Influence of anterior cruciate ligament injury and fatigue on mediolateral knee control during different jump-landing tasks

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Summary

An increase in mediolateral knee movement might suggest altered neuromuscular control strategies in single-leg landings. This study highlights the impact of single-leg landings, fatigue, and ACL injury on mediolateral knee stability. Findings suggest a joint stiffening strategy may be employed to maintain knee control under fatigue.

Introduction

Single-leg landings are performed in various athletic movements and functional tests, including rehabilitation following an anterior cruciate ligament (ACL) injury. The forces exerted during those landings must be absorbed by the joints of the lower extremities. While the deceleration primarily occurs in the sagittal plane, mediolateral knee movement is common during such tasks and may be an indicator of knee neuromuscular control [1]. Various factors may influence mediolateral knee control. First, the extent of mediolateral displacement may depend on the type of jump-landing task, which will result in different force vectors acting on the knee and thus different stabilization demands. Second, fatigue could contribute to mediolateral instability due to altered motor control, potentially compromising intermuscular coordination of hip and thigh muscles. Third, individuals with ACL injuries often exhibit impaired neuromuscular control [2], which may negatively affect mediolateral knee stability.

Methods

A total of 43 volunteers were recruited into ACL group (n= 21, 11 females) and control group (n= 22, 12 females). 3D motion data (Vicon, 250 Hz) were recorded during a single-leg hop (SLH), unilateral countermovement jump (CMJ), a unilateral cross-over hop (COH), and a unilateral 90° medial-rotational hop (MRH) before and after a fatigue-inducing intervention (single-leg squats and step-ups). The knee joint center (KJC) was calculated from the lateral and medial knee markers. Path length (PL) and number of zero crossings of the KJC velocity (nZC) were calculated between initial contact (GRF> 20N) and 500ms after. Jumps-by-group-by-fatigue (4x2x2) mixed-factor ANOVA (a= 0.05) and effect sizes effect (η^2p) were computed.

Results and Discussion

For the nZC, a significant main effect was found for jump (p= .001; η^2p= .129) and fatigue (p= .004; η^2p= .183). Bonferroni post hoc revealed an increase in nZC in the SLH compared to COH and an increase in nZC in the CMJ compared to COH and MRH. Additionally, nZC increased under fatigue. No significant effects were found for group, nor were any interaction effects observed.

For PL, a significant main effect was found for jump (p< .001; η^2p= .137). Bonferroni post hoc revealed an increase in the PL in the COH and MRH compared to CMJ. No significant effects were found for group, condition or any interactions.

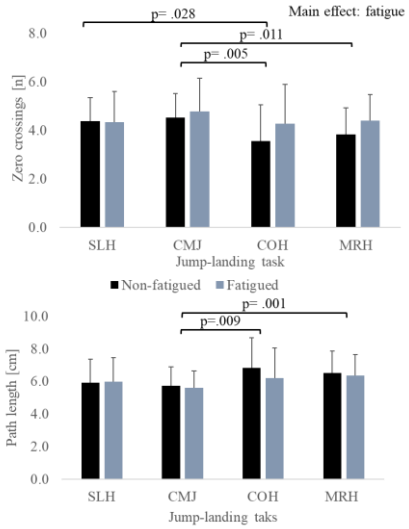

Figure 1: Mean and standard deviation of nZC and PL for the four jump-landings in non-fatigued and fatigued conditions.

The following points can be discussed: (i) An increased nZC in the CMJ may be linked to its maximal performance demands, requiring greater neuromuscular adjustments upon landing, while the purely vertical motion results in less displacement in KJC. In contrast, the increased PL in the rotational hops, suggests greater displacement, likely due to the rotational component. These findings confirm that neuromuscular control strategies differ depending on the type of landing task. (ii) The increased nZC in the fatigued condition may represent the increasing effort of the control system to stabilize the leg axis. In conjunction with the slight decrease in PL, although only a trend, this could indicate a strategy to stiffen the joint and maintain stability under fatigue. (iii) No significant group effect was found, suggesting that neuromuscular control had fully recovered in individuals with a previous ACL injury (four years post-injury).

Conclusions

Knee-related neuromuscular control strategies vary depending on the type of jump-landing task and fatigue status, with fatigue leading to more frequent corrections of the mediolateral knee position. The absence of a group effect suggests that neuromuscular control had fully recovered in the ACL-injured individuals.

References

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