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The effects of single-leg landing technique on ACL loading

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ABSTRACT

Anterior Cruciate Ligament (ACL) injury is one of the most serious and costly injuries of the lower extremity, occurring more frequently in females than males. Injury prevention training programs have reported the ability to reduce non-contact ACL injury occurrence. These programs have also been shown to alter an athletes' lower extremity position at initial contact with the ground and throughout the deceleration phase of landing. The purpose of this study was to determine the influence of single-leg landing technique on ACL loading in recreationally active females. Participants were asked to perform "soft" and "stiff" drop landings. A series of musculoskeletal models were then used to estimate muscle, joint, and ACL forces. Dependent t-tests were conducted to investigate differences between the two landing techniques ($p < 0.05$). Instructing participants to land 'softly' resulted in a significant decrease in peak ACL force ($p = 0.05$), and a significant increase in hip and knee flexion both at initial contact (IC) and the time of peak ACL force (F_{PACL}). These findings suggest that altering landing technique using simple verbal instruction may result in lower extremity alignment that decreases the resultant load on the ACL. Along with supporting the findings of reduced ACL force with alterations in sagittal plane landing mechanics in the current literature, the results of this study suggest that simple verbal instruction may reduce the ACL force experienced by athletes when landing.

1. Introduction

Anterior cruciate ligament (ACL) ruptures frequently occur in non-contact athletic maneuvers during significant and rapid decelerations of the body's center of mass such as those that occur with cutting or landing from a jump (Boden et al., 2000). Due to a gender disparity in the rate of occurrence of ACL injuries (Arendt and Dick, 1995), ACL injury literature has examined gender differences in lower extremity mechanics and established risk factors (Hewett et al., 2006) and mechanisms of injury (Hewett et al., 2006), which can be examined experimentally. Mechanisms of injury have been suggested to occur in all three planes of motion due to increased knee valgus (Ford et al., 2005; Hewett et al., 2005), increased knee internal rotation (Besier et al., 2001; McLean et al., 2004b), and decreased knee flexion (Fagenbaum and Darling, 2003; McLean et al., 2004a).

To gain a more complete understanding of the effects of sagittal plane knee motion on loading of the ACL during dynamic activities, authors have conducted a number of *in vitro* (Markolf et al., 1990; Markolf et al., 1995; Withrow et al., 2006), *in vivo* (Cerulli et al., 2003; Isaac et al., 2005), and musculoskeletal modeling (Kernozek and Ragan, 2008; McLean et al., 2003; Pflum et al., 2004) studies. *In vitro* and *in vivo* studies have reported peak ACL force (F_{PACL}) occurs between 15° and 40° of knee flexion and diminish to zero beyond 40°. Computational modeling investigations add further support that F_{PACL} occurs near full knee extension and within the first 25 ms following initial contact (IC) (Kernozek and Ragan, 2008; Pflum et al., 2004).

Neuromuscular and proprioceptive training programs aimed at reducing ACL injury risk have been developed and implemented in longitudinal investigations (Chappell and Limpisvasti, 2008; Mandelbaum et al., 2005; Myklebust et al., 2003). These programs include strength, balance, agility, and proprioceptive exercises in pre-activity warm-ups and have reported a reduction in post-training ACL injury rates from 40% to 80% (Gilchrist et al., 2008; Mandelbaum et al., 2005). Post-training biomechanical analyses have reported a number of neuromuscular and mechanical changes attributed to program participation (Hewett et al., 1996; Myer et al., 2006). Of these reported changes, it has been suggested that alterations in sagittal plane landing mechanics, particularly an increase in the knee flexion angle at IC as well as the deceleration phase peak knee flexion angle, may contribute to the decreased rate of injury (Chappell and Limpisvasti, 2008; Myer et al., 2006).

Although ACL injury intervention training studies suggest that increasing knee flexion during landing may reduce an athletes' risk of incurring a non-contact ACL injury, there is no experimental evidence that manipulating landing posture decreases F_{PACL}. Therefore,

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