Research in Developmental Disabilities 34 (2013) 2098–2106

Contents lists available at SciVerse ScienceDirect

Research in Developmental Disabilities

A comparison of the oxygen cost and physiological responses to running in children with and without Developmental Coordination Disorder

L.C. Chia *, S.L. Reid, M.K. Licari, K.J. Guelfi

School of Sport Science, Exercise and Health, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia

ARTICLE INFO

Article history:
Received 5 December 2012
Received in revised form 18 March 2013
Accepted 26 March 2013
Available online 30 April 2013

Keywords:
Developmental Coordination Disorder
Running
Oxygen cost
Physiological response

ABSTRACT

The aim of this study was to compare the oxygen cost of running in boys with and without Developmental Coordination Disorder (DCD). Fourteen boys with DCD (9.1 ± 1.4 yr) and 16 typically developing (TD) controls (9.4 ± 1.3 yr) were tested on two separate occasions at least a week apart. On the first visit, motor proficiency, body composition and maximal aerobic capacity were established. On the second visit, oxygen consumption was determined via indirect calorimetry while participants ran at three submaximal speeds (7.2 km/h, 8.0 km/h and 8.8 km/h) on a motorised treadmill for 4 min each. Additional physiological responses such as blood lactate, respiratory exchange ratio (RER), heart rate, salivary alpha amylase and pain threshold were monitored at baseline and after each submaximal effort. Although there were no differences in the oxygen cost of running at all three speeds, the boys with DCD had higher blood lactate concentration (7.2 km/h, $p = 0.05$; 8.0 km/h $p = 0.019$), heart rate ($p \leq 0.001$), RER (8.0 km/h, $p = 0.019$; 8.8 km/h, $p = 0.001$), salivary alpha amylase (8.0 km/h, $p = 0.023$; 8.8 km/h, $p = 0.020$) and a lower pain threshold ($p < 0.01$). The higher overall metabolic cost of running in boys with DCD as indicated by the higher RER, heart rate and blood lactate concentrations, together with the higher levels of sympathoadrenal medullary activity and sensitivity to pain, may be deterring factors for participation in physical activity in this population.

1. Introduction

Developmental Coordination Disorder (DCD) is a condition diagnosed in children when their performance of movement skills is substantially below that expected given their chronological age and measured intelligence in the absence of neuromuscular disorders (Diagnostic and Statistical Manual of Mental Disorders, 4th ed., American Psychiatric Association, 2000). The condition has implications for both fine and/or gross motor skills, impacting on activities of daily living and participation in sports and games (Cairney et al., 2005; Hands & Larkin, 2002; Missiuna et al., 2008). Of particular interest is the ability of children with DCD to run proficiently, as this skill is central to many sports, games and children's active free play.

We have recently compared the running gait of children with and without DCD using 3D motion analysis and found higher cadence, and a tendency for shorter strides and longer foot contact times (Chia, Licari, Guelfi, & Reid, 2012). In addition, children with DCD displayed less peak knee extension immediately prior to foot contact, as well as greater

* Corresponding author. Tel.: +61 8 6488 1383.
E-mail address: 10545338@student.uwa.edu.au (L.C. Chia).

0891-4222/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ridd.2013.03.023

variability in sagittal plane hip and ankle kinematics during toe-off. The DCD group also had different kinetic profiles, with lower knee extensor moments, peak knee absorption powers and peak ankle power generation. These differences may have implications for the oxygen cost of running since both kinematic and kinetic variables have been found to contribute to the differences in the oxygen cost of running in adults and children (Cavanagh & Williams, 1982; Tseh, Caputo, & Morgan, 2008; Williams & Cavanagh, 1987). Given that motor competence is related to participation in physical activity (Hands, 2008; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006), the complexity of running as a skill itself, coupled with the possibility that it requires a greater metabolic cost in children with DCD may be an important limitation to participation in running-based activities in this population.

