Research in Developmental Disabilities 71 (2017) 42–52

Contents lists available at ScienceDirect

Research in Developmental Disabilities

journal homepage: www.elsevier.com/locate/redevdis

Best seating condition in children with spastic cerebral palsy: One type does not fit all

Mattana Angsupaisal[a], Linze-Jaap Dijkstra[a], Sacha la Bastide-van Gemert[b], Jessika F. van Hoorn[c], Karine Burger[d], Carel G.B. Maathuis[c], Mijna Hadders-Algra[a,*]

[a] University of Groningen, University Medical Center Groningen, Department of Paediatrics – Division of Developmental Neurology, Groningen, The Netherlands
[b] University of Groningen, University Medical Center Groningen, Department of Epidemiology, Groningen, The Netherlands
[c] University of Groningen, University Medical Center Groningen, Department of Rehabilitation Medicine, Center for Rehabilitation, Groningen, The Netherlands
[d] Vogellanden Rehabilitation Center, Zwolle, The Netherlands

ARTICLE INFO

Number of reviews completed is 3

Keywords:
Cerebral palsy
Seating inclination
Foot-support
Head stability
Reaching movement
Kinematics

ABSTRACT

Background: The effect of forward-tilting of the seat surface and foot-support in children with spastic cerebral palsy (CP) is debated.
Aim: To assess the effect of forward-tilting of the seat surface and foot-support in children with CP on kinematic head stability and reaching.
Methods: Nineteen children functioning at Gross Motor Function Classification System levels I–III participated [range 6–12y; ten unilateral spastic CP (US-CP) and nine bilateral spastic CP (BS-CP)]. Kinematic data were recorded of head sway and reaching with the dominant arm in four sitting conditions: a horizontal and a 15° forward (FW) tilted seat surface, each with and without foot-support.
Results: Seating condition did not affect head stability during reaching, but did affect kinematic reaching quality. The major reaching parameters, i.e., the proportion of reaches with one movement unit (MU) and the size of the transport MU, were not affected by foot-support. Forward-tilting had a positive effect on these parameters in children with US-CP, whereas the horizontal condition had this effect in children with BS-CP.
Implications: A 15° forward-tilted seating and foot-support do not affect head stability. Reaching in children with US-CP profits from forward-tilting; in children with BS-CP forward-tilting worsens reaching − effects that are independent of foot-support.

What this paper adds?

The nature of the best seating condition in children with cerebral palsy (CP) is debated due to conflicting study results. The latter is presumably due to the mixed composition of the study groups, the specifics of the seating conditions and the measurement methods We studied the contribution of seat surface forward tilting, foot support and the type and severity of CP on the kinematics of head stability and reaching of children with spastic CP. The study showed that in school-age children with spastic CP (6–12 years) functioning at Gross Motor Function Classification System level I to III, a 15° forward-tilted seating with or without foot-support did not affect head stability during reaching. Seat surface tilting did however affect the kinematic quality of reaching. In children with

* Corresponding author at: Departments of Paediatrics—Developmental Neurology, University Medical Center Groningen, Hanzeplein 1, 9713 GZ Groningen, The Netherlands.
E-mail address: m.hadders-algra@umcg.nl (M. Hadders-Algra).

http://dx.doi.org/10.1016/j.ridd.2017.09.016
Received 17 February 2017; Received in revised form 11 September 2017; Accepted 24 September 2017

unilateral spastic CP forward-tilting of the seat surface resulted in the best reaching quality, in children with bilateral spastic CP a horizontal seat surface was associated with best reaching performance. The effect of seating adaptation did not depend on severity of CP (GMFCS level I to III). However, the latter conclusion should be interpreted with caution, as the severity subgroups were small. Foot support affected reaching to a minor extent only.

1. Introduction

Dysfunctional postural control is one of the major impairments in children with cerebral palsy (CP) (Hadders-Algra & Carlberg, 2008). The dysfunction directly influences daily activities, such as sitting and reaching (Hadders-Algra & Carlberg, 2008). On the impairment level, dysfunctional postural control may result in a larger sway of the head (Sochaniwskyj, Koheil, Bablich, Milner, & Lotto, 1991), and a worse quality of reaching movements during sitting (van der Heide, Fock, Otten, Stremmelaar, & Hadders-Algra, 2005a). The stability of the head in space is considered to be a major goal of postural control during dynamic activities, such as reaching while sitting (Assaiante and Amblard 1993; Pozzo, Berthoz, & Lefort 1990), as the head functions as the base for the visual and vestibular systems (Assaiante and Amblard 1993).

