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Sensory organization of balance control in children with developmental coordination disorder

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ABSTRACT

This study aimed to (1) compare functional balance performance and sensory organization of postural control between children with and without developmental coordination disorder (DCD) and (2) determine the association between postural control and participation diversity among children with DCD. We recruited 81 children with DCD and 67 typically developing children. Balance was evaluated with the Sensory Organization Test (SOT) and the Movement Assessment Battery for Children-2 (Movement ABC-2). Participation patterns were evaluated using the Children Assessment of Participation and Enjoyment assessment. Analysis of variance was used to compare outcome variables between the two groups. A multiple regression analysis was performed to examine the relationship between participation diversity and balance performance in children with DCD. The DCD group had significantly lower Movement ABC-2 balance scores, SOT-derived equilibrium scores, and sensory ratios than the control group ($p < 0.05$). However, only the Movement ABC-2 balance score was significantly associated with participation diversity in children with DCD. After accounting for the effects of age and gender, Movement ABC-2 balance score remained significantly associated with participation diversity, explaining 10.9% of the variance ($F_{\text{change}1,77} = 9.494$, $p = 0.003$). Children with DCD demonstrate deficits in sensory organization of balance control. This suboptimal balance ability contributes to limited participation in activities.

1. Introduction

Developmental coordination disorder (DCD) is a relatively common motor disorder, affecting 6% of children (APA, 2000). Balance dysfunction is one of the most common sensorimotor impairments observed among children with DCD. Indeed, it has been reported that 73–87% of children with DCD have balance problems (Macnab, Miller, & Polatajko, 2001). The ability to maintain balance requires optimal reception, processing, and integration of sensory information from different systems (i.e., somatosensory, visual, and vestibular).

Several studies have investigated sensory contributions to postural control deficits in children with DCD, and results have been inconsistent (Cherng, Hsu, Chen, & Chen, 2007; Grove & Lazarus, 2007; Inder & Sullivan, 2005). Using the EquiTest Sensory Organization Test (SOT), Grove and Lazarus (2007) evaluated 16 children with DCD and 14 typically developing children and found that the ability to use vestibular feedback for postural control was impaired in children with DCD; somatosensory and visual inputs were therefore weighted more heavily for postural control. In contrast, Cherng et al. (2007) used the modified Clinical Test of Sensory Interaction and Balance (CTSIB) and found that sensory ratio scores, which indicate

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the ability to use information from the somatosensory, visual, and vestibular systems to maintain balance, were not significantly different between children with DCD ($n = 20$) and their typically developing peers ($n = 20$). These conflicting results may be due to small sample sizes and different testing instruments used across studies. To more accurately characterize the relationship between sensory organization and balance control in children with DCD, it is thus important to use standardized tools and evaluate larger samples.

The suboptimal balance performance demonstrated in children with DCD (Inder & Sullivan, 2005) needs to be addressed in both clinical practice and research, as any bodily impairments, including postural control, may limit activity participation, according to the International Classification of Functioning, Disability and Health model (Grove & Lazarus, 2007; WHO, 2001). Although many daily activities require good postural control (e.g., attending school and playing sports), few studies have explored the relationships among functional balance, sensory organization, and activity participation in children with DCD. Inder and Sullivan (2005) provided the first glimpse into the relationship between motor performance and participation in a sample of four children with DCD, and speculated that poor functional balance may influence activity participation patterns in these children. However, due to the small sample size, no conclusion about the relationship between balance performance and activity participation could be drawn.

The objectives of this study were to (1) compare the functional balance performance, sensory organization of standing balance control between children with DCD and their typically developing peers and (2) determine the relationships among different aspects of postural control with activity participation diversity among children with DCD.

2. Methods

2.1. Study design

This was a cross-sectional, exploratory study.

2.2. Participants

Sample size calculations were based on a statistical power of 0.80 and an alpha level of 0.05 (two-tailed). Grove and Lazarus (2007) previously reported SOT composite equilibrium scores of 63.9% (14.1%) and 72.4% (11.7%) for the DCD group ($n = 16$) and control group ($n = 14$) respectively, which translates into a medium to large effect size (0.66). Based on this study, the minimum sample size needed to detect a significant between-group difference in outcomes (objective 1) is 38 for each group (children with DCD and control) (Portney & Watkins, 2009). Regarding the regression analysis (objective 2), Jarus, Lourie-Gelberg, Engel-Yeger, and Bart (2011) reported that the Movement Assessment Battery for Children-2 (Movement ABC-2) percentile score had fair to good correlation with various activity participation scores ($r = 0.29$–0.64) among children with DCD. Therefore, with three predictors and an effect size of 0.20 (medium to large), a minimum sample size of 59 children with DCD would be required for multiple regression analysis (Portney & Watkins, 2009).

Participants with DCD were recruited from a local Child Assessment Centre and hospital by convenience sampling. Inclusion criteria were (1) formal diagnosis of DCD according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (APA, 2000); (2) age 6–12 years; (3) study in a regular education framework; and (4) no intellectual impairment. Exclusion criteria were (1) formal diagnosis of emotional, neurological, or other movement disorders or (2) significant musculoskeletal or cardiopulmonary conditions that may influence motor performance. For the control group, children with normal development were recruited from the community on a volunteer basis using the same inclusion and exclusion criteria stated above, except that they did not have any history of DCD.

2.3. Procedures

The study was approved by the human subjects ethics review subcommittee of the Hong Kong Polytechnic University and by the Hospital Authority. After explaining the study to each participant and their guardian, written informed consent was obtained. Data were collected by two experienced pediatric physiotherapists. All procedures were conducted in accordance with the Declaration of Helsinki.

2.3.1. Demographic information

Basic demographic information was obtained by interviewing the children and their guardians.

2.3.2. Sensory organization of balance control

The SOT, which has demonstrated good reliability and validity, was used to evaluate the sensory organization of balance control in our participants (Di Fabio & Foudriat, 1996; NeuroCom, 2008). During the test, participants stood with bare feet on the platform of the computerized dynamic posturography machine (Smart EquiTest® system, NeuroCom International Inc., OR, USA), wearing a security harness to prevent falls. They were instructed to stand quietly with arms resting on both sides of the trunk. Participants were exposed to six different combinations of visual and support surface conditions, in the order specified by the manufacturer's protocol (Table 1) (NeuroCom, 2008). Each participant was tested three times under each condition.