How to determine spatiotemporal variables on an accelerating treadmill?

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Introduction. Measures of times of initial contact and toe off and treadmill belt speed (TBS) are used in gait transition research on treadmill to compute spatiotemporal parameters. The calculation of related variables (step frequency (SF), step length (SL), etc.) is straightforward [1]. In this procedure it is assumed that subjects match their speed exactly to the TBS and thus remain at the same position in relation to the (non-moving) laboratory reference frame. However own preliminary research indicates that subjects do move in this frame. Particularly when the TB is accelerating and gait transitions are evoked subjects tend to move forward or backward, respectively moving temporarily faster or slower than the TB. In this study we propose a method to determine spatiotemporal variables in treadmill locomotion allowing to correct for deviations of TBS. As realization of the walk-to-run transition (WRT) has been discussed in several studies, the effect of the use of the presented method on spatiotemporal variables of the transition step will also be discussed.

Methods: Instead of using TBS and contact times, we suggest using contact instants and corrected step length (SL_{corr}) as input variables for actual subject's speed (V_{corr}). Instants of initial contact and toe off were visually determined using high speed (100 Hz) sagittal video images at the height of the treadmill belt. These same images also served as a means to determine the horizontal locations (X) of succeeding initial contacts relative to the lab frame. The difference between two successive locations being ΔSL_i ($X_{i+1} - X_i = \Delta SL_i$), $SL_{corr\ i}$ was then determined as the distance the treadmill belt covered during the step plus ΔSL_i. By dividing this step length by step time mean actual step velocity was obtained ($V_{corr\ i} = SL_{corr\ i}$ / step time $_i$). In the following analysis walk-to-run transitions of 19 subjects during three different treadmill belt acceleration conditions (0.1, 0.2 and 0.5 $m.s^{-2}$) were used. Statistical tests consisted of repeated measures anovas using acceleration (3 levels) and method (2 levels) as within factors.

Table 1: Corrected and uncorrected V and SL of the transition step during an accelerated treadmill protocol.
SL=step length, V=speed, M=mean, SD =standard deviation

	Uncorrected			Corrected			
	VALUES						
	M		*SD*	M		*SD*	p
SL (m)	1.05	±	*0.09*	0.99	±	*0.10*	0.000
V (m/s)	2.33	±	*0.22*	2.20	±	*0.24*	0.000
	COEFFICIENT OF VARIANCE						
	M		*SD*	M		*SD*	p
SL (%)	4.07	±	*1.93*	5.90	±	*2.67*	0.000
V (%)	3.17	±	*1.63*	5.80	±	*2.60*	0.000

Results: SL_{corr} of the transition step was 0.06 m less (effect size = 0.63) opposed to the traditional calculation, leading to a decrease of transition speed of 0.13 $m.s^{-1}$ (effect size = 0.56). Both effects were highly significant. Intravariability of both SL and transition speed was significantly higher using the corrected values. For the preceeding and following step statistically significant discrepancies between both methods were also apparent.

Conclusions: The selection of input variables for calculating spatiotemporal parameters has a significant effect on the outcomes. The size of this effect is in the same order as conditional effects in gait transition research and therefore cannot be neglected. Moreover the method presented enables gaining new insights into treadmill locomotion, which could not be detected by previous methods. Firstly, by adding the extra degree of freedom (correction of SL) variability of both SL and V is increased. Continued the correction for movement relative to the lab reference frame enables the observation of a speed jump during walk-to-run transition on treadmill, which was up till now only observed during overground walk-to-run transition [2]. And lastly the difference between TBS and subject's actual speed could be interpreted as a measure of adaptation to the treadmill belt acceleration.

References

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