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Longitudinal assessment of left ventricular structure and function in adolescents with developmental coordination disorder

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ABSTRACT

Children with developmental coordination disorder (DCD) are more likely to develop cardiovascular disease (CVD) risk factors such as obesity and reduced cardio-respiratory fitness. It has also been shown that adolescents with probable DCD (p-DCD) have elevated cardiac output (CO) and stroke volume (SV) compared to typically developing (TD) controls, which in turn may heighten their risk of developing elevated left ventricle mass (LVM) or left ventricular hypertrophy (LVH). The purpose of this study was to assess left ventricular structure and function longitudinally in adolescents with and without p-DCD. This three year study included 86 adolescents with significant motor impairment (33) and TD controls (53). Adolescents were 12 years old at the beginning of the study. The Movement ABC test (M-ABC-2) was used to classify children as p-DCD. Cardiac dimensions were measured using ultrasound echocardiography. Body mass, fat mass (FM) and body mass index (BMI) were significantly elevated in the p-DCD group in all three years. Peak aerobic fitness normalized to fat-free mass (peak VO_{2FFM}) was significantly elevated in the TD controls in each year. Heart rate was also increased in the p-DCD group in years one and three. A repeated measures ANCOVA with time-varying covariates was performed for CO and LVM on p-DCD while controlling for peak VO_2 and FFM. CO and LVM were significantly elevated in the p-DCD which remained constant over time. FM completely mediated the association between p-DCD and CO in adolescents. For LVM, both FM and CO accounted for elevated LVM in adolescents with p-DCD. In conclusion, elevated FM in adolescents with p-DCD contributes to a higher CO and LVM over time compared to TD controls. If this persists throughout adolescents and into adulthood, these adolescents may be at risk of developing LVH.

1. Introduction

Developmental coordination disorder (DCD) is a neuro-developmental disorder characterized by significant impairment in fine and/or gross motor coordination. Motor coordination in children with DCD is well below that expected for age and intelligence, resulting in significant functional impairment associated in social and academic domains (American Psychiatric

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Association, 2000). Studies have shown that the prevalence of DCD in school children ranges between 1.7 and 6%, depending on the application of diagnostic criteria (American Psychiatric Association, 2000; Lingam, Hunt, Golding, Jongmans, & Emond, 2009).

In recent years, significant attention has been directed to the reduced levels of physical activity in children with DCD (Baerg et al., 2011), and the associated health risks that follow (Faught, Hay, Cairney, & Flouris, 2005). Studies have shown that children with DCD participate less in both free play and organized activities, compared to their typically developing (TD) peers (Cairney, Hay, Faught, Wade, et al., 2005; Cairney, Hay, Wade, Faught, & Flouris, 2007). Furthermore, it has been shown that this activity deficit remains constant over time and persists into adolescence (Cairney, Hay, Veldhuizen, & Faught, 2010). Studies have also assessed health related physical fitness and consistently demonstrated poorer muscle strength, flexibility, aerobic fitness, and body mass index (BMI) in children with the condition (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008; Li, Wu, Cairney, & Hsieh, 2011; Schott, Alof, Hultsch, & Meermann, 2007). In fact, several field and lab-based studies have found that children with DCD have lower levels of aerobic fitness and greater prevalence of overweight and obesity than TD peers (Cairney, Hay, Faught, Flouris, & Klentrou, 2007; Silman, Cairney, Hay, Klentrou, & Faught, 2011; Wu, Lin, Li, Tsai, & Cairney, 2009). These findings are concerning considering the detrimental effects obesity and reduced aerobic fitness can have on cardiovascular health in children and adolescents (Ekblom-Bak, Hellenius, Ekblom, Engstrom, & Ekblom, 2009). Indeed, it has been shown that children with DCD are at an increased risk of developing cardiovascular disease risk factors (Faught et al., 2005).

Despite the previously mentioned findings, there remains limited research assessing cardiovascular health in children with DCD. One study assessed health indices in children, adolescents, and adults with low motor competence compared to those with high motor competence (Cantell, Crawford, & Tish Doyle-Baker, 2008). Those with low motor competence had lower HDL and higher triglyceride levels. Additionally, measures of body composition (DEXA scan), indicated that adults with low motor competence had a higher percentage of trunk fat compared to those with high motor competence (Cantell et al., 2008). A more recent study by Wahi et al. (2011) expands these findings by demonstrating that although children with probable DCD (p-DCD) do not demonstrate a significantly greater prevalence of metabolic syndrome, they do demonstrate significantly elevated components of metabolic syndrome. The increased prevalence of obesity, elevated triglycerides, and higher blood pressure (BP) in children with p-DCD may put them at risk of meeting the criteria of metabolic syndrome in the future (Wahi et al., 2011).

Examining left ventricular structure and function has and continues to be an important marker of cardiovascular risk in both children and adults (Gosse, 2005; McNiece et al., 2007). Left ventricular hypertrophy (LVH) is an adaptation which develops in response to a chronic increase in work load imposed on the heart (Grant, Greene, & Bunnell, 1965; Grossman, Jones, & McLaurin, 1975). When the heart faces a hemodynamic burden such as elevated BP or obesity, there is an increased workload and resultant increase in wall stress placed on the left ventricle (Grossman et al., 1975). In an attempt to normalize ventricular wall stress, there is an increase in left ventricular muscle mass (LVM) to bear the extra workload (Grossman et al., 1975). When this increase in LVM exceeds normal physiological limits, it is referred to as LVH. LVH is a strong, independent predictor of cardiovascular morbidity and mortality in adults (Levy, Garrison, Savage, Kannel, & Castelli, 1990).

We previously examined left ventricular structure and function in adolescents with p-DCD using non-invasive ultrasound echocardiography (Chirico et al., 2011). Altered ventricular structure, as evinced by increased ventricular diameter at end-diastole, and heightened pump function as evidence by elevated stroke volume (SV) and cardiac output (CO) were found in adolescents with p-DCD. These alterations in ventricular structure and function may increase the stress and work load placed on the heart (Grossman et al., 1975), which can lead to elevated LVM or even LVH in the future. Therefore, it is important to assess the long-term risk of LVH in adolescents with p-DCD. The purpose of this study was twofold: (1) to investigate whether adolescents with p-DCD demonstrated elevated LVM and CO over a three year time period, and (2) to determine factors most strongly associated with elevated LVM and CO in adolescents with p-DCD.

2. Method

2.1. Participants

The study sample was drawn from a larger, population-based study making use of data collected from the PHAST (Physical Activity Health Study Team) study. The design of this study has been described in detail elsewhere (Cairney, Hay, Veldhuizen, Missiuna, et al., 2010). This study was approved by the Brock University Research Ethics Board and the District School Board of Niagara. There were 198 students identified with p-DCD using the Bruininks–Oseretsky Test of Motor Proficiency-Short Form (BOTMP-SF) who scored below the 10th percentile during school testing. These students were then invited by telephone to participate in annual lab-based assessments for three consecutive years. All participants tested in the lab were administered the Movement Assessment Battery for Children-2 (M-ABC2) to verify clinically significant motor coordination difficulties. A total of 63 cases (37 M and 26 F) agreed to participate in the study. Healthy control subjects (63) were selected randomly from consenting students who scored above the 10th percentile on the BOTMP-SF and were matched for sex, school, and age within 6 months. The final study sample consisted of participants who completed all three years of lab testing. Motor coordination was assessed each year for three years on every child who remained in the study. In order to optimize accuracy and consistency in diagnosing p-DCD, M-ABC2 scores were averaged over three years for each