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Gait pattern differences in children with unilateral cerebral palsy

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ABSTRACT

Children with cerebral palsy (CP) often have atypical body posture patterns and abnormal gait patterns resulting from functional strategies to compensate for primary anomalies that are directly attributable to damage to the central nervous system. Our previous study revealed two different postural patterns in children with unilateral CP: (1) a pattern with overloading of the affected body side and (2) a pattern with under-loading of the affected side.

The purpose of present study was to test whether different gait patterns dependent on weight distribution between the affected and unaffected body sides could be detected in these children. The study included 45 outpatients with unilateral CP and 51 children with mild scoliosis (reference group). The examination consisted of two inter-related parts: paedobarographic measurements of the body mass distribution between the body sides and three-dimensional instrumented gait analysis.

Using cluster analysis based on the Gillette Gait Index (GGI) values, three gait patterns were described: a scoliotic gait pattern and two hemiplegic gait patterns, corresponding to overloading/under-loading of the hemi-side, which are the pro-gravitational gait pattern (PGP) and the anti-gravitational gait pattern (AGP), respectively. The results of this study showed that subjects with AGP presented a higher degree of deviation from the normal gait than children with PGP. This proof that there are differences in the GGI between the AGP and PGP could be a starting point to identify kinematic differences between these gaits in a follow-up study.

1. Introduction

Children with cerebral palsy (CP) often have atypical body posture patterns and abnormal gait patterns (Rosenbaum et al., 2007) resulting from functional strategies to compensate for primary anomalies that are directly attributable to damage to the central nervous system. These primary impairments due to this upper motor neuron syndrome can lead, in the longer term, to adaptations in the musculoskeletal system, which are known as secondary impairments, such as inadequate muscle growth, which causes contractures (shortening) of muscles and tendons, bone deformities, misalignment of the joints and excessive fatigue with movement and walking (Rosenbaum et al., 2007). One of the most striking features of CP is the

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variability in its clinical presentation. The diversity of gait deviations observed in children with CP has led to repeated efforts to develop gait classification systems to assist in the diagnosis, clinical decision-making and communication (Hullin, Robb, & Loudon, 1996; Lin, Guo, Su, Chou, & Cherng, 2000; Rodda, Carson, Graham, Galea, & Wolfe, 2004; Stebbins et al., 2004; Sutherland & Davids, 1993; Winters, Gage, & Hicks, 1987).

Although the majority of studies have used advanced three-dimensional measurement systems to collect gait data on three planes of motion, most classifications of CP gait have been constructed using only sagittal plane data (Boyd & Graham, 1999; Corry et al., 1998; Koman et al., 2001; Mackey, Lobb, Walt, & Stott, 2003). Although these classifications are used for diagnostic purposes as well as to streamline communication and facilitate clinical decision-making process, including surgical interventions (Dobson, Graham, Baker, & Morris, 2005; Dobson, Morris, Baker, & Graham, 2007; Graham & Selber, 2003; Gage, 1991; Ounpuu, Deluca, & Davis, 2000; Rodda & Graham, 2001), none of the classifications have appeared to be useful in the physiotherapy planning for the children with CP.

The term ''gait classification'' refers to a system that allows for the allocation of gait patterns into groups that can be differentiated from one another based on a set of defined variables. This classification is distinct from gait indices, assessment scores and scales, which score individual gait variables or provide an overall index to quantify the deviations from normal gait without group allocation. Currently, one of the most commonly used indices for quantifying the deviations from normal gait is the Gillette Gait Index (GGI; previously called the Normalcy Index; Gage, 2004; Schutte et al., 2000). The GGI uses a single number to measure the deviation of the patient's gait from the average gait of a subject without pathology. The GGI values have been standardised for particular diagnostic categories in children with hemiplegia, according to Winter's classification by Schutte et al. (2000). The average and range of index values were determined for each diagnosis group of hemiplegia: types I, II, III and IV (Schutte et al., 2000). Moreover, the GGI was shown to be efficient in categorising the pathology in children with CP, to be clinically applicable (Assi, Ghanem, Lavaste, & Skalli, 2009; Schutte et al., 2000) and to be correlated with physical functioning (Romei, Galli, Motta, Schwartz, & Crivellini, 2004).

Despite the observation that a group of children with hemiplegia (SH) appears to be relatively homogeneous in terms of body posture, our previous study showed that their postural patterns were different (Domagalska, Szopa, & Lembert, 2011). Based on weight bearing between the affected and unaffected body sides, two types of asymmetrical postural patterns were described: (1) the postural pattern with overloading of the affected body side (pro-gravitational postural pattern [PGPP]) and (2) the postural pattern with under-loading of the affected side (anti-gravitational postural pattern [AGPP]; Domagalska et al., 2011).

Because the results of previous research have been promising, we decided to test whether different gait patterns corresponding to weight bearing on the hemi-side could be detected in these children. The present study aimed to verify the hypothesis that the degree of deviation of a hemiplegic gait pattern from a normal gait (evaluated by the GGI) depends on the nature of weight bearing on the unaffected or affected body side. Proof that there are differences in the GGI between hemiplegic gait patterns could be a starting point for identifying kinematic differences between these gaits in a follow-up study.

2. Materials and methods

This study was approved by the Local Ethical Committee. The patients and their parents provided informed consent before data collection.

2.1. Subjects

From all of 111 children with a diagnosis of unilateral CP, resident in our geographical region, who were the outpatients of the local paediatric rehabilitation centres, 57 met the inclusion criteria for study of three-dimensional instrumented gait analysis. Although the exclusion criteria included lower limb surgery in the previous 6 months and botulinum toxin A injection into the lower limb in the previous 6 months, appointments were arranged over the period of data collection to minimise these exclusion. However, out of 57 eligible, identified individuals, a representative sample of 45 participated in study: 17 girls and 28 boys; deficits occurred on the right side in 29 patients and on the left side in 16 patients; the mean age was 9 years 5 months old (range, 7 years 4 months to 12 years 2 months; SD = 2.11); 75.5% at Level I and 24.5% at Level II on the Gross Motor Function Classification System.

All subjects met the following criteria: (1) older than 7 years of age (to minimise the incidence of instability of kinematic parameters), (2) able to walk without assistive mobility devices and orthoses, (3) able to follow verbal directions, (4) no surgical procedures in the lower extremities and (5) no dislocation of the hip. The subjects with CP had the following additional criteria: (1) diagnosis of SH, (2) non-use of pharmacological agents at the time of the study and (3) no spasticity management 6 months before the evaluation.

Fifty-one children with mild scoliosis (scoliosis curve 10–20°), range of lateral curvature of 11−20° (mean, 18°) and a mean age of 9 years 2 months old (range, 7 years, 5 months to 12 years, 3 months; SD = 1.99) were recruited as references. All of them were outpatients at a local Centre for Corrective Gymnastics.

Statistical analysis confirmed that the patient demographic characteristics were similar in both groups.