Research in Developmental Disabilities 35 (2014) 1087–1097

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Physical fitness in children with Developmental Coordination Disorder: Measurement matters

Gillian D. Ferguson [a,b,*], Wendy F.M. Aertssen [c], Eugene A.A. Rameckers [c,d], Jennifer Jelsma [a], Bouwien C.M. Smits-Engelsman [b]

[a] *University of Cape Town, Faculty of Health Sciences, Department of Health and Rehabilitation Sciences, Suite F45: Old Main Building, Groote Schuur Hospital, Main Road, Observatory 7925, Cape Town 8000, South Africa*
[b] *Katholieke Universiteit Leuven, Faculty of Kinesiology and Rehabilitation Sciences, Department of Kinesiology, Movement Control and Neuroplasticity Research Group, Tervuursevest 101, Postbox 1501, B-3001 Heverlee, Belgium*
[c] *Avans + University of Professionals, Department of Physiotherapy, Heerbaan 14-40, Postbox 2087, 4800 CB Breda, The Netherlands*
[d] *Maastricht University Medical Centre, Department of Rehabilitation Medicine & Adelante Center of Expertise in Rehabilitation & Audiology, P.O. Box 616, 6200 MD Maastricht, The Netherlands*

ARTICLE INFO

Article history:
Received 13 December 2013
Received in revised form 29 January 2014
Accepted 29 January 2014
Available online 26 February 2014

Keywords:
Physical fitness
Strength
Anaerobic muscle capacity
Muscle power
Aerobic capacity
Developmental Coordination Disorder
South Africa

ABSTRACT

Children with Developmental Coordination Disorder (DCD) experience considerable difficulties coordinating and controlling their body movements during functional motor tasks. Thus, it is not surprising that children with DCD do not perform well on tests of physical fitness. The aim of this study was to determine whether deficits in motor coordination influence the ability of children with DCD to perform adequately on physical fitness tests. A case–control study design was used to compare the performance of children with DCD ($n = 70$, 36 boys, mean age = 8y 1mo) and Typically Developing (TD) children ($n = 70$, 35 boys, mean age = 7y 9mo) on measures of isometric strength (hand-held dynamometry), functional strength, i.e. explosive power and muscular endurance (Functional Strength Measurement), aerobic capacity (20 m Shuttle Run Test) and anaerobic muscle capacity, i.e. muscle power (Muscle Power Sprint Test). Results show that children with DCD were able to generate similar isometric forces compared to TD children in isometric break tests, but were significantly weaker in three-point grip strength. Performance on functional strength items requiring more isolated explosive movement of the upper extremities, showed no significant difference between groups while items requiring muscle endurance (repetitions in 30 s) and items requiring whole body explosive movement were all significantly different. Aerobic capacity was lower for children with DCD whereas anaerobic performance during the sprint test was not. Our findings suggest that poor physical fitness performance in children with DCD may be partly due to poor timing and coordination of repetitive movements.

1. Introduction

The American College of Sports Medicine (ACSM) defines physical fitness as a set of measurable health and skill-related attributes that include body composition, cardiorespiratory fitness (CRF), muscular fitness, flexibility, and neuromotor

* Corresponding author at: University of Cape Town, Department of Health and Rehabilitation Sciences, Suite F45: Old Main Building, Groote Schuur Hospital, Main Road, Observatory 7925, Cape Town 8000, South Africa. Tel.: +27 21 406 6045; mobile: +27 82 9743924.
E-mail addresses: gillian.ferguson@uct.ac.za (G.D. Ferguson), wendyverhoef@live.nl (Wendy F.M. Aertssen), eaa.rameckers@hetnet.nl (Eugene A.A. Rameckers), jennifer.jelsma@uct.ac.za (J. Jelsma), bouwiensmits@hotmail.com (Bouwien C.M. Smits-Engelsman).

http://dx.doi.org/10.1016/j.ridd.2014.01.031
0891-4222/

fitness (Garber et al., 2011). In the last decade, physical fitness in children with Developmental Coordination Disorder (DCD) has gained recognition as an important factor influencing performance in daily activities and as a mediator of health and wellbeing (Wahi et al., 2011). Children with DCD are reported to have reduced levels of physical fitness (Nascimento et al., 2013; Rivilis et al., 2011; van der Hoek et al., 2012) and are considered to be at increased risk for cardiovascular problems later in life (Cairney, Hay, Veldhuizen, & Faught, 2011).

Studies examining body composition report that children with DCD have higher body mass indices (BMI) (Rivilis et al., 2011), higher body fat percentage (Cairney, Hay, Faught, & Hawes, 2005) and increased waist circumference (Cairney, Hay, Veldhuizen, Missiuna, et al., 2010; Wahi et al., 2011) compared to their Typically Developing (TD) peers. Regular participation in moderate to vigorous physical activity has therefore been recommended to reduce the risk of children developing cardiovascular conditions later in life (Lipnowski & Leblanc, 2012). However, participation in physical activity is often hampered by the limited motor performance capacity of children with DCD (Fong et al., 2011; Haga, 2009).

