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Baroreflex sensitivity is reduced in adolescents with probable developmental coordination disorder

Nicole S. Coverdale [a], Deborah D. O'Leary [a,*], Brent E. Faught [a], Daniele Chirico [a], John Hay [a], John Cairney [b]

[a] Department of Community Health Sciences, Brock University, 550 Glenridge Ave., St Catharines, ON, Canada L2S 3A1
[b] Departments of Family Medicine, Psychiatry, and Behavioural Neurosciences & Kinesiology, McMaster University, 1280 Main St W, Hamilton, ON, Canada L8S 4L8

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ABSTRACT

Developmental coordination disorder (DCD) is a neurodevelopmental condition characterized by poor motor skills leading to a significant impairment in activities of daily living. Compared to typically developing children, those with DCD are less fit and physically active, and have increased body fat. This is an important consequence as both sedentary lifestyle and obesity are risk factors for cardiovascular disease. One indicator of cardiovascular health is baroreflex sensitivity (BRS), which is a measure of short term blood pressure (BP) regulation and is partly accomplished through changes in heart rate. Diminished BRS is predictive of future cardiovascular morbidity and mortality. The purpose of this study was to compare BRS in typically developing (TD) adolescents with probable DCD (pDCD) or suspect pDCD (spDCD) adolescents (13–14 years of age). Percentile scores on the Movement Assessment Battery for Children, 2nd edition, assessed at two time points were averaged and used to classify participants into the following groups: pDCD $\leq$ 5th percentile, spDCD > 5th percentile and $\leq$16th percentile and TD > 16th percentile. Following 15 min of supine rest, 5 min of continuous beat-by-beat blood pressure (Finapres) and R–R interval were recorded (standard ECG). Spectral indices were computed using Fast Fourier Transform with transfer function analysis used to compute BRS in the low frequency region (0.04–0.15 Hz). BRS was compared between groups with an ANOVA and post hoc Bonferroni correction. BRS was reduced in the pDCD compared to the TD groups. In multivariate regression analyses predicting BRS, when pDCD and spDCD were entered as the only variables, pDCD was found to be a significant predictor of BRS ($b = -6.74$, $p = 0.016$). However, when sex, VO_2 peak, and percent body fat (PBF) were entered as covariates, pDCD was no longer a predictor, while PBF approached significance (-0.32, $p = 0.056$). Therefore, in this sample, BRS was reduced in adolescents with pDCD principally due to increased PBF.

1. Introduction

Developmental coordination disorder (DCD) is a neuro-developmental condition characterized by deficits in fine and/or gross motor coordination (American Psychiatric Association, 2000). To establish a diagnosis of DCD, these motor coordination difficulties must significantly interfere with activities of daily living or academic achievement in the absence of a pre-existing medical or neurological condition (American Psychiatric Association, 2000). Prevalence estimates vary between 1.8% and 5% based on how stringently the diagnostic criteria are applied (Lingam, Hunt, Golding, Jongmans, & Emond, 2009).

* Corresponding author. Tel.: +1 905 688 5550x4339; fax: +1 905 688 8954.
E-mail address: doleary@brocku.ca (D.D. O'Leary).

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Motor coordination difficulties may affect many aspects of a child's life including their participation in both free and organized play (Cairney et al., 2005). For example, when children with movement difficulties were observed during school recess periods, these children participated less in vigorous activity than their peers without movement difficulties (Bouffard, Watkinson, Thompson, Causgrove Dunn, & Romanow, 1996). Similar findings using accelerometry data for children aged 12–13 years have demonstrated that children with probable DCD (pDCD) are less active than their typically developing peers (Silman, Cairney, Hay, Klentrou, & Faught, 2011). As well, a longitudinal investigation examining data collected at five time points over 30 months, showed that children with pDCD consistently participated in less free and organized play over that time span (Cairney, Hay, Veldhuizen, Missiuna, & Faught, 2010).

In addition to decreased participation in physical activity, children with DCD also have lower levels of fitness and increased fat mass compared to typically developing peers. Fitness levels have been examined using field tests such as the Leger 20-m shuttle run and with laboratory measures to establish peak aerobic power (VO_2 peak). Using either methodology, levels of fitness are consistently lower in children with pDCD than their typically developing peers (Faught, Hay, Cairney, & Flouris, 2005; Silman et al., 2011; Wu, Lin, Li, Tsai, & Cairney, 2010). Additionally, using whole body air-displacement plethysmography to evaluate body composition children with pDCD display increased fat mass, but similar lean mass to that of typically developing peers (Cairney, Hay, Veldhuizen, & Faught, 2011).

