical factor in providing early preparatory and continuous reactive muscle contractions needed for maintaining functional joint stability (Swank, Covassin, Stearne, & Schatz, 2007; Swank et al., 2004). Therefore, any brief failure in coordination or judgment can temporarily interrupt muscle stiffness regulatory strategies intended to protect the joint (Kirkendall & Garrett, 2000). This would leave static restraints such as the ACL vulnerable to excessive loads, regardless of laxity, because the entire dynamic restraint mechanism would be compromised (Swank, 2015).

Sudden unanticipated events often result in a universal unconscious startle response in the extremities (Maslovat, Kennedy, Forgaard, Chua, & Franks, 2012). This brief, and involuntary startle response, may be a result of increased errors in motor planning processes because the brain’s cognitive network is not sufficient to simultaneously prepare for the overabundant environmental cues (DeAngelis et al., 2014). Altered joint stiffness regulation strategies have been displayed when an unexpected acoustic stimulus is delivered prior to a knee perturbation (DeAngelis et al., 2014).