DIFFERENTIAL EFFECT OF M. TIBIALIS ANTERIOR FATIGUE ON WALK-TO-RUN AND RUN-TO-WALK TRANSITION SPEED IN UNSTEADY STATE LOCOMOTION CONDITIONS

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INTRODUCTION

There are basically two forms of human locomotion, namely walking and running, kinematically distinguished from one to another by presence resp. absence of a double stance phase. When increasing resp. decreasing speed, a gait transition occurs at the point people intuitively feel that it is easier, more naturally to run resp. to walk even though it is possible to walk faster or run slower than the preferred transition speed. [1]. One of the most puzzling aspects of the transition-dilemma is to reveal the reason why gait transitions occur at that specific speed.

The purpose of the present study was to examine the role of the m. tibialis anterior -a possible trigger [2]- in a protocol with gradually changing speed before and after fatigue of the m. tibialis anterior. Our hypotheses are (1) that there is a relationship between the m. tibialis anterior and transition speed also in a protocol with gradually changing speed and (2) that within burst endurance rather than the strength is determinative for transition speed. Muscular fatigue of the dorsiflexors is therefore assumed to affect the transition speed.

METHODS

A group of 20 active female human subjects participated in the study after given informed consent. The WRT (walk-to-run transition) and RWT (run-to-walk transition) speed were determined on a treadmill in a protocol with gradually changing speed. The accelerations used in this research were 0.1 ms^{-2}; 0.07 ms^{-2}; 0.05 ms^{-2} for the WRT and -0.1 ms^{-2}; -0.07 ms^{-2} and -0.05 ms^{-2} for the RWT. WRT and RWT speed were determined using high speed video-images (200 Hz) before and after a fatigue protocol, in which the subjects performed submaximal dorsiflexions (ROM : 30°, ±75% 1RPM) until exhaustion was reached.

EMG of the m. tibialis anterior was obtained using bipolar electrodes and Noraxon-software. The signal was rectified, filtered (bandpass 4-500 Hz) and integrated. EMG-intensity (integral) and duration of the first peak of the m. tibialis anterior (end swing- begin stance), being the most dominant activity in RWT and WRT, were calculated. A 2 (fatigue) x 3 (acceleration) ANOVA and with step number as factor and Post Hoc Tukey tests were used for WRT and RWT to find differences for transition speed, energy-intensity and duration of the burst of the m. tibialis anterior.

Table 1. Transition speed

	Acceleration	Transition Speed (ms^{-1}) Before fatigue	After fatigue
WRT	**0.1 ms^{-2}**	2.16 ±0. 12	2.06 ±0. 07*
WRT	**0.07 ms^{-2}**	2.10 ±0. 06	2.00 ±0. 07*
WRT	**0.05 ms^{-2}**	2.12 ±0. 08	2.04 ±0. 09 *
RWT	**-0.1 ms^{-2}**	2.19 ±0. 14	2.19 ±0. 14
RWT	**-0.07 ms^{-2}**	2.12 ±0. 09	2.20±0. 14*
RWT	**-0.05 ms^{-2}**	2.17 ±0. 06	2.18 ±0. 06

Asterisk: significant difference between transition speed before and after fatigue *$p<0.01$ *$p<0.05$

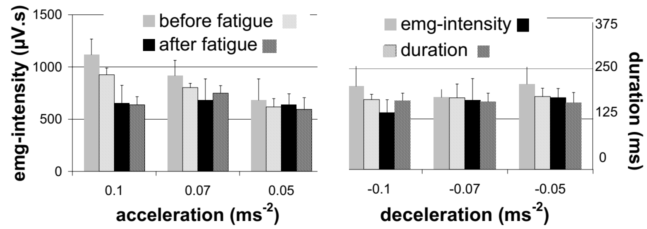
(a)  (b)

Figure 1: EMG -intensity and duration of energy burst of the m. tibialis anterior for the (a) WRT and (b) RWT

RESULTS AND DISCUSSION

Transition speed is significantly changed after introducing muscular fatigue. After fatigue, WRT speeds are lower for all accelerations. RWT-speeds do not change, except for the intermediate deceleration (Table 1). The differential effect of fatigue of the m. tibialis anterior is in agreement with the findings of Prilutsky and Gregor [3]. They claim that WRT is triggered by the increased sense of effort due to the augmented activity in the muscles activated during swing (m. tibialis anterior, m. rectus femoris and hamstrings), and, on the other hand, that RWT would be triggered by the activity during stance (m. soleus, m. gastrocnemius and m. vastii). [3]

Post hoc Tukey tests reveal that tibialis anterior EMG–intensity is higher in the steps around transition (step0) in both WRT and RWT. Therefore, EMG– intensity of the burst is averaged over 3 steps in the transition-zone (step-1 → step+1).

In the WRT before fatigue EMG-intensity is higher, except for the lowest acceleration and duration is higher for the highest acceleration. In the RWT there is no significant effect, nor for duration nor for EMG-intensity. This might indicate that in the WRT the m. tibialis anterior is no longer capable of maintaining the desired muscle tension, a combination of both a loss in power and duration, resulting in a higher sense of effort [4] accompanied by a change in locomotion pattern[3].

CONCLUSIONS

Walk-to-run transition speed is clearly affected by fatigue of the m. tibialis anterior. The increased sense of effort, due to the muscular fatigue, might explain this phenomenon. Further research is necessary since evolution of EMG-intensity on a step to step basis can provide meaningful information.

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