Research in Developmental Disabilities 38 (2015) 213–222

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Short-term motor learning of dynamic balance control in children with probable Developmental Coordination Disorder

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ARTICLE INFO

Article history:
Received 20 October 2014
Received in revised form 18 December 2014
Accepted 18 December 2014
Available online 6 January 2015

Keywords:
Dynamic balance
Motor learning
Developmental Coordination Disorder
Speed–accuracy trade off
Wii Fit

ABSTRACT

Purpose: To explore the differences in learning a dynamic balance task between children with and without probable Developmental Coordination Disorder (p-DCD) from different cultural backgrounds.
Participants: Twenty-eight Dutch children with DCD (p-DCD-NL), a similar group of 17 South African children (p-DCD-SA) and 21 Dutch typically developing children (TD-NL) participated in the study.
Methods: All children performed the Wii Fit protocol. The slope of the learning curve was used to estimate motor learning for each group. The protocol was repeated after six weeks. Level of motor skill was assessed with the Movement ABC-2.
Results: No significant difference in motor learning rate was found between p-DCD-NL and p-DCD-SA, but the learning rate of children with p-DCD was slower than the learning rate of TD children. Speed–accuracy trade off, as a way to improve performance by slowing down in the beginning was only seen in the TD children, indicating that TD children and p-DCD children used different strategies. Retention of the level of learned control of the game after six weeks was found in all three groups after six weeks. The learning slope was associated with the level of balance skill for all children. This study provides evidence that children with p-DCD have limitations in motor learning on a complex balance task. In addition, the data do not support the contention that learning in DCD differs depending on cultural background.

1. Introduction

Children with motor coordination problems, such as Developmental Coordination Disorder (DCD), frequently experience challenges in performing motor activities in which balance is required. Evidence suggests that the poor motor performance seen in these children may be partially explained by deficits in postural control (Geuze, 2005; Johnston, Burns, Brauer, & Richardson, 2002). Children with DCD also appear to learn differently compared to typically developing (TD) children,

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http://dx.doi.org/10.1016/j.ridd.2014.12.027
0891-4222/

which affects their acquisition of balance-related motor skills (American Psychiatric Association, 2013). In particular, these children seem to be delayed in reaching the level of automaticity (Visser, 2003). Consequently, children with DCD need more time, to reach an appropriate level of performance in motor tasks compared to their TD peers (Kirby, Sugden, & Edwards, 2010). There are, however, only a few studies that directly tested skill acquisition in children with DCD (Gheysen, Waelvelde, & Van Fias, 2011; Lejeune, Catale, Willems, & Meulemans, 2013; Marchiori, Wall, & Bedingfield, 1987); and of these only one multiple case study used a skill that required whole body postural control (Marchiori et al., 1987).

Postural control is a prerequisite for skilled motor performance. It is referred to as an active process of control of the body in static or dynamic situations. Postural control manifests in four ways: (i) awareness of the orientation of body segments in relation to the environment or task; (ii) controlling the center of mass within the base of support, also referred to as balance; (iii) preparing for a movement or action by anticipatory postural adjustments; (iv) reacting to an internal or external perturbation of posture also known as reactive postural adjustments (Dusing & Harbourne, 2010; Goldfield, 1995). Poor postural control, including inadequate dynamic balance strategies, delayed anticipatory and slow reactive postural adjustments are commonly seen among children with DCD (Geuze & Wilson, 2008; Johnston et al., 2002).

Studies investigating how children with DCD control the perturbations that arise during goal-directed movements (i.e. dynamic balance) have typically examined performance within tasks such as gait (Rosengren et al., 2009) and obstacle crossing (Deconinck, Savelsbergh, Clercq, & De Lenoir, 2010). Deconinck et al. (2006a) reported that children with DCD make adaptations to their gait pattern on a treadmill. Rosengren et al. (2009) reported more variability, complexity and asymmetry in the movement pattern of gait in children with DCD. However, dynamic balance seems specifically compromised when balance demands increase. Characteristic difficulties that show up are slowing down of gait with increase of the medio-lateral sway, both in the dark (Deconinck et al., 2006b) and during obstacle crossing (Deconinck et al., 2010). Children with DCD seem to rely more on sensory and visual information compared to their peers (Bair, Barela, Whitall, Jeka, & Clark, 2011; Cherng, Hsu, Chen, & Chen, 2007).

