RESISTING VERSUS ASSISTING THE ANKLE MUSCULATURE HAS AN UNIDIRECTIONAL EFFECT ON WALK-TO-RUN TRANSITION SPEED

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INTRODUCTION

Various descriptive studies point towards the dorsiflexor or the plantarflexor muscles as determinants for the walk-to-run transition (WRT). It is generally accepted that an experimental design is the next step after descriptive analysis towards finding the underlying (pool of) determinant(s). Until now there is only one such study in which specifically the dorsiflexors were weakened by a fatigue protocol and indeed a lower WRT speed was found [1]. An even more critical test would be to check if there is an increase in WRT speed after experimentally assisting potential determinants. In order to accomplish this goal a powered exoskeleton was developed because this is the only method that allows to provide direct and focused assistance to the dorsiflexor or plantarflexor muscles during the WRT.

METHODS

In two separate experiments respectively 8 and 11 young adult female subjects performed several WRT's on an accelerating treadmill while wearing a bilateral ankle-foot-exoskeleton. The ankle musculature was assisted or resisted by pneumatic muscles mounted on the exoskeleton (figure 1). In the dorsiflexor experiment the pneumatic muscles were activated around heel contact i.e. when the endogenous dorsiflexors are highly activated. The conditions were: dorsiflexion resist, control and dorsiflexion assist [2]. In the plantarflexor experiment the pneumatic muscles were activated during the push off phase. The conditions were: plantarflexion resist, control and plantarflexion assist. WRT speed was measured as the average treadmill belt velocity during the transition step. Differences between conditions within each experiment were analyzed by means of a Wilcoxon non parametric analysis.

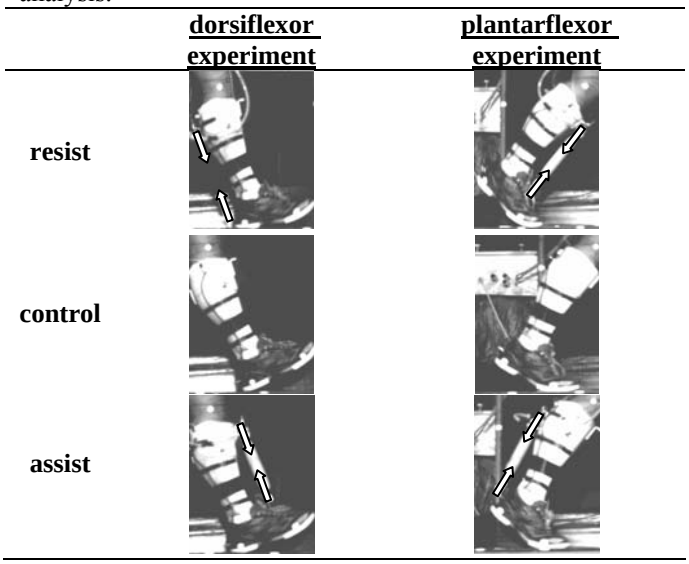

Figure 1: Experimental conditions (the difference between the dorsiflexor and plantarflexor experiment consists in the timing of the pneumatic muscle activation)

RESULTS AND DISCUSSION

WRT speed was significantly lower in the resist condition than in the corresponding assist ($p \leq 0.006$) and control condition ($p \leq 0.002$) in the dorsiflexor experiment as well as in the plantarflexor experiment. Also in both experiments there was no significant difference in WRT speed between the assist and control condition ($p \geq 0.132$). (table 1)

	WRT speed ($m.s^{-1}$)			p		test
dorsiflexor experiment						
resist	2.06	±	0.09	0.001	▪▪	**resist-control**
control	2.10	±	0.10	0.006	**	**resist-assist**
assist	2.12	±	0.11	0.132		**assist-control**
plantarflexor experiment						
resist	1.93	±	0.15	0.002	**	**resist-control**
control	2.11	±	0.21	0.002	**	**resist-assist**
assist	2.09	±	0.17	0.722		**assist-control**

Table 1: WRT speed in the resist, control and assist condition in the dorsiflexor and plantarflexor experiment.
**=p<0.01 ▪▪ =p<0.01 after elimination of one outlier

CONCLUSIONS

The fact that the effect from the resist condition cannot be extrapolated in the opposite direction is a striking analogy between both experiments. A possible explanation is that it would be easy to lower WRT speed by sufficiently resisting a specific muscle group whereas when assisting the same muscle group there would always be some weak link (figure 2) preventing a substantial increase in WRT speed. In order to obtain an increase in WRT speed the most likely option would be to affect multiple determinants simultaneously. The fact that Bartlett et al. [3] did actually find significant increases in transition speed by means of more general manipulations could be interpreted from this perspective.

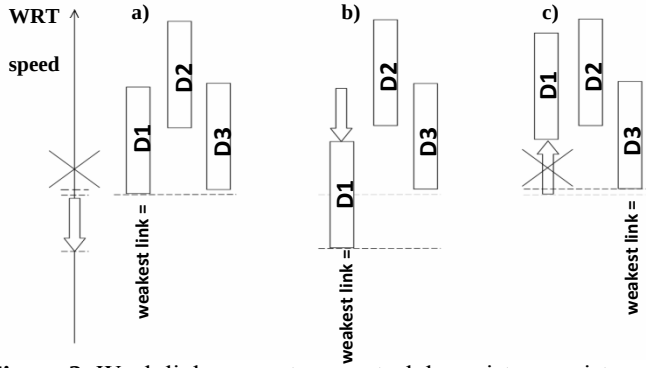

Figure 2: Weak link concept: a=control, b=resist, c=assist
D1= manipulated determinant D2, D3=other determinants

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2. Malcolm P, et al., *Gait Posture*; **29**: 6-10, 2009.
3. Bartlett JL, et al., *J Exp Biol*; **211**: 1281-8, 2008.