Decreased CRF in DCD has been reported in several studies in which aerobic capacity was measured using field-based running tests such as the Léger 20 m shuttle run test (20 mSRT) (Rivilis et al., 2011) or less frequently, in laboratory tests using cycle ergometry (Cairney, Hay, Veldhuizen, & Faught, 2010) and treadmill protocols (Chia, Reid, Licari, & Guelfi, 2013). Laboratory-based measures of CRF (i.e. volume of oxygen consumed at maximal physical exertion/VO_2max) are considered to be the gold standard for assessing aerobic capacity, whereas field-based measures have been criticized for the confounding factors associated with measuring maximal effort in the absence of objective indicators of exertion (Cairney, Hay, Veldhuizen, & Faught, 2010). In DCD specifically, the main factors associated with poor performance in field-based tests of CRF are thought to be related to lowered perceived self-efficacy (Cairney, Hay, Wade, Faught, & Flouris, 2006), low motivation and reduced levels of physical activity (Cairney, Hay, Faught, Wade, et al., 2005). Despite this, various authors agree that field-based running testing using standardized protocols, such as the Léger 20mSRT, are valid and reliable means to assess aerobic capacity in children with and without DCD (Cairney, Hay, Veldhuizen, & Faught, 2010).

In contrast to the endurance running tests used to measure aerobic capacity, tests of anaerobic capacity include maximal running speed tests (e.g. 10 m $\times$ 5 m, 20m and 50m sprint tests). Importantly, Verschuren, Takken, Ketelaar, Gorter, and Helders (2007) highlight that the agility requirements within the 10 m $\times$ 5 m sprint test may confound the interpretation of anaerobic capacity in children with poor coordination (Verschuren et al., 2007).

Another important attribute of physical fitness is flexibility. The sit and reach test is the most commonly reported flexibility measure used among children with DCD (Rivilis et al., 2011). Results show that children with DCD have a heterogeneous flexibility profile, with some studies showing poorer flexibility (Cantell, Crawford, & Tish Doyle-Baker, 2008; Hands, Larkin, Parker, Straker, & Perry, 2009) and others reporting no difference in flexibility compared to TD children (Schott, Alof, Hultsch, & Meermann, 2007; Tsiotra, Nevill, Lane, & Koutedakis, 2009).

Concerning muscular fitness, three elements are typically evaluated: muscle strength, power and endurance. Findings from studies using either isometric or isokinetic dynamometry, which are considered the most robust forms of measuring muscular strength report that muscle strength is decreased in most muscle groups in DCD (Raynor, 2001; van der Hoek et al., 2012). Muscle power and muscular endurance tests on the other hand, are commonly used to make inferences about anaerobic muscle capacity. Tests of explosive muscle power examine parameters such as distance covered (e.g. throwing a heavy ball or performing a standing-long-jump) whereas tests of anaerobic muscle endurance measure the maximal number of repetitions within a specific time constraint (e.g. number of sit- or push-ups executed in 30 s). While the extent to which motor coordination deficits influence performance on these tests is acknowledged (Raynor, 2001; Rivilis et al., 2011) few studies have examined the relationship between muscle fitness and task constraints in DCD.

The term neuromotor fitness is a collective noun, introduced by Garber et al. (2011) to describe motor skills such as balance, coordination, agility, and proprioceptive ability. Neuromotor fitness is a skill-related component of physical fitness and considered to be important in injury prevention. Neuromotor skills are by definition, functional skills and the motor tasks used to evaluate neuromotor fitness include running, walking on a line or hopping. Outcome measures designed to evaluate motor performance in children with DCD include standardized measures such as the Movement Assessment Battery for Children 2nd Edition (MABC-2) (Henderson, Sugden, Barnett, & Smits Engelsman, 2010), the Bruininks–Oseretsky Test of Motor Proficiency – 2nd edition (BOT-2) (Bruininks & Bruininks, 2005) and the McCarron Assessment of Neuromuscular Development (MAND) (McCarron, 1997). On examination of the items in these tests, it is evident that aspects of neuromotor fitness (i.e. balance, agility, coordination) are evaluated in each test.

Importantly, adequate performance in neuromotor fitness tests is influenced by the ability to mitigate the variable influence of external forces and environmental constraints affecting movement quality. Evidently, motor proficiency plays an important role since carefully graded and well-timed muscle contractions lead to more economical and efficient ways of moving. Poor balance and agility in children with DCD (Chia, Licari, Guelfi, & Reid, 2012) may therefore explain their less favorable performance on neuromotor fitness measures. In DCD, compensatory strategies for motor control deficits are likely to influence physical fitness outcomes. One of the strategies frequently used in early stages of skill learning is co-activation of muscles, which leads to increased stability but can also potentially hamper force production (Raynor, 2001). Since DCD is a motor skill-learning deficit by definition, it is likely that the fine-tuning (grading) of multi-joint movements used in agility or dynamic power tests will be harder to optimize. Freezing joints may then be used as a temporary solution for controlling degrees of freedom or as a kind of mechanical filter to suppress the effects of force variability (Smits-Engelsman & Wilson, 2013).