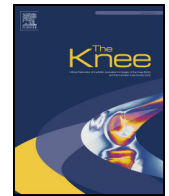




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The Knee



The effect of knee flexor and extensor fatigue on shock absorption during cutting movements after a jump landing

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ABSTRACT

Background: Sporting situations include instances of continuous and/or integrated movements. However, the effect of fatigue on the performance of these movements remains unclear.

Purpose: To investigate the effect of knee flexor and extensor fatigue on the shock absorption strategy of the lower limb during cutting movements performed after jump landings.

Methods: Twenty-four healthy participants performed cutting movements following jump landings from two heights – 30 cm and 40 cm – and under three levels of lower limb fatigue: pre-fatigue (100% peak knee extension torque), and post-fatigue 50% (post-50%) and 30% (post-30%) peak knee extension torque. Fatigue was induced by repeated isokinetic flexion/extension of the knee (60°/s).

Results: Compared to the pre-fatigue condition, power and work at the knee joint decreased under both post-50% and post-30% conditions ($P < 0.001$), while the work performed by the ankle ($P < 0.001$) increased significantly. An increase in height from 30 cm to 40 cm was associated with an increase in the range of motion of the ankle ($P < 0.001$) and knee ($P = 0.022$), peak vertical ground reaction force ($P < 0.001$), rate of loading ($P < 0.001$), knee stiffness ($P = 0.026$) and peak power of the knee ($P < 0.001$), as well as the work performed by the knee ($P < 0.001$) and hip ($P < 0.001$) joints.

Conclusions: Under substantial muscle fatigue the proportion of shock absorption contributed by the knee for cutting movements performed after jump landings from a height of 40 cm decreased; there was an adaptive increase in the contribution by the ankle.

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1. Introduction

Fatigue is commonly experienced during dynamic physical and daily activities [1,2]. Functionally, fatigue is defined as a reduction in maximum force production and power output, loss of exercise capacity, decreased reaction time, and an over-perception of the force generated during repeated muscle contraction [3,4]. It has been proposed that fatigue also alters the biomechanical and neuromuscular factors associated with the risk of sustaining a musculoskeletal injury [5–7]. Therefore, researchers have considered fatigue in their evaluation of injury mechanisms related to sport.

Fatigue has been investigated as a predisposing factor for injury in sports in general [8]. Specifically for landing activities (including jumping down from a height, a drop jump, and hopping) researchers have evaluated the effect of lower limb muscle

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fatigue on the mechanics of landing activities using both general [9,10–14], and local muscle fatigue protocols [5,7,15–17]. General fatigue involves multiple joints and muscle groups, whereas local fatigue is induced at muscles that are specifically relevant to a joint or injury mechanism under investigation [10,18]. Within the context of landing from a jump, local fatigue has been induced using repeated cycles of isokinetic knee extension and flexion at angular velocities of 120–180°/s. The effects of fatigue at the knee joint have subsequently been evaluated using different landing tasks (drop landing, jump landing or hopping) performed from heights varying between 25.4 and 50 cm, at torque values for the target muscle group of 25–50% of peak torque measured at rest [5,7,15,17].

However, the effects of two different levels of general lower limb fatigue on lower limb shock absorption strategies during landing and cutting tasks have not been investigated. Therefore, the purpose of the current study was to investigate the effect of knee flexor and extensor fatigue on the shock absorption strategy of the lower limb during cutting movements performed after jump landings. It was hypothesized that the effects of decreased peak knee torque on the shock absorption strategy would be modulated by the height of the jump.

2. Methods

2.1. Participants

Twenty-four participants were recruited among physical education students at the current university. The study group included 13 females (age 20.77 ± 1.01 years; height 165.62 ± 6.51 cm; and mass 58.76 ± 6.58 kg) and 11 males (age 21.27 ± 2.24 years; height 179.68 ± 4.79 cm; and mass 72.20 ± 7.19 kg). All participants regularly performed recreational activities and sport at least three times per week. Participants had no history of orthopedic or neurologic disorder of the lower limb within the 6 months preceding data collection. All participants provided informed consent, and the study was approved by the Institutional Review Board of Dong-A University.

2.2. Instrumentation

Nine infrared cameras (Vicon MX-T10, Oxford Metrics, Oxford, UK) and one force plate (AMTI OR6-7, Watertown, MA, US) were used to combine motion capture with ground reaction force (GRF) data. The GRF system (1200 Hz) was synchronized to the motion capture system (120 Hz) using the Nexus software. Motion data were low-pass filtered, using a second-order Butterworth filter with a cut-off frequency of 6 Hz, and analog force data filtered at 25 Hz [8,19,20].

Based on a customized version of the Vicon Plug-in Gait marker set [19,21], retroreflective markers (14-mm spherical type) were attached on the following anatomical landmarks: the clavicle, sternum, seventh cervical vertebra, tenth thoracic vertebra, and bilaterally on the front and back of the head, shoulder, lower third of the upper arm, lateral humeral epicondyle, lower third of the forearm, medial

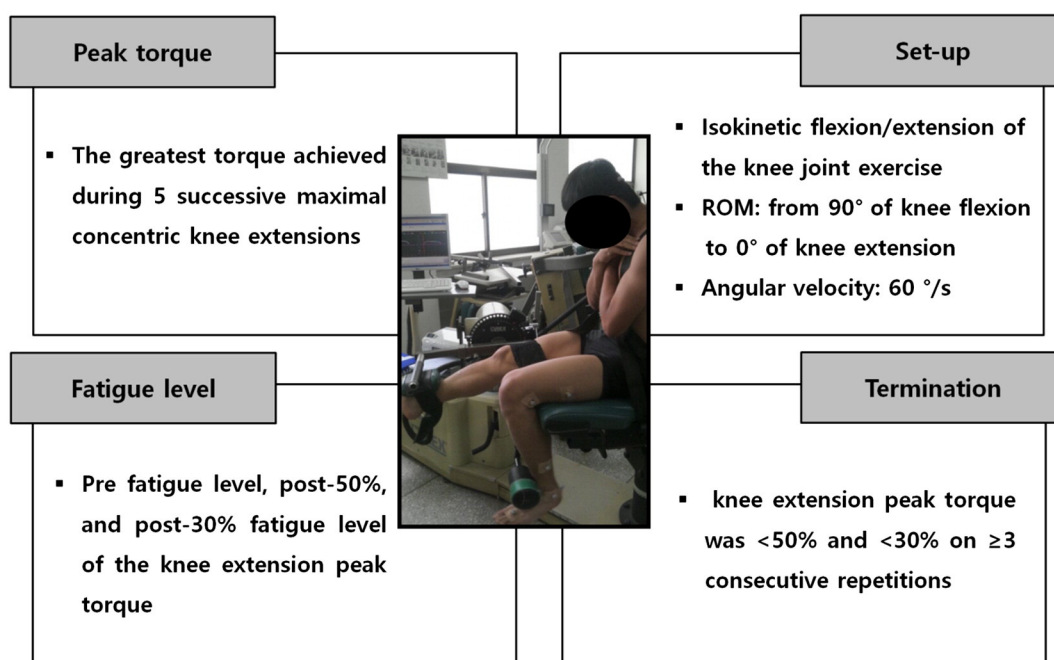


Figure 1. A schematic diagram of the fatigue protocol.

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