Research in Developmental Disabilities 35 (2014) 3624–3631

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Gait characteristics of children with cerebral palsy as they walk with body weight unloading on a treadmill and over the ground

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ARTICLE INFO

Article history:
Received 3 June 2014
Received in revised form 31 August 2014
Accepted 2 September 2014
Available online

Keywords:
Body weight support system
Spatial–temporal parameters
Joint angles

ABSTRACT

Body weight support (BWS) has become a typical strategy for gait training, in special with children with cerebral palsy (CP). Although several findings have been reported in the literature, it remains uncertain how different types of surfaces and gradual amount of BWS can facilitate the mobility of children with CP. The aim of this study was to investigate gait kinematic parameters of children with CP by manipulating BWS and two different types of ground surfaces. Ten children (7.7 ± 2.1 years old) diagnosed with spastic CP and GMFCS classification between levels II and IV were asked to walk on a treadmill and over the ground. In both conditions, BWS was manipulated to minimize gravitational effects and spatial–temporal gait parameters and lower limb joints were analyzed. The results revealed that the type of ground surface causes greater impact on the gait pattern of children with CP as compared to body weight unloading. This finding may provide new insights into the behavioral heterogeneity of children with CP, and offers critical information to be considered on interventional programs specifically designed to improve mobility on this population.

1. Introduction

While gait is an activity that most of us take for granted, it is a motor skill that requires an optimal pattern of motor coordination and involves complex control mechanisms (Inman, Ralston, & Todd, 1994; Winter, 1991). The optimal performance level might be specified by the interaction of three different categories of constraints (Newell, 1986): organism, including structural features (e.g., body mass and height) and functional features (e.g., synaptic connections); environment (e.g., gravity, ambient temperature, natural light, cultural backgrounds); and task, including goals of the task and rules and implements specifying response dynamics. Constraints are considered as boundaries that limit an individual's motion at the same time that lead to alternative patterns of movement coordination and control; even if a movement is performed under the same set of environmental and task constraints.

CP has been described as a group of disorders of the development of movement and posture that are permanent and cause activity limitation, and are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain (Rosenbaum, Paneth, Leviton, Goldstein, & Bax, 2007). The effect of CP on functional abilities varies greatly. Some people are

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http://dx.doi.org/10.1016/j.ridd.2014.09.002
0891-4222/

able to walk while others are not. Some people show normal to near typical intellectual function, but others may have intellectual disabilities. Its motor severity is generally classified according to the Gross Motor Function Classification System (GMFCS) (Palisano et al., 1997; Palisano, Rosenbaum, Bartlett, & Livingston, 2008).

Among several movement deficiencies, the gait impairment is one of the major concerns for parents and caregivers. According to Chang, Rhodes, Flynn, and Carollo (2010), the gait impairment is due to spasticity (or abnormal muscle tone), reduced motor control ability and impaired balance. As these children grow with no simultaneous lengthening of skeletal muscles, muscular tightness and muscle contractures, they eventually develop bony torsion. Consequently, children with CP on ambulatory condition usually present a decline in gait function over time (Bell, Ounpuu, DeLuca, & Romness, 2002; Johnson, Damiano, & Abel, 1997; Norlin & Odenrick, 1986). To overcome the inability to typically develop gait movement patterns, different categories of treatment have been proposed and investigated, including therapeutic interventions and neuromuscular invasive techniques.

For instance, the use of body weight support (BWS) is a typical therapeutic intervention technique that provides task-specific gait training. The rationale for using the BWS system is that the reduction of gravitational forces would reduce the load that should be overcome by the individual; facilitating the walking constraints. Consequently, this strategy might promote a gait pattern close to typical (Finch, Barbeau, & Arsenault, 1991). In general, the BWS systems consist of a mounting frame and a harness to support a percentage of the individual's weight as s/he walks on a motorized treadmill (Mattern-Baxter, 2009; Mutlu, Krosschell, & Spira, 2009). The use of a treadmill is usually adopted to stimulates rhythmical and repetitive steps (Visintin, Barbeau, Korner-Bitensky, & Mayo, 1998). In addition, the treadmill belt triggers interlimb symmetry causing positive effects on the temporal parameters of walking (Harris-Love, Macko, Whitall, & Forrester, 2004), as well as diminishing the need for propulsive force generation at the end of the stance period (Norman, Pepin, Ladouceur, & Barbeau, 1995). More recently, the BWS systems have been employed during over ground walking in individuals with stroke (Lamontagne & Fung, 2004; Miller, Quinn, & Seddon, 2002; Prado-Medeiros et al., 2011; Sousa, Barela, Prado-Medeiros, Salvini, & Barela, 2009; Sousa, Barela, Prado-Medeiros, Salvini, & Barela, 2011) and children with CP (Matsuno, Camargo, Palma, Alveno, & Barela, 2010). However, to the best of our knowledge, it remains unclear whether the type of surface and/or the amount of body weight unloaded could influence the way that children with CP walk. This study was designed to investigate gait kinematic parameters of children with CP by manipulating BWS and two different types of ground surfaces (treadmill and over ground).

2. Methods

2.1. Participants

Ten children (7.7 ± 2.1 years old) diagnosed with spastic CP and GMFCS classification between levels II and IV were selected to participate in this study (Table 1). The inclusion criteria also account for the individual's ability to walk approximately 7 m with or without assistance, and to understand the experimental instructions and procedures. Fourteen children were initially recruited and assessed. However, data from four participants were excluded due to experimental difficulties encountered either during data acquisition ($n = 2$) or data processing ($n = 2$). Prior to participation, each child's parent or legal guardian provided informed consent. All experimental procedures were approved by the Institutional Review Board at the University of Cruzeiro do Sul, Sao Paulo, Brazil (Protocol 020/2010).

2.2. Procedures

The children were asked to walk at a comfortable speed along a walkway (7 m) and on a treadmill under three different conditions: walking wearing a harness and bearing full body weight ("0% BWS" condition); walking wearing a harness and 15% of full body weight unloaded ("15% BWS" condition); and walking wearing a harness and 30% of full body weight

Table 1
General information about the children considered in the final sample.

ID	Sex	Age (years)	Mass (kg)	Height (cm)	Diagnosis	GMFCS
1	F	9.3	19.7	123	Diplegia	III
2	M	8.3	23.8	132	Diplegia	II
3	M	9.5	25.3	130	Diplegia	II
4	F	3.2	13.1	93	Diplegia	III
5	F	7.8	34.5	138	Hemiplegia	III
6	F	7.5	30.0	108	Diplegia	IV
7	M	8.9	30.7	122	Diplegia	III
8	M	8.6	23.2	136	Diplegia	III
9	F	4.9	15.5	110	Diplegia	IV
10	F	9	19.1	104	Hemiplegia	II
Mean	–	7.7	23.5	119.6	–	–
SD	–	2.1	6.9	15.1	–	–

Abbreviation: ID, child's identification; GMFCS, Gross Motor Function Classification System (Palisano et al., 1997).