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Assessment of cardiorespiratory and neuromotor fitness in children with developmental coordination disorder

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ABSTRACT

The decreased participation in physical activity by children with probable developmental coordination disorder (pDCD) has raised concerns about their aerobic fitness and lung function levels. The purpose of the present study was to examine assessment of cardiorespiratory and neuromotor fitness, using laboratory-based tests during an incremental treadmill protocol in healthy children with and without pDCD. Twenty sex children ages 6–9 years took part in this study. Motor coordination was assessed using the Movement Assessment Battery for Children (MABC). All participants performed a cardiopulmonary exercise test (CPET) on a cycle ergometer. Pulmonary function was assessed by spirometric measurements (forced vital capacity: FVC, forced expiratory volume in 1 s: FEV_1) and walking distance (6MWD) was assessed using the 6-min walking test. The children with pDCD had lower $VO_{2\ max}$ than children without pDCD ($p < 0.01$). Moreover, FVC and FEV_1 were significantly higher in children without pDCD than in children with the disorder ($p < 0.05$, $p < 0.01$ respectively). Likewise, children with pDCD had poorer performance on the 6MWD than children without pDCD ($p < 0.01$). A significant correlation between the absolute value for FEV_1 and 6MWD ($r = 0.637$, $p < 0.05$) in pDCD group was observed. We found a significant correlation between $VO_{2\ max}$ and MABC score ($r = -0.612$, $p < .001$) and between $VO_{2\ max}$ and 6MWD ($r = 0.502$, $p < .001$) for all children. Moreover, a significant correlation between $VO_{2\ max}$ and FEV_1 ($r = 0.668$, $p < .05$) was found in children with pDCD. Overall, the reduced aerobic capacity of DCD was associated with decreased of lung function, as well as an alteration of peripheral muscle responses.

1. Introduction

The diagnosis of developmental coordination disorder (DCD) is based on performance level of movement skills substantially below that expected for a child's chronological age and measured intelligence (American Psychiatric Association, 1994). The decreased participation in physical activity by children with DCD has raised concerns regarding their

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aerobic fitness levels. In fact, children with DCD are frequently found to have lower fitness levels when compared to their typically developing peers (Cairney, Hay, Faught, Flouris, & Klentrou, 2007; Haga, 2007).

Children with DCD experience difficulty performing a variety of motor tasks, which significantly effects their involvement in activities of daily living as walking, running, climbing and jumping (Wu, Lin, & Li, 2010). As a result of their coordination difficulties, many children with DCD are less physically active (Bouffard, Watkinson, Thompson, Causgrove Dunn, & Romanow, 1996; Cairney et al., 2005), and much more likely to be sedentary than children without DCD (Cairney, Hay, Veldhuizen, & Faught, 2011). Previously, it has been reported that children with DCD may, in addition to their motor problems, develop lower levels of health-related physical fitness (Rivilis et al., 2011). However, much of this research examined differences between children with low motor coordination and typically developing children in non-clinical settings. To date, the level of physical fitness for children who are clinically diagnosed with DCD and referred to treatment is unclear, even though DCD can cause decreased participation in physical activity and below average performance on different components of physical fitness (Haga, 2009). One particular component of poor fitness strongly correlated with health is aerobic power, which is consistently found to be lower in children with DCD (Cairney et al., 2011; Wu et al., 2010).

The gold standard for assessing cardiopulmonary fitness is maximal oxygen uptake ($VO_{2\ max}$) measured during cardiopulmonary exercise test (CPET) until exhaustion according to standardized protocols (Chia, Guelfi, & Licari, 2009). The CPET can be performed in field or in laboratory-based settings. Recent research has shown that estimates of peakVO_2 obtained in both settings show that children with DCD have significantly lower aerobic fitness than typically developing children regardless of the test used (Cairney, Hay, Veldhuizen, & Faught, 2010).

DCD has been identified as a chronic health condition, which is associated with a decrease in cardiopulmonary function, as well as an alteration of peripheral muscle responses (Van der Hoek et al., 2012). Therefore, sub-maximal exercise testing may provide a safe, practical means of evaluating functional status, monitoring treatment effectiveness and establishing prognosis. Recently, the development of field tests, such as walking tests, can be used to measure the functional exercise capacities of healthy or unfit subjects. The 6-min walking test (6MWT) has emerged as a common sub-maximal test in clinical settings, and recent normative data have extended its application (Li et al., 2005). The 6MWT has shown good validity and reliability, and is considered to be a clinically relevant test because it closely resembles common physical activities of daily living (walking), and cab be used to estimate cardiopulmonary fitness in healthy children (Lesser et al., 2010) and in children with various diseases (Solway, Brooks, Lacasse, & Thomas, 2001). The 6MWT may be a particularly useful sub-maximal test for children with DCD because the motor coordination demands of the test are minimal. Children with DCD, especially those with balance problems, may find treadmill running difficult. Pedaling (cycle ergometer) and line contact pivots on shuttle run tests may also be difficult for children with DCD. Compared to these other tasks, walking may be easier for children with motor coordination difficulties.

Previous studies have shown that lung function is directly related to cardiopulmonary fitness (Eisenmann et al., 1999). For example, Jakes et al. (2002) showed that adults without regular physical activities had generally poorer lung function. Like sub-maximal testing, assessing lung function in children with DCD might provide a safe and efficient means of assessing aerobic fitness. Interestingly, only one study has examined indices of lung function and $VO_{2\ max}$ in children with DCD (Wu, Cairney, Lin, Li, & Song, 2011).

To the best of our knowledge, the possibility of a relationship between 6MWT, FVC, FEV_1 and $VO_{2\ max}$ has never been verified. Therefore, the purpose of the present study was to examine, through a cross-sectional study, cardiorespiratory and neuromotor fitness using laboratory-based tests during an incremental treadmill protocol in children with and without DCD.

2. Materials and methods

2.1. Participants

The study has been approved by the Ethical local Committee of the University Hospital of Sfax. To recruit participants for the lab-based component of the current study, we received permission from 3 of 5 primary schools (60%) from a middle-class region in Tunisia; After being screened with the Movement ABC test (Henderson & Sugden, 1992), children were categorized into one of two groups: DCD (17 boys and 4 girls) and Without DCD (21 boys and 7 girls). All children with DCD were asked to participate in the laboratory test. Four children (2 boys and 2 girls) were excluded because they have intellectual impairment. In addition, four children (2 boys and 2 girls) did not attend the assessment session. However, thirteen boys without DCD ranging between 6 and 9 years were randomly selected from 28 children. Finally, 26 boys (13 DCD and 13 without DCD) attended laboratory test to assess their maximal cardiopulmonary function.

Prior to testing, the protocol was explained in detail to the subjects and their parents. After this, all subjects signed a written informed consent in accordance with the principals outlined in the Declaration of Helsinki in 1975. The subjects were examined by a physician to ensure their health was sufficient to participate in testing and to rule out the presence of chronic diseases. Children were assigned to the DCD group if they had difficulties with daily living skills as assessed using parent questionnaires and clinical interviews. Inclusion criteria included no intellectual impairment; no diagnosed emotional, neurological, or motor disorder, and no intervention during the past 3 months that affected leisure participation patterns. Children were excluded if a history of learning difficulties or any behavioral or orthopedics problems were reported. Because the pulmonary function test was conducted in this study, children with any cardio-respiratory diseases (cystic fibrosis, asthma) or acute respiratory infection prior to 1 month of data collection were also excluded. As controls,