Treadmill-based Gait Analysis for Children with Cerebral Palsy: Biomechanical Comparison of Treadmill and Overground Walking

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Introduction

Computerized three-dimensional motion analysis has emerged as one of the most advanced and reliable methods of gait assessment [1]. Its conventional use has involved overground (OG) walking on a walkway in a laboratory, where the ability to obtain more meaningful gait measurements is restricted by the limited length of the walkway and qualitative means of controlling walking-velocity. As it is important to control walking-velocity for gait assessment, considering its significant influence on gait parameters [2], treadmill (TM)-based gait analysis offers a potential advantage over the traditional method, as well as many other benefits; such as controlling environmental constraints, acquiring more consecutive strides, and improving trial-to-trial and session–to-session reliability [3].

Although it has been theorized there is no mechanical difference between the two modes based on a mathematical model by Van Ingen Schenau [4], previous studies have addressed concerns about the differences between TM and OG locomotion and have published inconsistent results[3)-5)]. Several recent studies have documented statistically significant differences including temporal-spatial, joint kinematics, and kinetic gait parameters [3),5)]. As most of those studies examined healthy adults and running as opposed to walking, it is unreasonable to apply such research results to gait assessment of children with cerebral palsy (CP). The purpose of this study was to determine the biomechanical differences between TM and OG walking in children with CP and children without disability. It was hypothesized that the two conditions were not identical and the difference between the two would be more obvious for children with CP.

Statement of Clinical Significance

TM-based gait analysis may provide improved clinical insight through greater experimental control and better inter-trial/session reliability. However, it is first necessary to understand the relationship between TM and OG walking before TM-based gait analysis becomes widely used for clinical purposes. This study should form a valid foundation for the usage of TM-based gait analysis in children with CP by revealing the differences of the two walking conditions.

Methodology

Figure 1. Test setting for TM walking

20 children with ambulatory spastic CP (10 males/10 females; ages range 6-16 yrs, mean 11 yrs) and 20 children without disability (age and gender matched) were tested for this study both on a treadmill (Biodex, Shirley, NY) and 10 meter walkway by using Vicon 512 system (Vicon Ltd, Oxford, UK). All TM walking trails were performed by using a safety suspension harness (Figure.1), which did not provide any weight support during gait. Standard 14mm reflective markers were attached by gait lab physical therapists, and Vicon Workstation v.4.4 and Polygon v. 2.0 programs were used to collect and process data

from two consecutive gait cycles. All children had three TM probe trials, with 20-minute intervals between each trial, to find their self-selected TM comfortable (TM-C) and fastest (TM-F) walking velocity. Three OG-C and three OG-F walking velocity trials were collected on the walkway. The average of 3 OG-C walking velocities were calculated immediately and applied to TM walking trial to compare gait parameters at the same velocity. Prior to this TM walking trial, all the children were familiarized with a minimum of 6-minute TM walking time accumulated from the beginning of the test. Dependent variables were cadence, stride length, and self-selected walking velocity for comfortable and fastest walking. Repeatability of three self-selected TM walking velocity for comfortable and fastest walking was evaluated as well.

Result

Statistically significant differences were observed in cadence, stride length, and self-selected walking velocity on TM (Table 1.). For both test groups with CP and without disability, significantly greater cadence and shorter stride length on TM were noted when the same walking velocity was applied to TM walking as OG. As for self-selected walking velocity, children in both test groups selected significantly slower velocity for comfortable and fastest walking on TM compared to OG. In addition, the test of inter-trial reliability showed that there was no significant difference in walking velocity selected by the children three times through TM probe trials as for their comfortable and fastest walking velocity.

	Group with CP (n=20)			Group without Disability (n=20)		
	OG	TM		OG	TM	
	Mean ± SD	Mean ± SD	P-value	Mean ± SD	Mean ± SD	P-value
Cadence (step/min)	114.21± 18.33	129.25 ± 20.03	p<0.0004	118.92 ± 8.79	126.31 ± 8.60	p<0.0438
Stride Length (m)	1.04 ± 0.17	0.98 ± 0.14	p<0.0293	1.26 ± 0.17	1.19 ± 0.16	p<0.0122
SS-CWV (m/sec)	1.03 ± 0.53	0.75 ± 0.34	p<0.0001	1.36 ± 0.32	1.14 ± 0.28	p<0.0027
SS-FWV (m/sec)	1.58 ± 0.59	1.28 ± 0.43	p<0.0011	2.36 ± 0.32	2.19 ± 0.32	p<0.0077

Table 1. Statistically significant differences between OG and TM walking. SD: standard deviation SS-CWV: self-selected comfortale walking velocity, SS-FWV: self-selected fastest walking velocity.

Discussion

The results of this study and other previous studies demonstrate that statistically significant differences exist between OG and TM walking. In particular, this study identified the significant differences in children with CP. The interpretation of TM-based gait analysis should consider these differences for clinical gait interventions of children with CP. It is important for clinicians to understand and further consider the differences when they use a TM for gait assessment or training for children with CP. Furthermore, it will be valuable to determine whether the differences are only statistically significant or also clinically and functionally meaningful.

References

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