To date, only one study has investigated the oxygen cost of locomotion in children with DCD compared with their peers (Chia, Guelfi, & Licari, 2010). Surprisingly, this study by our group reported no difference in the oxygen cost of running despite poorer qualitative ratings of running proficiency in the DCD group, although the relationship between the oxygen cost of running and proficiency approached significance at a speed of 8.4 km/h. These preliminary findings concluded that the differences in running proficiency in children with DCD may not be large enough to significantly impact the oxygen cost of running. However, it is important to note that the boys in this previous study were not matched for body mass and less than 60% of the children with DCD completed the fastest running speed (8.4 km/h), potentially affecting the power to detect differences between groups, especially if those that could not complete the higher speed were those with poorer proficiency. Therefore, it still remains questionable whether the differences in running technique in DCD translate to increased oxygen consumption.

Furthermore, in relation to the inability of a large proportion of DCD participants to complete the running task involved in this prior study, it has been reported that children with DCD tend to withdraw from physically demanding tasks sooner (Bouffard, Watkinson, Thompson, Dunn, & Romanow, 1996; Cairney et al., 2005; Chia et al., 2010). Whether this withdrawal is related to a higher oxygen cost of movement, lower perceived adequacy (Cairney et al., 2005; Cairney, Hay, Wade, Faught, & Flouris, 2006; Skinner & Piek, 2001), increased anxiety while performing challenging tasks (Pratt & Hill, 2011), or other somatosensory factors (Scherder, Rommelse, Broring, Faraone, & Sergeant, 2008) is unclear. Therefore, the primary purpose of the present study was to extend our previous work by comparing the oxygen cost of running at a range of standardised speeds between children with and without DCD matched for age, height and body mass. In addition, the responses of salivary alpha-amylase (as an index of sympathoadrenal medullary activity) and pain sensitivity to running were assessed to gain further insight into possible reasons for withdrawal from physically demanding tasks. It was hypothesised that children with DCD would have a higher oxygen consumption when running at standardised speeds and that they would be more sensitive to pain and experience higher levels of stress in response to exercise, given that these children tend to withdraw from physically demanding tasks sooner.

2. Methods

2.1. Participants

Thirty boys aged 7–10 years participated in this study; 14 with a diagnosis of DCD, and 16 typically developing (TD) controls matched for age, height and body mass (Table 1). The participants with DCD were recruited from the Unigym Program from the University of Western Australia (UWA), where a formal diagnosis of DCD was made by a paediatrician and low motor proficiency was confirmed using an age standardised movement assessment (MABC-2; Henderson & Sugden, 2007). The TD group was willing volunteers obtained from the community. Exclusion criteria included any musculoskeletal injury that might impede exercise ability, any co-occurring disorders (such as Attention Deficit Hyperactivity Disorder), or an overweight body mass index based on the definition of Cole, Bellizzi, Flegal, and Dietz (2000). Only boys aged 7–10 years were studied given that DCD is more prevalent in boys than girls and to control for any gender or maturational differences in running gait or oxygen uptake kinetics (Barker et al., 2008; Kadesjo & Gillberg, 1999; Willson, Petrowitz, Butler, & Kernozek, 2012). Ethical approval was obtained from the UWA Human Research Ethics Committee (RA/4/1/4444). Written consent was obtained from both a parent/guardian and the child prior to participation and ongoing verbal assent was obtained from each child throughout the study.

Table 1
Characteristics of participants with developmental coordination disorder (DCD) and typically developing controls (TD), mean (SD).

	TD ($n = 16$)	DCD ($n = 14$)
Age (years)	9.4 (1.3)	9.1 (1.4)
Age range (years)	7.2–10.8	7.0–10.7
Height (cm)	139.2 (10.0)	136.4 (9.6)
Body mass (kg)	32.3 (5.9)	30.5 (6.1)
Body mass index (kg/m^2)	16.5 (1.2)	16.2 (1.4)
MABC-2 (percentile)	73.3 (17.1)	3.5 (2.9)*
MABC-2 score range (percentile)	50–98	0.5–9

MABC-2, movement assessment battery for children-2.
* Significantly different from TD group, $p < 0.05$.