Children with CP also demonstrate upper limb motor deficits, such as impaired reaching, grasping and manipulation (Schneiberg, McKinley, Sveistrup et al., 2010). In terms of kinematics, reaching quality may be described with the help of movement units. Movement units (MUs) are submovements of the reaching movement (van der Heide et al., 2005a; von Hofsten, 1991). Typical reaching movements of adults consist of one MU, reflecting the feedforward control of the movement (von Hofsten, 1991). Less well programmed reaching movements, for instance of infants (Fallang, Saugstad, & Hadders-Algra, 2000; von Hofsten, 1991) or children with CP (van der Heide, Fock, Otten, Stremmelaar, & Hadders-Algra, 2005b), consist of multiple MUs. In movements with multiple MUs, the relative part of the movement covered by the first MU, i.e., the transport MU, reflects the contribution of preprogrammed control (van der Heide et al., 2005b).

To improve activities and participation of school-age children with CP often seating adaptations are used (Hadders-Algra & Carlberg, 2008; ICF-CY, WHO 2007; McNamara & Casey 2007; Stavness, 2006). From a theoretical perspective, the position of the pelvis is considered to be a crucial factor to achieve a seating position that is optimal for upper extremity function (Green and Nelham, 1991; McNamara & Casey 2007; Pope, 2002; Reid, Sochaniwskyj & Milner, 1992; Stavness, 2006). The idea is to achieve a seating position in which the line of gravity of the child's trunk and pelvis is close to the ischial tuberosities. The mechanical effects of this position are considered to improve stabilization of the proximal body segments (pelvis, trunk, or head), which in turn is associated with increased freedom to move and functional effectiveness of the distal parts (upper extremities) (Green & Nelham, 1991; Pope, 2002). Notwithstanding these theoretical considerations, the nature of optimal seating is debated, especially during an activity that is associated with a subtle shift in the centre of gravity of the body segments, such as reaching (Angsupaisal, Maathuis & Hadders-Algra, 2015; Chung et al., 2008; McNamara & Casey, 2007; Ryan, 2016; Stavness, 2006).

In the present paper, we focus on children with CP who are ambulatory. It is common practice to provide these children, just as children with Developmental Coordination Disorder, with adaptive seating, to enhance their functional performance in daily life activities (Case-Smith & Clifford O'Brien, 2015; Ryan, 2012). In ambulatory children with CP, i.e., children who are able to sit independently and who function at Gross Motor Function Classification System (GMFCS) levels I to III (Palisano, Rosenbaum, Bartlett, & Livingston, 2007), focus of research on adaptive seating is on the potential effect of seat inclination (McNamara & Casey, 2007; Reid et al., 1992; Sochaniwskyj et al., 1991; Stavness, 2006). This implies that the focus of research in these children differs from that in children with severe CP in whom focus is on adaptive seating systems (Angsupaisal et al., 2015; Chung et al., 2008; McNamara & Casey, 2007; Stavness, 2006).

For the potential effect of seat inclination, evidence is emerging that backward tilting of the seat surface is associated with worse functional performance in children with GMFCS levels I–III (Nwaobi (1986): only children with GMFCS levels I-III; Hadders-Algra et al. (2007): including also some children with GMFCS level IV). Nevertheless, studies disagreed on the effect of forward (FW) tilting, due to the use of different methodology, outcome parameters, and differences in the nature of the CP of study participants. One point of variance was the seat angle which varied from 5° (Cherng, Lin, Ju, & Ho, 2009; McClenaghan, Thombs, & Milner, 1992), 10° (Cherng et al., 2009; Reid et al., 1992; Sochaniwskyj et al., 1991), to 15° (Cherng et al., 2009; Hadders-Algra et al., 2007; McClenaghan et al., 1992; Reid, 1996; Sochaniwskyj et al., 1991; Tsai, Yu, Huang, & Cheng, 2014). The studies did not reveal one consistently best seating angle, both with respect to head stability and reaching activities. Yet, in children functioning at GMFCS levels I–III, the 10° and 15° FW tilt were most frequently associated with functional improvement postural control (Cherng et al., 2009; Reid, 1996; Sochaniwskyj et al., 1991) and reaching (Cherng et al., 2009; Hadders-Algra et al., 2007). As the study of Cherng et al. indicated that a 15° FW-tilt was associated with a slightly better effect than a 10° FW-tilt, we opted to evaluate the effect of a 15° FW-tilt.

The evidence about the influence of the nature of the CP is illustrated by the study of Hadders-Algra et al. (2007) that evaluated the effect of seat inclination in a relatively large sample of children with bilateral (BS-CP) or unilateral spastic CP (US-CP), functioning at GMFCS levels I–IV. The results showed that in children with BS-CP, 15° FW-tilting resulted in a larger head sway, i.e., worse head control, and had no effect on the kinematics of reaching. In children with US-CP, 15° FW-tilting did not affect head sway, but it was associated with better reaching movements, i.e., with movements in which the transport MU covered a larger part of the reaching movement. However, the majority of participants did not receive foot support (Hadders-Algra et al., 2007) which differs from daily life situations (Angsupaisal et al., 2015; Ryan, Rigby, & Campbell, 2010).

Therefore, the aim of the present study is to explore the immediate effect of 15° FW-tilting in combination with the effect of foot-support in school-age children with spastic forms of CP, i.e. spastic unilateral and bilateral CP (US-CP and BS-CP) functioning at