The findings that children with DCD participate less in physical activity, have reduced fitness levels, and increased fat mass are concerning, as these are all risk factors for cardiovascular disease. For example, childhood obesity tracks into adulthood and is associated with an increase in arterial stiffness (Raitakari, Juonala, & Viikari, 2005), which is a surrogate marker of atherosclerosis. In addition, both decreased fitness and physical activity levels are associated with cardiovascular risk factors such as blood pressure (BP), fasting glucose levels, and cholesterol levels in children (Ekelund et al., 2007) and with all-cause mortality and heart attack risk in adults (Blair et al., 1989; Lakka et al., 1994). Therefore, it is necessary to more closely examine the cardiovascular health of children with DCD.

The autonomic nervous system (ANS) is an important regulator of BP and heart rate. The ANS is composed of parasympathetic and sympathetic branches that act antagonistically to regulate BP around a set point (Berne & Levy, 1997). When BP changes, arterial baroreceptors, located in the carotid sinus and aortic arch, are triggered and in turn send a neural signal to the brain stem where parasympathetic and/or sympathetic activity is altered. Parasympathetic nervous system activation decreases heart rate, while sympathetic activation increases heart rate and peripheral vasoconstriction (Berne & Levy, 1997). For example, when BP increases, baroreceptors trigger parasympathetic activation, along with sympathetic deactivation, resulting in a decrease in BP.

One way to evaluate autonomic function is to measure heart rate variability (HRV). In healthy individuals, heart rate or R–R interval (RRI) varies within a specific range of frequencies typically grouped in terms of high frequency (HF: 0.15–0.40 Hz) and low frequency (LF: 0.04–0.15 Hz) (Berntson et al., 1997). High frequency fluctuations represent parasympathetic activity, while LF fluctuations represent a combination of sympathetic and parasympathetic activity (Berntson et al., 1997). Additionally, the ratio of LF to HF (LF/HF) is often used as a measure of sympathovagal balance (Berntson et al., 1997). Decreased total HRV and HF power and increased LF power are associated with cardiovascular morbidity and mortality (Guzzetti et al., 1988; Hayano et al., 1991; Tsuji et al., 1994). In addition, baroreflex sensitivity (BRS; ms/mm Hg), defined as the change in RRI for a change in BP, is another measure of autonomic regulation. In fact, decreased BRS has been found to be indicative of cardiovascular morbidity and mortality (La Rovere, Bigger, Marcus, Mortara, & Schwartz, 1998; Mortara et al., 1997).

It is fairly well established that BRS is reduced with obesity in adults and adolescents (Beske, Alvarez, Ballard, & Davy, 2002; Lazarova et al., 2009; Skrapari et al., 2007). As well, the age-associated decline in BRS can be attenuated with aerobic exercise (Monahan et al., 2000), while elderly people with higher levels of fitness have higher BRS than sedentary elderly adults (Shi et al., 2008). The impact of fitness and/or physical activity on BRS in children and adolescents has received little research attention. However, Gutin et al. (2005) found that higher levels of fitness and amount of moderate-vigorous physical activity were associated with parasympathetic modulation as measured with HRV. The purpose of this study was to examine BRS in adolescents with pDCD. It was hypothesized that adolescents with pDCD would display lower BRS compared to typically developing peers as a result of lower fitness levels and a higher percentage of body fat.

2. Methods

2.1. Sample

The sample for this study was drawn from a population-based study that examined motor coordination and physical health known as PHAST (Physical Health and Activity Study Team), the details of which have been described in detail elsewhere (Cairney, Hay, Veldhuizen, & Faught, 2010; Cairney, Hay, Veldhuizen, Missiuna, et al., 2010). Initially, all adolescents who scored below the 10th percentile on the Bruininks–Oseretsky test of motor proficiency short form during school testing were contacted and 63 agreed to take part in the study. Following this, 63 adolescents who scored at or above the 10th percentile were matched to those already recruited for age, sex, and school location (total $n = 126$). This study uses data from the second year of lab-based testing. After the first year of testing, 21 participants declined the invitation to participate in the study for a second year, resulting in a sample size of 105. The Brock University research ethics board and