

Kinematic and Temporospacial Changes in Children with Cerebral Palsy during the Initial Stages of Gait Development

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ABSTRACT

Purpose: To identify changes in the gait kinematics and temporospacial parameters of children with bilateral Cerebral Palsy (CP) at 8 months after the onset of independent walking and identify differences to Typical Development (TD) children at the onset of independent walking and at 8 months follow up.

Method: Sixteen children with bilateral CP, GMFCS levels I and II, and 15 TD children were recruited. Gait kinematics and temporospacial parameters were recorded using a 3-D gait analysis system; the sagittal plane of the lower limb joints was analyzed. Baseline measurements were recorded at the individual's onset of independent walking and follow up was after 8 months.

Results: Compared to baseline, children with bilateral CP demonstrated increased (mean difference \pm SE) plantar flexion (11.79 ± 2.96), single support (0.04 ± 0.01), step length (0.2 ± 0.05) and stride length (0.4 ± 0.09), at follow up; all $p < .05$. Compared to TD children, they also had lower gait speed (0.16 ± 0.05), higher single support (0.02 ± 0.01) and lower maximum knee extension (9.14 ± 4.49) during the swing phase, at baseline and follow up (0.1 ± 0.04 , 0.05 ± 0.01 , 23.04 ± 4.17 , respectively); all $p < .05$.

Conclusion: There are changes in the sagittal plane kinematics and temporospacial parameters of the gait during the first 8 months of independent walking. These indicate gait maturation changes and highlight the impact of walking experience on the gait characteristics of children with bilateral CP.

ARTICLE HISTORY

Received August 22, 2020
Revised April 01, 2021
Accepted April 05, 2021

KEYWORDS

Gait; kinematics; temporospacial; cerebral palsy

Introduction

Cerebral palsy (CP) is the most common cause of physical disability in childhood.¹ By definition, it describes "a group of permanent disorders of the development of movement and posture, causing activity limitation that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain".² Independent walking is a major motor milestone, which is often significantly affected in children with CP. Research indicates that 58.2% of all children with CP are eventually able to walk independently without the use of a hand-held mobility device, although with certain limitations [Gross Motor Function Classification System (GMFCS) levels I and II].³ However, these limitations often result into restrictions in transportation and consequently in the child's participation in activities of everyday life.

The gait characteristics of children with CP have been the subject of research interest for several years.⁴ Identifying common patterns of gait in children with CP and detecting differences in the gait characteristics between children with CP and Typical Development (TD) children allows a better understanding about the development of walking. This could improve clinical reasoning and support therapeutic decision making. Recent technological developments in the field of three-dimensional gait analysis offer greater accuracy in recording motion, thus enabling researchers to study gait characteristics more extensively.

To date, studies investigating the gait characteristics of children with bilateral CP either focus on children who are over 4 years old or have a wide age range,⁵ thus we cannot draw conclusions about young children. Studies that use three-dimensional gait analysis to assess the gait development of children less than 4 years have been conducted only in children with unilateral CP.⁶ Still, children with bilateral CP above the age of 4 years are more likely to have established musculoskeletal limitations.⁷ The impact of muscle contractures, joint deformities, muscle tone changes over time, muscle activation failure, as well as changes in anthropometric parameters, may play an important role in shaping the gait characteristics of older children with bilateral CP. These children have also often undergone various medical interventions, such as botulinum toxin injection or orthopedic surgery,⁸ which may affect their gait. Studying walking in young children with bilateral CP, i.e. <4 years old, can provide important information about the parameters that characterize common gait development.

Furthermore, most studies assess the gait of children with CP, of different age groups and variable walking experience. Differences in gait characteristics can therefore be partially attributed to variance in walking experience amongst the children, i.e. the differences on how long each child has been practicing walking. In contrast, the onset of independent walking is a definite time-point, set as the time when a child is able