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Kinesthetic deficit in children with developmental coordination disorder

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ABSTRACT

The aim of this study was to measure and compare kinesthetic sensitivity in children with developmental coordination disorder (DCD) and typically developing (TD) children between 6 and 11 years old. 30 children with DCD aged 6 to 11 years (5 in each age group) and 30 TD children participated in the study. Participants placed their forearms on a passive motion apparatus which extended the elbow joint at constant velocities between 0.15 and 1.35° s^{-1}. Participants were required to concentrate on detection of passive arm motion and press a trigger held in their left hand once they sensed it. The detection time was measured for each trial. The DCD group was significantly less sensitive in detection of passive motion than TD children. Further analysis of individual age groups revealed that kinesthetic sensitivity was worse in DCD than TD children for age groups beyond six years of age. Our findings suggested that individual with DCD lag behind their TD counterparts in kinesthetic sensitivity. Between the ages of 7 and 11 years the difference between groups is quantifiable and significant with 11 year old children with DCD performing similar to 7 year old TD children.

1. Introduction

Developmental coordination disorder (DCD) is characterized by motor clumsiness in children and commonly affects academic achievement and activities of daily living (ADLs) (APA, 2013). The prevalence of DCD in school-aged children is about 5–6% (APA, 2013). At present, the clinical approach to treating individuals with DCD is not well developed due in large part to the lack of knowledge surrounding the etiology and underlying mechanism of the disorder.

Children diagnosed with DCD often have perceptual motor problems, such as poor cross-modal integration (Schoemaker et al., 2001), perceptual impairment (Smyth & Mason, 1998), poor postural control (Fong, Ng, & Yiu, 2013), and visualspatial deficits (Alloway, 2011). These clinical features have a potential impact on the activity level and social participation of children with DCD. These individuals often have difficulties in ADLs such as dressing and handwriting, and in physical education (Wang, Tseng, Wilson, & Hu, 2009). Furthermore, DCD can also lead to a problematic interaction of lack of practice, lack of motivation and low esteem (Zwicker, Harris, & Klassen, 2013).

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Kinesthesia has been reported as one of the possible perceptual factors related to motor incoordination (Coleman, Piek, & Livesey, 2001; Visser & Geuze, 2000). Here we define kinesthesia as the conscious awareness of body position and motion (Bosco & Poppele, 2001). Intact kinesthesia is important for postural control and efficient motor performance (Gentilucci & Negrotti, 1994; Gentilucci, Toni, Chieffi, & Pavesi, 1994; Sainburg, Ghilardi, Poizner, & Ghez, 1995; Sainburg, Poizner, & Ghez, 1993). The research pertaining to kinesthetic sensitivity for children with DCD is limited and inconsistent (Coleman et al., 2001; Elbasan, Kayhan, & Duzgun, 2012; Lord & Hulme, 1987; Piek & Coleman-Carman, 1995; Sigmundsson, Whiting, & Ingvaldsen, 1999; Smyth & Mason, 1998; Smyth, 1994). For example, Visser, Geuze, and Kalverboer (1998) found that clumsy adolescents had poor kinesthetic acuity which is speculated as one of the factors underlying the clumsiness; however, poor kinesthetic acuity was not found in other studies of children aged 5 to 12 (Piek & Coleman-Carman, 1995; Smyth & Mason, 1998).

Children with DCD experience difficulties in the performance of a multitude of motor skill and kinesthetic deficits may underlie these difficulties. We hypothesize that poor motor skills in school-aged children with DCD is related to a deficit in kinesthetic sensitivity. While considerable attention has been paid to kinesthetic sensitivity in clumsy children, the literature lacks an objective measurement of kinesthetic sensitivity in children with DCD.

Previous research has primarily relied on the kinesthetic sensitivity test (KST) (Laszlo & Bairstow, 1980) and the kinesthetic acuity test (KAT) (Livesey & Parkes, 1995) to examine kinesthesia in children with DCD (Bairstow & Laszlo, 1981; Coleman et al., 2001; Smyth & Mason, 1998; Visser & Geuze, 2000). The KST has been criticized for its accuracy and discriminative validity (Doyle, Elliott, & Connolly, 1986; Sims, Henderson, Hulme, & Morton, 1996a; Sims, Henderson, Morton, & Hulme, 1996b). The test items require cross-modal transformation and motor performance to measure kinesthetic acuity. Due to the short attention span of children, it is often difficult to assess kinesthesia in this population. For clinical evaluation, a useful kinesthetic testing tool should measure kinesthesia in isolation, uninfluenced by the other sense. In other words, a true index of kinesthetic sensitivity should avoid requiring motor response as this may confound the measure. In addition, the testing should be easy to understand for children and administered in a simple and standardized manner by practitioners (Pickett & Konczak, 2009). As there are no objective assessment tools in clinical use and no psychophysical data available on kinesthesia in individuals with DCD, the aim of this study is to compare kinesthetic sensitivity for typically developing children and children with DCD. We adopted and modified the apparatus and protocol which were successfully used with patients with Parkinson's disease (Konczak, Krawczewski, Tuite, & Maschke, 2007), and typically developing children (Pickett & Konczak, 2009). The results of the current study could provide more knowledge to further understanding the perceptual impairments in children with DCD and help to shape the manner in which these individuals are treated therapeutically.

2. Methods

2.1. Participants

30 Children with DCD aged 6 to 11 year (5 children in each age group) and 30 typically developing (TD) children participated in the study. Children with developmental coordination disorders (DCD) were recruited from Chang Gung Memorial Hospital and 6 rehabilitation clinics in Taipei. Healthy controls were recruited by posters on campus and through word of mouth. A certified and trained occupational therapist screened 60 children with MABC-2. Inclusion criteria for all participants were: (a) no reported history of arm injury that could lead to atypical kinesthesia; (b) ability to follow verbal commands; (c) no diagnosed attention deficits abnormalities; (d) right handedness as determined by the Edinburgh handedness inventory (Oldfield, 1971). In addition, all individuals in the DCD group had significant motor difficulties, with performance below the 15th percentile on the Movement Assessment Battery for Children-2nd edition (MABC-2) (Henderson & Sugden, 2007). These motor difficulties had a significant impact on their activities of daily living, as reported by their parents and evident on the Vineland adaptive behavior scale-2nd edition (VABS-2) (Sparrow, Cicchetti, & Balla, 2005). All individuals with DCD had an IQ score above 70 as determined by the Test of Nonverbal Intelligence-3rd edition (TONI-3) (Brown, Sherbenou, & Johnsen, 2010). Children with any neurological disorders (e.g., cerebral palsy, Down syndrome, or muscular dystrophy) and severe attention deficits as determine by the disruptive behavior screening scale (Hung, Chiu, Chang, Meng, & Tsai, 2001) were excluded. For children with DCD, the initial screening was done by doctors specialized in rehabilitation medicine. We then performed a chart review and disruptive behavior screening scale which was developed for Taiwanese individuals to rule out ADHD. For TD group, 30 TD children were free from any developmental delay or physiological impairment. All participants provided assent and written consent forms were signed by a parent. The study was approved by the Institutional Review Board of Chang Gung Memorial Hospital.

2.2. Instruments

A passive motion apparatus was used to measure kinesthetic acuity. An apparatus with similar specifications has previously been used in studies of individuals with Parkinson's disease (Konczak et al., 2007) as well as with typically developing children (Pickett & Konczak, 2009). The device consisted of a rectangular metal splint (60 × 9 cm) supported by a