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Subtyping children with developmental coordination disorder based on physical fitness outcomes

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ABSTRACT

Purpose: Children with Developmental Coordination Disorder (DCD) are known to have poor physical fitness. However, differentiating homogenous subgroups of DCD using fitness performance has not yet been established. Therefore the purpose of this study was to identify subtypes in children with and without DCD using measures of physical fitness.
Method: Children (aged 6–10 years, n = 217) constituted the sample for this study. They were assessed on 1) aerobic fitness (20m Shuttle Run test), 2) anaerobic fitness (Muscle Power Sprint Test), 3) isometric muscle strength (handheld dynamometry) 4) functional upper and lower body strength (Functional Strength Measurement) and 5) motor coordination [Movement Assessment Battery for Children-2nd edition (MABC-2) test]. The Ward method was used to identify the various clusters.
Results: Five subtypes emerged in the entire sample. In the typically developing (TD) children mainly 2 subtypes (number 5 and 2) were found containing 89% of the TD children (n = 55), with the largest group demonstrating above average performance on all measures (cluster 5). Children in subtype 2 had just above average motor coordination and good aerobic fitness but lower muscle strength. Subtypes 1, 3 and 4 were clearly "DCD" clusters, however they showed difference in fitness performance. Subtype 1 contained children with DCD who showed poor performance on all fitness outcomes (n = 45). Children with DCD in subtype 3 had poor aerobic but average strength and anaerobic fitness (n = 48). Subtype 4 contained children with DCD (n = 45) who had good muscle strength and anaerobic fitness. Of these, 36% were at risk of DCD while 24% had definite motor coordination problems.
Conclusion: Our findings indicate that children with and without DCD demonstrate heterogeneous physical fitness profiles. The majority of the children (66%) with DCD belonged to subtypes with lower fitness performance. Further studies are needed to confirm these findings in other samples of DCD children.

1. Introduction

Developmental coordination Disorder (DCD) is a complex childhood disability that is common in school-aged children worldwide

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(Lingam, Hunt, Golding, Jongmans, & Emond, 2009; Pieters, Roeyers, Rosseel, Van Waelvelde, & Desoete, 2015; Wright, Sugden, Ng, & Tan, 1994). DCD is primarily characterized by motor coordination impairments, which negatively impact the child's routine activities and academic performance, and is unexplained by a medical condition (American Psychiatric Association, 2013). Children with DCD are often slower than their typically developing (TD) peers when performing everyday tasks such as writing, running, and shoe lacing. Apart from the motor coordination impairments, children with DCD are known to experience secondary symptoms. These include lower cardiorespiratory fitness (Cairney, Hay, Veldhuizen, & Faught, 2010; Cairney, Veldhuizen, King-Dowling, Faught, & Hay, 2017), lower muscle strength (Ferguson, Jelsma, Jelsma, & Smits-Engelsman, 2013; Smits-Engelsman, Jelsma, & Ferguson, 2016), and increased risk for obesity and coronary vascular disease (Chirico et al., 2011; Philips et al., 2016). Given that physical fitness is an important attribute for healthy living and participation, previous research focused on assessment and tracking of physical fitness of children with DCD (Cairney, Hay, Faught, Flouris, & Klentrou, 2007; Cairney et al., 2010, 2017; Farhat et al., 2014, 2015; Ferguson, Aertssen, Rameckers, Jelsma, & Smits-Engelsman, 2014; Aertssen, Ferguson, & Smits-Engelsman, 2016). Though much progress has been made on the measurement of physical fitness in DCD research, current understanding of fitness performance among children with DCD is still limited. Differentiating subgroups of DCD on the basis of physical fitness would extend the current body of knowledge. Physical fitness subtypes of DCD may create awareness of the need for considering physical fitness as important outcome in school health services.

