Human Movement Science 43 (2015) 9–14

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Level walking in adults with and without Developmental Coordination Disorder: An analysis of movement variability

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ARTICLE INFO

Article history:
Received 17 March 2015
Revised 19 June 2015
Accepted 20 June 2015
Available online 5 July 2015

Keywords:
Gait
Locomotion
Movement variability
Developmental Coordination Disorder

ABSTRACT

Several studies have shown that Developmental Coordination Disorder (DCD) is a condition that continues beyond childhood. Although adults with DCD report difficulties with dynamic balance, as well as frequent tripping and bumping into objects, there have been no specific studies on walking in this population. Some previous work has focused on walking in children with DCD but variation in the tasks and measures used has led to inconsistent findings. The aim of the current study therefore was to examine the characteristics of level walking in adults with and without DCD. Fifteen adults with DCD and 15 typically developing (TD) controls walked barefoot at a natural pace up and down an 11 m walkway for one minute. Foot placement measures and velocity and acceleration of the body were recorded, as well as measures of movement variability. The adults with DCD showed similar gait patterns to the TD group in terms of step length, step width, double support time and stride time. The DCD group also showed similar velocity and acceleration to the TD group in the medio-lateral, anterior–posterior and vertical direction. However, the DCD group exhibited greater variability in all foot placement and some body movement measures. The finding that adults with DCD have a reduced ability to produce consistent movement patterns is discussed in relation to postural control limitations and compared to variability of walking measures found in elderly populations.

1. Introduction

Developmental Coordination Disorder (DCD) is characterized by difficulties in the execution and coordination of body movements which cannot be accounted for in terms of an intellectual impairment or identifiable physical or neurological disorder (APA, 2013). Children with DCD display difficulties with fine and/or gross body movements such as handwriting, doing up shoelaces, participating in ball sports and riding a bicycle. Studies have demonstrated persistence of the condition, with a majority of individuals continuing to show motor difficulties throughout adolescence and into adulthood (Kirby, Edwards, & Sugden, 2011). These include frequent tripping and bumping into things, which have a negative impact on everyday life, including playing sports and moving in the environment (Kirby et al., 2011). Despite the evidence to suggest that DCD is a life-long condition, there is a paucity of research exploring the movement patterns of basic skills, such as walking, in adults with DCD. The only study on motor difficulties in adults with DCD to have reported relevant data on this type of task was conducted by Cousins and Smyth (2003). They tested 19 adults with DCD, and found that they were slower

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http://dx.doi.org/10.1016/j.humov.2015.06.010
0167-9457/

and made more errors when walking backwards on a line and were slower than controls in avoiding obstacles. However no further details of walking performance were reported.

Walking has been examined in children with DCD and is anecdotally reported to be poorly executed in these children (Gillberg & Kadesjö, 2003). Woodruff, Bothwell-Myers, Tingley, and Albert (2002) devised a one-dimensional measure of gait which combined the typical foot placement measures that describe gait (step length, step width, double support time, etc.). This classified six out of seven children with DCD as having an 'abnormal' pattern. However, this does not pinpoint the exact nature of the problem and combining variables in this way may statistically increase small differences. Deconinck et al. (2006) examined the same foot placement measures in children with DCD while walking on a treadmill and found that children with DCD took shorter steps and walked at a higher frequency than their peers. They concluded that these children adapt their walking pattern to compensate for difficulty with balance control. However, these findings could be an artifact of treadmill walking, which forces a consistent and possibly artificial walking speed. Two further studies have considered gait patterns of children with DCD while walking on level ground, both of which reported no quantitative differences between DCD and typically developing (TD) groups in terms of walking speed, cadence, stride length, step width or percentage of time in double support (Cherng, Liang, Chen, & Chen, 2009; Deconinck, Savelsbergh, De Clercq, & Lenoir, 2010).

