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# H-reflex excitability is inhibited in soleus, but not gastrocnemius, at the short-latency response of a horizontal jump-landing task

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ABSTRACT

Impaired spinal-level neuromuscular control is suggested to contribute to instability and injury during dynamic landing tasks. Despite this suggestion, spinal-level neuromuscular control is yet to be examined during a horizontal jump-landing task. The aim of the current study was to assess changes in H-reflexes and its reliability at the short-latency response of landings from short and long distances. Eight healthy individuals (five male, three female; age, 22 ± 1.2 yrs; height, 178 ± 8.1 cm; weight, 72 ± 15.7 kg) participated in the study. H-reflexes were evoked at the SLR in the soleus and medial gastrocnemius muscles, during two landing conditions: 25% and 50% of maximal broad jump distance. H-reflexes were expressed relative to the background electromyography (EMG) and maximal M-wave responses (M-max). Soleus H-reflexes were inhibited when landing from shorter distance (25%, 13.9 ± 7.6%; 50%, 8.3 ± 6.5%; $p < 0.01$). No change in H-reflex excitability was observed in medial gastrocnemius. Background EMG was unaltered across landing conditions. Inhibition of soleus H-reflex excitability from 25% to 50% landing condition indicates a reduced contribution of Ia-afferent feedback to the alpha-motor neuron during landings from greater distances, which may contribute to stiffness regulation at the ankle joint. Unaltered H-reflex excitability of medial gastrocnemius is most likely attributed to its functional role during the landing task.

## 1. Introduction

Landing is an essential movement in many sporting activities (i.e. basketball, netball) that is consistently associated with high rates of lower limb injury, particularly at the ankle (Bahr & Bahr, 1997; Fong, Hong, Chan, Yung, & Chan, 2007; McKay, Goldie, Payne, & Oakes, 2001; Zelisko, Noble, & Porter, 1982). Further, re-injury rates are thought to exceed 70% in sports involving landings (Yeung, Chan, So, & Yuan, 1994). As both preparatory and reactive muscular responses of the lower limb assist in providing postural stability (Riemann & Lephart, 2002), impaired neuromuscular control at ground contact of a landing task would likely contribute to instability and injury. Despite this, mechanistic control (i.e. commands from within the central nervous system) of reactive muscle responses at ground contact of a horizontal jump landing task is yet to be

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comprehensively examined. As a result, there is a gap in the understanding of how the central nervous system regulates neuromuscular control and contributes to successful landings involving horizontal translation.

Research has consistently reported longer stabilization times and reduced dynamic postural stability measures in subjects exhibiting instability during landing tasks (Ross, Guskiewicz, & Yu, 2005; Wikstrom, Arrigenna, Tillman, & Borsa, 2006; Wikstrom, Tillman, Chmielewski, Cauraugh, & Borsa, 2007). It is suggested that longer stabilization times and reduced stability scores result from altered afferent feedback (Wikstrom et al., 2006). However stabilization times and stability scores have not provided insight into the neuromuscular mechanisms (i.e. afferent activity) that contribute to reactive postural control at ground contact. Further, researchers have hypothesized that altered afferent feedback may adversely affect stabilization by impairing an individual's ability to appropriately respond to perturbation at ground contact of the landing task (Wikstrom et al., 2006). The contribution of afferent feedback to successful landing performance is still unclear as limited evidence has explored these responses during landing.

The first muscular response to perturbation following ground contact of a landing, defined as the short latency response (SLR), largely represents activation of Ia-afferents in response to muscle stretch (Duncan & McDonagh, 2000; Taube et al., 2008). During dynamic tasks, the SLR functionally contributes to neuromuscular control by regulating muscle stiffness (Cronin, Carty, & Barrett, 2011). Thus exploration of Ia-afferent feedback at the SLR, commonly probed using the Hoffmann reflex (H-reflex), is of particular interest as a mechanism of neuromuscular control during landing. Previous research shows Ia-afferent activity at the SLR is reduced with increasing drop height (Leukel, Gollhofer, Keller, & Taube, 2008; Leukel, Taube, Gruber, Hodapp, & Gollhofer, 2009). It is suggested that reduced spinal stretch reflexes during dynamic tasks likely indicates a shift towards supra-spinal regulation of muscle stiffness (Cronin et al., 2011; Taube et al., 2008) and greater precision of neuromuscular control (Zehr, 2002).

Although performed in drop-jumps from differing heights, it is unknown how (if at all) Ia-afferent activity contributes to neuromuscular control of landings. Furthermore, the reliability of the assessing H-reflexes during this task is unknown. Exploring afferent activity at ground contact of a horizontal jump-landing is necessary to improve understanding of the functional regulation of neuromuscular control during landing tasks commonly associated with injury. Therefore, the aim of the current study was to compare changes in H-reflex amplitude and the reliability of this measure at the SLR between two jump distances: 25% and 50% of maximal standing jump length. Assuming that neuromuscular control of drop-jump and landings are similar, it was expected that Ia-afferent activity would be reduced at the SLR during landings from greater jump distance.

## 2. Methods

### 2.1. Participants

Eight healthy participants (five male, three female; age, 22 ± 1.2 yrs; height, 178 ± 8.1 cm; weight, 72 ± 15.7 kg) with no history of neurological or orthopedic impairment participated in the study. Prior to testing, participants were informed about the experimental procedure and asked to provide written consent. Participants were excluded from testing if they consumed any medications capable of altering nervous system activity, stimulants (including nicotine, caffeine and pseudoephedrine) and/or alcohol in the 24 h period prior to testing. The experiment complies with the Declaration of Helsinki and was approved by the local ethics committee. Post-hoc analysis using a *t*-test for difference between two means (G*POWER 3.1.9.2, Universitat Dusseldorf) determined results for the eight participants had high power ($1 - \beta = 0.94$) and large effect size ($d = 1.25$).

### 2.2. Experimental procedure

Familiarization of the jump-landing procedure and H-reflex/M-wave recruitment curves was completed three-to seven days prior to testing. Following familiarization, participants completed a single testing session to evaluate Ia-afferent activity at the SLR from two landing conditions: 25% and 50% of maximal broad jump distance. After a five-min warm-up comprised of skipping and stretching, maximal horizontal-jump distance and maximal vertical-jump height were determined from three trials. Following this, H and M-wave recruitment curves were attained during quiet stance, before each participant completed fifteen jumps without stimulation to determine the soleus SLR. Before each jump, participants positioned themselves with arms akimbo and with feet shoulder-width apart. Participants were instructed to land in the center of the force platform with toes touching a line marked to signify the desired landing distance. Each subject was required to jump off both legs with eyes fixated directly ahead and touch an overhead marker placed at a position equivalent to 50% of the subject's maximal vertical jump before landing on the force plate. Jump height was controlled at a low-moderate intensity (50% of vertical jump-max) to ensure consistency of the jump-landing procedure between trials and at an intensity unlikely to induce fatigue. Between each jump, participants were also provided with a ten-fifteen second rest to control for fatigue. A force plate (Metler Toledo, Changzhou) was used to identify touch down, defined by the first increase in ground reaction force (GRF) above 10 $\mu$V, as shown in Fig. 1. Force signals were sampled at 1000 Hz using an analog to digital converter (PowerLab 26T, ADInstruments Australia) and smoothed using a digital low-pass filter at 50 Hz.