To effectively address the physical deficits exhibited by children with DCD, it is useful to categorize them into distinct subgroups based on similar characteristics. This may aid the development of interventions tailored at the specific needs of each subgroup. In the light of this, previous research identified subtypes of DCD using psychomotor and clinical characteristics (Asonitou & Koutsouki, 2016; Farmer, Echenne, & Bentourkia, 2016; Green, Chambers, & Sugden, 2008; Hoare, 1994; Lalanne, Falissard, Golse, & Vaivre-Douret, 2012; Macnab, Miller, & Polatajko, 2001; Miyahara, 1994; Pieters et al., 2015; Vaivre-Douret et al., 2011; Visser, 2003). Though these studies differ in many ways (sample size, assessment procedures, instrumentation, number of subgroups, and statistical methods), they all support the presence of subtypes or the idea of heterogeneity among children with DCD, with most studies agreeing to the existence of a subtype with generalized sensori-motor problems (Hoare, 1994; Macnab et al., 2001; Miyahara, 1994; Visser, 2003). Most subtype studies have used small samples ($n < 100$) with only a few reporting relatively large sample sizes. In addition, the majority of studies described different subtypes based on the perceptuo-motor skills, cognitive variables and/or neurological examination findings. Researchers have indicated that more studies are needed to validate previously defined subtypes (Macnab et al., 2001). Until now, no study has differentiated subtypes of DCD using measures of physical fitness, although poor physical fitness is a major problem in this population. This may impact health practice, as practitioners working with children with DCD could better match children (those with low fitness performance) with the most appropriate therapy.

Cluster analysis is a common technique for subtyping cases and has been shown to be a useful statistical approach in DCD research (Macnab et al., 2001; Pieters et al., 2015). In cluster analysis, a set of measurements is performed, and subjects are grouped based on performance scores. This is a reliable method that attempts to find relatively homogeneous groups of children with similar characteristics (Hoare, 1994). A major limitation of cluster analysis relates to the selection of variables. Also, cluster analysis tends to produce clusters depending on the variables used as inputs. For instance, if a particular factor believed to be an important distinguishing variable between subgroups were omitted from the set of input variables, then that cluster would not emerge. Because of this, it has been suggested that careful consideration be given to the choice of outcomes prior to this type of analysis (Macnab et al., 2001).

Existing subtypes of DCD were derived from assessments of motor ability using tests of motor performance including the Movement Assessment Battery for Children test (MABC) (Wright et al., 1994), Bruininks-Oseretsky test of motor performance (BOTMP) (Green et al., 2008), and McCarron assessment of neuromuscular development (MAND) (Hoare, 1994). Other studies included aspects related to functional performance (e.g. 50 m dash) to assess running speed (Hoare, 1994), or the BOTMP running speed and agility test (Macnab et al., 2001) and clinical neurological examinations (Vaivre-Douret et al., 2011). These studies have provided more insights about the heterogeneous nature of DCD. Currently, subtype studies have documented the existence of about three to six clusters of DCD emerging from different combination of variables (Asonitou & Koutsouki, 2016; Dewey & Kaplan, 1994; Hoare, 1994; Macnab et al., 2001; Miyahara, 1994; Pieters et al., 2015).

Subtype studies are useful to examine differences within a group. While numerous previous studies have taken into account aspects of perception, motor performance, balance and muscle tone, fewer studies has differentiated subtypes of DCD using physical fitness parameters (Zhu et al., 2014). To better prevent adverse complications of poor fitness and to promote individualized fitness training, physical fitness profiling of children with DCD is necessary. Identification of subtypes based on measures of physical fitness would aid the development of interventions to address functional problems and to improve health outcomes in this population. Therefore, the purpose of this study was to identify subtypes of children with DCD using fitness profiles of children with and without DCD. We assessed several fitness outcomes including cardiorespiratory fitness, muscle strength and anaerobic capacity.

2. Methods

2.1. Study design and setting

This study was cross-sectional in nature and involved children with and without DCD, attending three mainstream elementary schools in low-income areas of Cape Town, South Africa. Resource constraints and unsafe playgrounds restricted implementation of physical education in these schools. Similarly, due to lack of sports facilities in these communities, children had limited access to opportunities for physical activity and/or sports.