



Gait symmetry in individuals with and without Developmental Coordination Disorder



K. Wilmut^{a,*}, J. Gentle^b, A.L. Barnett^a

^a Oxford Brookes University, Perception and Motion Analysis Lab, Faculty of Health and Life Sciences, Oxford, OX3 0BP, United Kingdom

^b University of Surrey, Department of Psychology, Guildford, United Kingdom

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ABSTRACT

Background: Symmetry between the left and right side of the body during locomotion is key in a coordinated gait cycle and is also thought to be important in terms of efficiency. Although previous studies have identified aspects of the gait cycle which are atypical in children and adults with Developmental Coordination Disorder (DCD), studies have not considered whether this could be explained by asymmetrical gait.

Method and procedure: The current study included 62 participants with and 62 without DCD (aged 7–34 years). Participants were asked to walk continuously for 1 min up and down a walkway while movement was captured using an optical tracking system. Measures of step length and step time were taken for both the right and the left leg and symmetry ratios were calculated.

Results: The DCD group showed significantly higher symmetry ratios for both measures compared to the typically developing (TD) group, with approximately a third of DCD participants falling outside the normative range for symmetry. Furthermore, a relationship was found between movement variability and degree of asymmetry.

Conclusions: These findings demonstrate an asymmetry in the gait of individuals with DCD which, despite improving with age, does not reach the same level as that shown by TD individuals.

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What this study adds

1. The symmetry of step length and step time was considered in individuals with and without Developmental Coordination Disorder.
2. Both measures showed a greater degree of asymmetry in DCD compared to TD participants.
3. For both groups as age increased gait became more symmetrical.
4. Asymmetry was not related to general motor control.
5. Findings points towards asymmetry leading to a less efficient walking pattern in individuals with DCD.

1. Introduction

Safely walking about our environment is a skill which most of us take for granted, however, for some individuals this is far more difficult. One such population is individuals with Developmental Coordination Disorder (DCD). The Diagnostic

* Corresponding author at: Perception and Motion Analysis Lab, Oxford Brookes University.
E-mail address: kwilmut@brookes.ac.uk (K. Wilmut).

and Statistical Manual of Mental Disorders, fifth edition (DSM 5) identifies four criteria for the diagnosis of DCD. These state that: motor coordination must be below the level expected given chronological age and opportunity for skill learning; motor deficits significantly interfere with activities of daily living and are not better explained by an intellectual disability, visual impairment or neurological condition; and that the onset of symptoms is in early childhood (American Psychiatric Association, 2013). DCD is thought to occur in between 2% (Lingam, Hunt, Golding, Jongmans, & Emond, 2009) and 5% of the population (American Psychiatric Association, 2013) and is characterised by deficits in both fine and gross motor skill. Research demonstrates that these individuals do not grow out of their motor difficulties but rather that these persist into adulthood (Losse et al., 1991) with associated social and emotional problems (Kirby, Williams, Thomas, & Hill, 2013).

Researchers and therapists working with these children often comment that they have a distinctly different pattern of gait (Gillberg & Kadesjo, 2003) and that this seems to be 'awkward' compared to their typically developing peers (Parker & Larkin, 2003). In an attempt to capture the gait patterns of children with DCD Woodruff and colleagues devised a one-dimensional measure of gait which combined spatial and temporal foot placement measures into one 'value'. This value classified six out of seven children with DCD as having an 'abnormal' pattern of gait (Woodruff, Bothwell-Myers, Tingley, & Albert, 2002). Although this confirms the anecdotal and qualitative observations it does not identify which aspects of gait are abnormal. In a bid to capture just that Deconinck et al. (2006) measured spatial and temporal aspects of gait while children walked on a treadmill. They found that children with DCD walked with shorter steps and at a higher frequency compared to typically developing (TD) controls. From their findings it was concluded that the shorter step length was due to a difficulty with balance control. However, treadmill walking can produce quantitatively different gait than walking on level ground (Savelberg, Vorstenbosch, Kamman, van de Weijer, & Schambardt, 1998) and so this difference between the groups may be an artefact of the method rather than a description of gait in DCD per se. Following this initial study two further studies considered traditional spatial and temporal measures of gait in children with DCD while walking on level ground and both reported no quantitative difference between children with and without DCD (Cherng, Liang, Chen, & Chen, 2009; Deconinck, Savelsberg, De Clercq, & Lenoir, 2010).

