EFFECTS OF WALKING SPEED ON HUMAN SOLEUS STRETCH RESPONSES

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INTRODUCTION

When a muscle is rapidly stretched, for example in response to a sudden trip, a short latency stretch reflex (SLR) is elicited due to excitation of Ia afferents in the muscle spindles. Sinkjaer et al. [1] found that in response to a rapid ankle dorsiflexion, SLR amplitudes increased at faster walking speeds. However, very little is known about muscle fascicle stretch responses during walking. The purpose of this study was to investigate muscle fascicle stretch behaviour in relation to SLR responses at different walking speeds.

METHODS

Twelve healthy subjects (8 males, 4 females; 27±4 years) walked on a treadmill with the left leg attached to a mechanical stretch device (Figure 1). An ultrasound device operating at 150 frames/s was used to measure soleus (SOL) fascicle lengths during walking, and EMG activity was recorded in the SOL and tibialis anterior (TA) muscles using bipolar surface electrodes. Perturbations of 6° were applied at the mid-stance phase at three different walking speeds (3, 4, and 5 km/h). At each speed, perturbations were imposed at three different velocities (Slow: ~170˚/s, Mid: ~230˚/s, Fast: ~280˚/s), and at least 30 trials were obtained at each velocity. Stretch reflex amplitude was calculated relative to background EMG within a 30ms window starting at the reflex onset.

RESULTS AND DISCUSSION

Between walking speeds of 3 and 5km/h, fascicle stretch amplitude decreased by approximately 40%, and fascicle stretch velocity by approximately 25% in response to a constant stretch at the ankle joint. Conversely, stretch reflex responses were unaffected by walking speed (Figure 2).

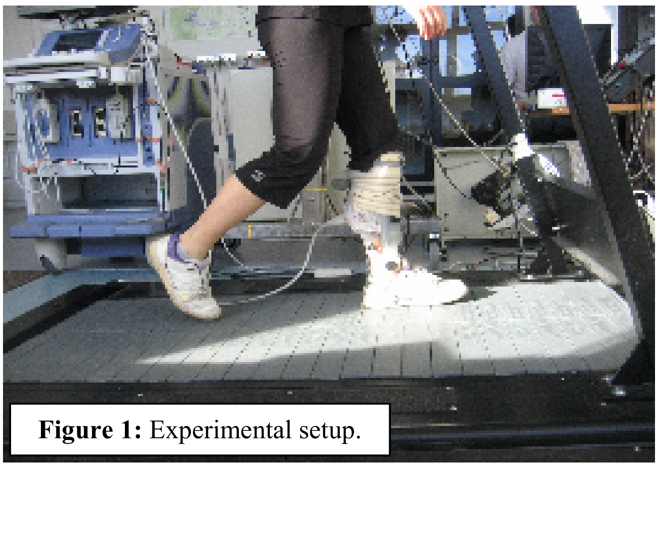

Figure 1: Experimental setup.

As a rapid stretch is known to be a potent stimulus to muscle spindles, a decrease in fascicle stretch velocity would decrease spindle afferent feedback, and would be expected to decrease reflex amplitudes. Therefore, it seems that other mechanisms acted to maintain output to the motoneurones as walking speed increased. For example, these findings may be due to a reduction in pre-synaptic inhibition with increasing walking speed. Alternatively, dynamic fusimotor activity may increase as movement speed increases, thus preventing unloading of the muscle spindles when the extrafusal muscle fibres shorten [2] and elevating spindle sensitivity [3]. Regardless of the mechanism, it is clear that changes in muscle fascicle length and velocity are not the only factors influencing stretch reflex responses during walking.

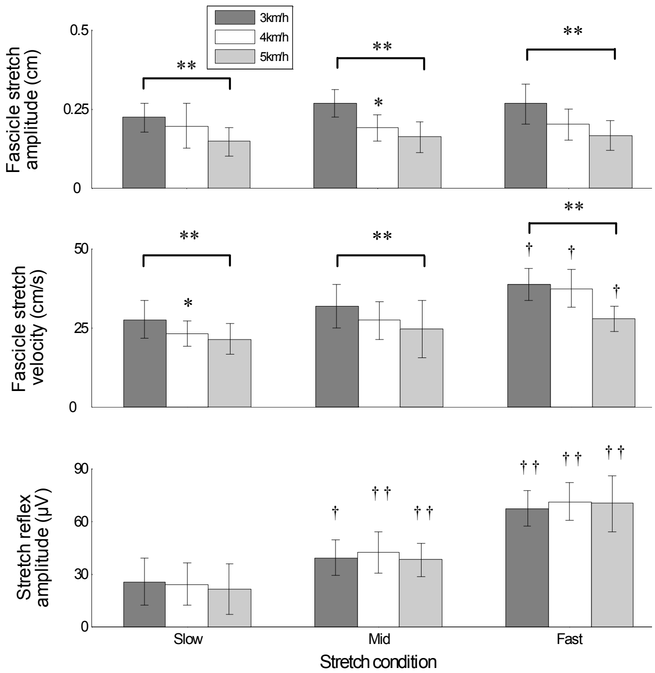

Figure 2: Group mean data. Reflex data were averaged from 25-30 trials per subject and fascicle data were averaged from 3 trials. Significant difference from previous walking speed: * p<.05, ** p<.01, *** p<.001. Significant difference from previous stretch condition: † p<.05, †† p<.01.

REFERENCES

1. Sinkjaer T, et al., *J Neurophysiol.* **76**: 1112-1120, 1996.
2. Proske U, et al., *Prog. Neurobiol.* **60**: 85-96, 2000.
3. Taylor A, et al., *J Physiol.* **571**: 711-723, 2006.