Motor learning in ACL injury prevention

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Introduction

Background

An anterior cruciate ligament (ACL) injury is a serious knee injury with an incidence of over two million cases annually worldwide.[2,3,11,12] Regardless of the type of therapy chosen, athletes are often forced to reduce their level of physical activity and their involvement in sport after ACL injury.[1] Prevention studies designed to reduce ACL injury rates show conflicting results.[6-10,14-16] Wide-spread implementation and compliance to ACL injury prevention programs with a reduction of the actual ACL injury rates in the long-term has yet to be accomplished. Furthermore, these studies have mainly focused on prevention of ACL injuries in female athletes, given their higher risk.[3,5] Risk factors in males have not been extensively studied, despite of their larger absolute number of ACL injuries on an annual basis; subsequently prevention has not been specifically addressed in the male athlete.

Hence, the ACL injury incidence and rate has remained constant over the past decades, despite the implementation of prevention programs for more than two decades.[4,11] The need for an innovative training approach to optimize the effects of ACL injury prevention is paramount.[13] The aim of this dissertation is therefore to contribute to the body of knowledge that may help to optimize ACL injury prevention programs, enhance motor learning and ultimately reduce ACL injury risk.

Outline of the dissertation

In **Chapter 1**, the results of a systematic review on biomechanical and neuromuscular sex differences during sidestep cutting maneuvers are presented. As ACL injury risk factors are commonly approached from a sex difference perspective, we chose to provide a comprehensive overview of male and female landing patterns during these tasks. This study is conducted to aid in understanding whether ACL injuries during sidestep cutting maneuvers are purely sex related. It is important to move beyond the purely descriptive sex comparison studies that dominate the literature and more critically examine which strategies can be used to enhance landing technique. The actual load at the knee is comprised of multiple factors, such as orientation of the leg and the ground reaction force and influenced by the trunk and hip, knee and ankle joints. Currently, it is not known whether there are optimal levels of variability and whether deviations from these optimal levels increase the risk of injury. We found in this review that the reported kinematic, kinetic sex differences during sidestep cutting maneuvers were small. This review helps in directing future ACL injury prevention programs, which might need to be more individualized and might require a multifactorial approach to be more effective in the long term.

As outlined above, despite ongoing initiatives and reported short term successes, ACL injury rates and the associated sex disparity have not diminished. To better understand this problem, we proposed a paradigm change in **Chapter 2** to explain the disparity and the missing link between positive laboratory results and actual effects on injury outcomes. Consciously learning optimal movement patterns rehearsed during training sessions might result in suboptimal transfer to the field, where complex, unanticipated automatic movements are required. That is, trying to consciously control one's movements during a practice session might interfere with the normal, automatic motor control processes needed on the field and break down the natural coordination of the movement. Learning new motor skills or optimizing motor skills can be conducted with the use of an internal focus of attention (IF, focus on the movements themselves) or with an external focus of attention (EF, focus on the movement effect). Prevention training employing instructions with an EF may enhance automatic movement control as well as performance.

In Chapter 2 we addressed the need to further develop the presented framework. We therefore provided practically applicable techniques in **Chapter 3** that may help to optimize current ACL injury prevention programs via increased retention and transfer of safe motor skills and thus to ultimately reduce the ACL injury incidence. The effects of attentional focus not only provide interesting insights into the effectiveness of automatic control capabilities of the motor system, but they also have important implications for performance improvements in applied settings.

In **Chapter 4** we applied some of the proposed techniques mentioned in Chapter 3. In Chapter 4, we wanted to move beyond the sex comparative studies and search for potential explanations why females and males move differently and how this might be addressed with proper interventions. An EF training strategy may enhance skill acquisition more effectively and increase the potential of retention and transfer to an actual practice of game compared to an IF learning strategy. We therefore explored the effects of an IF (by a verbal stimulus) and an EF (by a visual stimulus) on peak knee joint loading during sidestep cutting in female and male recreational basketball athletes.

To further investigate the effects of instruction and feedback on landing technique, we conducted the research project described in **Chapter 5**. Athletes performed a drop vertical jump (DVJ). The effects of instruction and feedback on landing technique during the DVJ were investigated. The DVJ was assessed with the Landing Error Scoring System (LESS). Since this score is giving an indication of ACL injury risk, it is very useful for coaches and athletes to evaluate the effect of instruction and feedback on technique and performance. The purpose of this study

was to investigate the differences on the LESS score in a training and retention session between four groups receiving different instructions: 1) IF instruction, 2) EF instruction, 3) video instruction and 4) no specific instruction (control group).

In the **Discussion** the findings of the research projects are summarized and placed in perspective with an outline for future research.

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