To date, therefore, our understanding of the walking pattern of children and adults with DCD is limited. In contrast, there has been considerable research on gait in the aging population in an attempt to better understand what underlies the increased incidence of falls in older adults. In addition to foot placement variables, studies on older adults have investigated the coordination of whole body motion during normal walking (Marigold & Patla, 2007; Mazzà, Iosa, Pecoraro, & Cappozzo, 2008; Menz, Stephen, & Fitzpatrick, 2003; Woledge, Birtles, & Newham, 2005). These studies have indicated that the reduced walking stability of older adults seems to be reflected by a different acceleration pattern of various segments of the body. The position, velocity and acceleration of the center of mass (CoM) of the whole body are also crucially important for body balance when walking (Hof, Gazendam, & Sinke, 2005). Hernández, Silder, Heiderscheit, and Thelen (2009) examined velocity and acceleration of the estimated CoM, in younger and older adults. They found that despite walking at a similar speed to younger adults, older adults showed a significant reduction in the medio-lateral CoM acceleration during double support that was not coupled to changes in anterior–posterior and vertical CoM acceleration. This may be due to decreased ankle power output, and an associated loss of control of medio-lateral stability (Hernández et al., 2009). Other studies on older adults have considered the variability of movement during walking, i.e., how consistently a participant can control their movements, with increased variability being a sign of impaired motor control (Moe-Nilssen & Helbostad, 2005). In these cases variability is measured by determining the standard deviation across the steps of an individual participant. Increased variability of step length and time in double support have been found to be associated with an increased risk of falling in elderly participants (Maki, 1997). It has also been reported that elderly walkers show a significantly higher step length variability and step width variability compared to younger walkers (Brach, Berlin, VanSwearingen, Newman, & Studenski, 2005; Hausdorff, Rios, & Edelberg, 2001; Menz et al., 2003; Woledge et al., 2005). This suggests that the increased variability could be related to a reduced ability to maintain upright stability. Moreover, the variability of acceleration at the pelvis has been considered as an indicator of poor balance control during gait (Menz et al., 2003), with medial–lateral acceleration of the trunk found to be increased in older adults (Marigold & Patla, 2007; Woledge et al., 2005). These studies on the older population demonstrate the importance of looking beyond traditional measures of foot placement, and it may be that these measures will better describe the 'atypical' walking patterns that are reported for individuals with DCD.

The aims of the current study were, firstly to consider the walking pattern of adults with DCD using similar foot placement measures to those previously used in children with DCD (Cherng et al., 2009; Deconinck et al., 2006, 2010); and secondly to examine velocity and acceleration of the body and measures of movement variability which have previously been considered in older adults but not in work on DCD. Given the previous research with children with DCD we would not expect any overt differences in foot placement measures on level-ground walking. However, given that these adults show differences in measures of dynamic balance and obstacle avoidance (Cousins & Smyth, 2003), we would expect some movement differences which may be apparent in the measures of velocity and acceleration of the body and variability of the measures.

2. Methods

2.1. Participants

Fifteen adults with DCD, 6 female and 9 male (mean age 25.3 years) and 15 gender and age-matched typically developing (TD) adults (mean age = 25.4 years) were recruited to take part in the study. Adults with DCD were recruited from two sources: (1) from a group known to the authors since having a diagnosis of DCD in childhood and; (2) from workshops run for a local support group for individuals with coordination difficulties. We followed the most recent UK guidelines for the assessment of adults with DCD (Barnett, Hill, Kirby, & Sugden, 2014), which are based on the DSM-5 criteria for children (APA, 2013). A number of different assessments were used to address the four diagnostic criteria in DSM-5. Since there is no motor assessment for individuals over 16 years of age that has UK norms, we addressed Criterion A by using two assessment instruments; the test component of the Movement Assessment Battery for Children second edition (MABC-2, (Henderson, Sudgen, & Barnett, 2007), which has UK norms for individuals up to 16 years of age and the Bruininks–Oseretsky Test of