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RESEARCH ARTICLE

The trampoline aftereffect: the motor and sensory modulations associated with jumping on an elastic surface

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Abstract After repeated jumps over an elastic surface (e.g. a trampoline), subjects usually report a strange sensation when they jump again overground (e.g. they feel unable to jump because their body feels heavy). However, the motor and sensory effects of exposure to an elastic surface are unknown. In the present study, we examined the motor and perceptual effects of repeated jumps over two different surfaces (stiff and elastic), measuring how this affected maximal countermovement vertical jump (CMJ). Fourteen subjects participated in two counterbalanced sessions, 1 week apart. Each experimental session consisted of a series of maximal CMJs over a force plate before and after 1 min of light jumping on an elastic or stiff surface. We measured actual motor performance (height jump and leg stiffness during CMJ) and how that related to perceptual experience (jump height estimation and subjective sensation). After repeated jumps on an elastic surface, the first CMJ showed a significant increase in leg stiffness ($P \leq 0.01$), decrease in jump height ($P \leq 0.01$) increase in perceptual misestimation ($P \leq 0.05$) and abnormal subjective sensation ($P \leq 0.001$). These changes were not observed after repeated jumps on a rigid surface. In a complementary experiment, continuous surface transitions show that the effects persist across cycles, and the effects over the leg stiffness and subjective experience are minimized ($P \leq 0.05$). We propose that these aftereffects could be the consequence of an erroneous internal model resulting from the high vertical forces produced by the elastic surface.

Keywords Stiffness · Internal models · Vertical jump · Perceptual illusion

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Introduction

When we walk, run or jump, our musculoskeletal system needs to adapt its stiffness according to the physical features of the surfaces, in order to store and restore elastic energy in the muscles and tendons (Cavagna 1977). Changes in stiffness have been modeled by a spring-mass model. According to this model, a single linear "leg spring" and a point-mass, equivalent to the mass of the body, can describe stiffness changes (Blickhan 1989). The stiffness of the leg spring represents the stiffness of the integrated musculoskeletal system (Farley et al. 1991, 1998; Farley and González 1996; Ferris and Farley 1997; Ferris et al. 1998; McMahon and Cheng 1990).

Many athletes include trampoline bouncing as part of their practice regimen in order to improve their balance and acrobatic skills (e.g. gymnastics, divers). By increasing leg stiffness on an elastic surface, humans reduce the average force required for jumping and, as such, increase the mechanical work done by the surface (Ferris and Farley 1997). Anecdotally, people report an intriguing and strong illusion when they attempt to perform a jump on the ground immediately after jumping on the trampoline. They report that their body is not able to detach itself from the floor and additional muscular effort is required to produce a jump from a non-elastic surface. We refer to this illusion as the trampoline aftereffect.