Adequate postural control is achieved by 'an active process that exploits the reactive forces from the environment by generating appropriate muscle activations' (p. 229, Geuze & Wilson, 2008). This active process of motor control includes the use of a combination of both feed-forward and feedback control strategies (Miall and Wolpert, 1996). Anticipatory postural adjustments (APAs) that accompany goal-directed active movements and are based on feed-forward motor control or internal forward modeling (Wing, Flanagan, & Richardson, 1997). Feed-forward motor control is defined as the ability to estimate the temporal and spatial requirements of a motor task and predict the sensory consequences of the impending action (Miall and Wolpert, 1996). If necessary, rapid online corrections (ROC) in real time can be used if the movement does not match the predicted outcome. The feedback system is reliant on adequate sensory information, error detection and integration (Scott, 2012) and if working well, it will drive reactive postural adjustments (RPAs). RPAs are usually rapid adjustments induced by external perturbations to help re-stabilize the body (Nashner, 1980; Shumway-Cook & Woollacott, 2007). RPAs are reliant on the ability to use sensory information (e.g. visual, tactile, and vestibular) to calculate an adjustment to disturbances.

Wilson, Ruddock, Smits-Engelsman, Polatajko, and Blanks (2013) conclude that children with DCD have a deficit in the forward modeling of movement, referred to as the internal modeling deficit (IMD). Specifically, predictions, based on efferent information and visual feedback, seem unreliable and ROCs are inadequate among children with DCD (Hyde & Wilson, 2011a, 2011b). Whether the postural control problems are caused by deficits in processing sensory information, lack of experience or deficits in motor learning is not known.

Although DCD is a disorder characterized by delayed acquisition of skilled motor actions or deficits in motor learning, remarkably little research focused on how children with DCD learn new motor skills. The few studies that have attempted to study questions relating to deficient or inefficient learning in children with DCD are inconsistent in outcome. For example, Missiuna (1994) examined the impact of explicit instruction on a simple aiming task using a Fitts paradigm (Fitts, 1954). Children were required to move a mouse pointer from a central point on the screen toward a target in response to a visual stimulus. Children with DCD were found to perform more poorly than their peers on measures of motor skill. Interestingly, groups did not differ in their rate of learning, or in the extent to which they were able to generalize the learned skills to other tasks. Lejeune et al. (2013) used adapted touch screen technology as a modification of the keyboard tasks used by Wilson, Maruff, & Lum (2003) and Gheysen et al. (2011). Children were required to respond as quickly and accurately as possible to stimuli appearing at different locations on a computer screen by pressing corresponding keys on the keyboard or the touch screen; participants were not told that the stream of stimuli corresponds to a repeating sequence. Learning of the sequence was demonstrated by improvement in the speed of response across trials and, more specifically, by the difference in response latency between a random block of stimuli and the repeating sequence block, indicating clearly that skill learning was sequence-specific. Their findings revealed no group differences, although Gheysen et al. (2011) found a lack of adaptation to a different sequence in children with DCD. In contrast, when training a more complex skill, Marchiori et al. (1987) found that after extensive training of two boys with poor motor skills on hockey slap shots for six weeks, the performance remained extremely variable in phasing and timing compared to the performance of two age matched boys. Thus, the question whether children with DCD have problems with motor learning remains a complex question, and the problems seem to depend on task and condition.

Based on the knowledge that the majority of children with DCD do experience balance problems, and the fact that no studies thus far have examined the rate at which children acquire balance skills, the aim of this study is to examine the rate of learning a dynamic balance task. Specifically, to examine the progress of learning of a dynamic balance task in typically