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Full Length Article

Dynamical structure of center-of-pressure trajectories with and without functional taping in children with cerebral palsy level I and II of GMFCS

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ABSTRACT

Postural control during quiet standing was examined in typical children (TD) and children with cerebral palsy (CP) level I and II of GMFCS. The immediate effect on postural control of functional taping on the thighs was analyzed. We evaluated 43 TD, 17 CP children level I, and 10 CP children level II. Participants were evaluated in two conditions (with and without taping). The trajectories of the center of pressure (COP) were analyzed by means of conventional posturography (sway amplitude, sway-path-length) and dynamic posturography (degree of twisting-and-turning, sway regularity). Both CP groups showed larger sway amplitude than the TD while only the CP level II showed more regular COP trajectories with less twisting-and-turning. Functional taping didn't affect sway amplitude or sway-path-length. TD children exhibited more twisting-and-turning with functional taping, whereas no effects on postural sway dynamics were observed in CP children. Functional taping doesn't result in immediate changes in quiet stance in CP children, whereas in TD it resulted in faster sway corrections. Children level II invest more attention in postural control than level I, and TD. While quiet standing was more automatized in children level I than in level II, both CP groups showed a less stable balance than TD.

1. Introduction

The levels of activity and participation in daily life of children with cerebral palsy (CP) are limited (Dos Santos, Pavão, Campos, & Rocha, 2011; Pavão, dos Santos, Oliveira, & Rocha, 2013; Pavão, Nunes, dos Santos, & Rocha, 2014), in part related to impaired postural control (Burtner, Woollacott, Craft, & Roncesvalles, 2007; Chen & Woollacott, 2007; Nashner, Shumway-Cook, & Marin, 1983). Neuromuscular impairments, muscle spasticity and muscle weakness are important determinants of postural deficits (Quinby & Abrahan, 2005; Verschuren et al., 2011). In addition, deficits in sensory processing play an important role in the impaired postural control of children with CP (Barela et al., 2011; Hadders-Algra et al., 2007; Saavedra, Woollacott, & van Donkelaar, 2010). For example, children with CP show in general larger postural perturbations (e.g. steps or falls) when sensory information is experimentally modified than typically developing children (Pavão, Silva, Savelsbergh, & Rocha, 2015, for a review).

Several studies on postural control in children with CP have explicitly addressed such sensory input variations, for example by reducing or enhancing available visual information for postural control (Barela et al., 2011; Donker, Ledebt, Roerdink,

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Savelsbergh, & Beek, 2008; Ledebt et al., 2005; Saavedra et al., 2010) and/or by manipulating the base of support (Chen & Woollacott, 2007; Corrêa, Corrêa, Franco, & Bigongiari, 2007). These studies showed that, compared to typically developing children, children with CP have an impaired ability to adapt postural control to sensory input variations.

In order to keep balance and avoid falls, children with CP commonly use specific postural strategies, such as standing with increased co-contraction in lower-limb musculature (Burtner, Qualls, & Woollacott, 1998; Nashner et al., 1983; Park, Park, Lee, & Kim, 2003). Although such a stiffening strategy may afford postural stability, the involved high levels of co-contraction are energetically and attentionally costly (Nashner et al., 1983; Stins, Roerdink, & Beek, 2011).

Functional bandages, such as kinesio taping and neoprene bandages, have been used in children with CP to provide an alternative means to support postural stability when applied around specific joints (Iosa, 2015; Iosa et al., 2009) or along the trajectory of specific muscles (Kara et al., 2015). It has been suggested that, in healthy young adults, the tape provides tactile stimulation that could activate gamma motor neurons to modulate Ia afferent activity allowing the continued firing of alpha neurons, leading to muscle contraction (Konishi, 2013). According to this suggestion the effect of tapping should be immediate.