Given that these traditional measures of gait control did not yield group differences, a recently conducted series of studies considered the *variability* of these spatial and temporal measures in both adults (Du, Wilmot, & Barnett, 2015) and children (Wilmot, Du, & Barnett, 2016) with DCD. Similarly to Cherng et al. (2009) and Deconinck et al. (2010) no quantitative differences in absolute spatial and temporal measures of foot placement in adults with DCD were found, however, adults with DCD did show higher variability in normalised step length, normalised step width, double support and stride time compared to their matched controls (Du et al., 2015). Similarly, in children with DCD apart from normalised step width no group differences in absolute measures were found but differences in the variability of stride time and time spent in double support were found and both of these were more variable in the children with DCD. Increased variability in children with DCD was also demonstrated by Rosengren et al. (2009) who used elliptical Fourier analysis. They found that children with DCD exhibited larger variation in the movement patterns of the right and left lower limbs as compared to their TD peers.

One factor which could result in an elevated variability in the gait cycle could be asymmetry, i.e. a difference in the temporal-spatial parameters of gait for the right versus the left leg. A symmetrical walking pattern is seen as the most energy efficient way to walk (Draper, 2000; Goble, Marino, & Potvin, 2003). The stereotyped rhythmic pattern of locomotion is thought to be controlled by a central pattern generator (a neural circuit located within the spinal cord which controls the muscles of the corresponding limb; Calancie et al., 1994; Grillner, 1981) which is modulated by sensory input enabling a functional step pattern (Forssberg, 1985). Research in both human and non-human populations has demonstrated the independence of the left and right leg through the use of split-belt treadmills. When the belts are run at different speeds, cats (Forssberg, Grillner, Halbertsma, Rossignol, 1980), human adults (Dietz, Fouad, & Bastiaanse 2001; Jensen, Prokop, & Dietz, 1998) and human infants (Yang, Lamont, & Pang, 2005) maintain coordination while their limbs operate independently, with the limb on the faster belt taking more steps. Essentially this evidence demonstrates that the pattern generator for each limb is autonomous but interacts with its counterpart for the contralateral limb (Yang et al., 2005).

Inter-limb symmetry is often assumed for the typical population (Eng & Winter, 1995; Hannah, Morrison, Chapman, 1984). A handful of research studies confirm this assumption and have found symmetry for vertical and horizontal reaction forces of typically developing adults and children (Claeys, 1983) and symmetry in measures such as step length, time spent in swing, stance and double support in a group of healthy older adults (Patterson, Gage, Brooks, Black, & McClory, 2010). In contrast, asymmetries in the gait patterns of typical individuals have also been identified. For example Gundersen et al. (1989) reported significant differences between limbs for the amount of time spent in stance and maximum knee extension and (Barr et al., 1987) reported asymmetries in step length, maximum knee flexion during stance and swing in five healthy men. It appears that the assumption of symmetry for typical participants is dependent to some extent upon the variable being measured and additionally the way in which symmetry is defined. For example, Herzog, Nigg, Read, & Olsson (1989) described symmetry in gait as the perfect agreement between the left and the right limb, whereas Griffin, Olney, & McBride (1995) suggest symmetry is only present when there are no statistical differences in parameters measured bilaterally. More recently, Patterson et al. (2010) have identified a normative range for symmetry values of 0.98–1.08, suggesting that symmetry may not indicate perfect agreement. The discord in the definition of asymmetry clouds our understanding of whether gait is truly symmetrical. However, studies which compare symmetry in children have demonstrated a clear developmental shift towards symmetry from 1.25 to 5.25 years (Bosch & Rosenbaum, 2010) which continues into later childhood (Diopa et al., 2004) and even into adolescence (Wheelwright, Minns, Law, & Elton, 1993).

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