To date, however, no studies are available that quantified the effects of functional neoprene bandage on postural control in children with CP, although two studies reported improvement of the sitting posture (Karabay, Doğan, Ekiz, Köseoğlu, & Ersöz, 2016; Şimşek, Türkücüoğlu, Çokal, Üstünbaş, & Şimşek, 2011). In children with CP (GMFCS level III to V), sitting posture improved after 12 weeks wearing kinesio tape applied on their back (Şimşek et al., 2011). Despite these positive effects on sitting (assessed by an observation scale), no improvements in other domains of the gross motor function or functional independence were observed. Recently, a combination of kinesio taping and neurodevelopmental therapy during four weeks improved the kyphosis in children with CP as well as the sitting posture (Karabay et al., 2016).

Interestingly, applying functional taping to children with CP is believed to influence neuromuscular function by means of stimulating cutaneous receptors (Kara et al., 2015). However, the question is to what extent children with CP may effectively utilize such taping-induced tactile information for postural control, in view of the earlier identified impairments in sensory-motor integration.

Thus, the aim of the present study was to (1) analyze postural control according to the level of gross motor function (typically developing, GMFCS I, GMFCS II); (2) examine the effects of functional taping on postural control in children with CP level I and II of GMFCS and in typically developing children. Functional taping was applied by means of neoprene bandage on the lower limbs. Postural control was examined on a force platform in quiet stance with and without functional taping, quantified using conventional posturography capturing the amount of postural sway (sway amplitude, sway path length) and dynamic posturography capturing the time-varying structure of postural sway (degree of twisting and turning, sway regularity). In line with the premise that functional taping may enhance afferent input and improve postural stability, we hypothesize a lower amount of sway with taping, most compellingly so for the CP children given their impaired postural control. We further expect changes in the dynamics of postural control with functional taping, with the additional somatosensory information provided by the taping exerts positive effect in postural control resulting in a reduction in regularity of postural sway, suggesting that they need to invest lower amount of attention in postural control (Donker, Roerdink, Greven, & Beek, 2007; Donker et al., 2008; Roerdink, Hlavackova, & Vuillerme, 2011a; Roerdink et al., 2006).

2. Methods

2.1. Participants

Three groups of children participated in the experiment. The first group consisted of 43 children with typical development, all born full term and without any musculoskeletal disorder (22 male and 21 female), aged ranged from 5 to 15 years old (mean ± SD; age: 9.9 ± 3.1 years old; height: 141.9 ± 19.7 cm; weight: 40.3 ± 17.7 kg). All the parents of the children gave their signed informed consent prior to their participation.

The second and third group comprised children with spastic CP classified according to the Gross Motor Function Classification System (GMFCS) as level I (17 children; 10 male, 7 female; 15/2 hemi-/diplegic; mean ± SD; age: 9.7 ± 3.2 years old; height: 130.7 ± 37.4 cm; weight: 31.4 ± 12.0 kg) or level II (10 children; 5 male, 5 female; 3/7 hemi-/diplegic; mean ± SD; age: 11.1 ± 2.7 years old; height: 139.9 ± 17.7 cm; weight: 35.5 ± 15.4 kg). All the children with CP demonstrated internally rotated thighs (on their affected side for children with hemiplegia and on both sides for children with diplegia). The children's classification in the level of GMFCS was performed by an experienced pediatric physical therapist.

Children with CP were recruited in specialized centers of child care. Children with CP whose parents gave informed consent to participation and complied with the following criteria were included. Inclusion criteria were: (a) ability to follow simple instructions; (b) attending physical therapy at least twice per week during the last six months. Exclusion criteria were: (a) presence of physical deformity that could compromise postural control; (b) orthopedic surgery and/or neurochemical block in the previous six months; (c) visual impairments not corrected by glasses or contact lenses. The study was approved by the local Ethics Committee (CAAE 17495213.8.0000.5504).

2.2. Procedures

Participants were instructed to stand barefoot on a force platform (Bertec400, sampling frequency 1000 Hz) with their feet parallel to and aligned with the side of their hips. While standing on the platform, the children were asked to stand as steady as