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ORIGINAL ARTICLE

Gait characteristics of children with developmental coordination disorders: A case study

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Abstract
In this case study, two male children (ages 6 and 7) with and without developmental coordination disorder (DCD) walked across a GaitRITE pathway under four 'walk' conditions (two single and two dual task conditions; simple and complex); gait variables studied included speed, cadence, step and stride length. Both groups exhibited consistent right-left symmetry in step and stride length across all 'walks'. Typical children adapted to walk conditions by holding stride length constant and varying step length; children with DCD linked stride-step length and modified them in parallel. In contrast to other studies, typical children were more variable in step-stride length than DCD children. Children with DCD linked modification of gait speed and cadence to single vs dual walk conditions; typically developing children modified speed and cadence with each change in 'walk' condition. Overall children with DCD walked slower, took fewer steps with shorter strides and steps than typical children. Possible explanations for differences in gait characteristics and underlying motor system processes are discussed.

Key words: Children, Developmental Coordination Disorder, Gait

Introduction

Children with developmental coordination disorder (DCD) exhibit motor coordination difficulties that are not associated with medical or intellectual pathologies or disorders but that are severe enough to interfere with activities of daily living and/or academic achievement (American Psychiatric Association, 2000). Although there is frequent co-occurrence with learning and/or behavioral problems, these conditions do not explain the motor deficits of children with DCD (Rosengren et al., 2009). Even though there is variation in the age at which various skills develop in 'typical' children, children with DCD are characterized by levels of motor skill development significantly below that of children of the same chronological age and intellectual ability. In addition children with DCD tend not to outgrow these difficulties (American Psychiatric Association, 2000).

Motor skill impairments of children with DCD include, but are not limited to, poor balance and postural control (Laufer, Ashkenazi & Josman, 2008), poor locomotor and ball skills (Cherng, Liang, Hwang & Chen, 2007) and a wide variety of fine motor control skills (e.g. finger tapping, tying shoes, writing, etc) (Larkin & Hoare, 1991; Lundy-Ekman, Ivry, Keele & Woollacott, 1991). Children with DCD are also characterized by slower reaction/movement times (Deconinck et al., 2006; O'Brien, Williams, Bundy, Lyons & Mittal, 2008) and by increased variability of motor responses (Cherng, Liang, Chen & Chen, 2009; Rosengren, Deconinck, Diberardino, Polk, Spencer-Smith, De Clercq, et al., 2009; Williams & Woollacott, 1997; Williams, Woollacott & Ivry, 1992).

The motor coordination difficulties of children with DCD are thought to be linked to difficulty in processing and/or organizing a variety of sensory inputs (e.g. visuo-spatial, tactile and proprioceptive inputs) (O'Brien et al., 2008; Piek & Dyck, 2004; Wilson & McKenzie, 1998). These multisensory processing deficits associated with DCD are speculated to be, in part, a result of central nervous system (CNS) dysfunction associated with either sensory-motor integration and/or motor system issues related to planning, organizing, and/or timing of movements (O'Brien et al., 2008; Williams & Woollacott, 1997).

Walking is one of many coordinative acts that are not easily carried out by children with DCD. Qualitative differences have been reported to exist between typically developing children and children with DCD; for example in walking on a treadmill these children use shorter steps, walk with a more forward-lean of the body, and generally display a stiffer, more awkward walking pattern (Deconinck et al., 2006). A few recent studies have reported that performing dual or concurrent motor tasks while walking have a more profound effect on gait efficiency in children with DCD than for comparison groups and takes the form of decreased speed, cadence, and stride length (Cherng et al., 2009; Rosengren et al., 2009).

Approximately 6-9% of 6-11 year olds are regularly diagnosed with DCD (American Psychiatric Association, 2000); this speaks to the importance of understanding the nature of the coordination difficulties of these children so that appropriate treatment or enrichment can be provided. Insight into differences in gait patterns of children with and without DCD may provide an important avenue to understanding the processes underlying motor coordination difficulties and ultimately provide a key to identifying mechanisms associated with these deficits. The purpose of this study was to examine gait characteristics and patterns of changes in gait characteristics of children with and without DCD when they walk under conditions of increasing levels of task difficulty.

Method

Participants

Participants were two typically developing and two children with DCD matched for age and gender (N=4; two of 6 yrs-old and two of 7 yrs-old males). Typically developing children were recruited from a local elementary school; children with DCD were recruited from The Perceptual-Motor Development Laboratory at the University of South Carolina, Columbia, SC. Each child was screened for level of motor skill performance using the CHAMPS Motor Skill Performance protocol (Williams et al., 2009). The right hand was the dominant hand for all participants. Medical histories of the children indicated no known underlying neurological or health issues; levels of cognitive function were reported to be within the normal range.

Measurements

Gait Assessment

The GAITRite walkway system was used to assess gait patterns (CIR Systems Inc., 2007). The electronic walkway uses an instrumented mat with sensors and the active area is 61 cm wide and 366 cm long. To mark the start for the walks across the mat, a line was placed on the floor 90 cm in front of the mat. The walkway system uses the whole active area of the mat to calculate the gait parameters for each walk. The GAITRite mat is interfaced with a computer that records a variety of gait parameters (e.g. velocity, stride length, stance width, etc). The GAITRite walking system has excellent reported reliability for most temporo-spatial parameters (intraclass correlation = .82 -.99 for speed, cadence, stride length, step length, etc.) (Bilney, Morris, & Webster, 2003; Menz, Latt, Tiedemann, Mun San Kwan, & Lord, 2004; van Uden & Besser, 2004). The parameters of interest in this study were velocity, cadence, step and stride length.

Motor Skill Performance Assessment

Each child was screened using the CHAMPS Motor Skill Performance Protocol (CMSP) (Williams et al., 2009). Scores on the CMSP are ratings of movement process characteristics of locomotor skills (Locomotor Subscale; run, jump, gallop, hop, etc.), ball skills (Object Control Subscale; throw, kick, catch, strike, etc.), and overall motor skills (Total Test score, a combination of Locomotor and Object Control Subscales). Reliability of the CMSP is high (intraclass correlation r=.92 for locomotor score, r=.90 for object control score, r=.94 for total score). Movement process characteristics are rated as “1” (present) or “0” (not present) for most skills and summed for the two trials. Higher scores indicate better motor skill performance. Two testers administered the skills; one tester demonstrated the skill and instructed the child; the second tester rated the movement characteristics and recorded the child's score.

Tasks

Four 'walking' tasks were used to examine gait patterns of the four participating children and included two single task conditions (simple/complex) and two dual task conditions (simple/complex). The concurrent task was motor-based.

Level I: Unobstructed Walk (Baseline Condition or simple single 'walk' condition). Children walked across GAITRite mat using their typical or normal walking pattern. They were instructed to walk naturally and not to hurry.

Level II: Obstacle Walk (complex single 'walk' condition. Children walked across the same instrumented mat and stepped over an obstacle placed at a point half-way through the path and at twenty-five percent of the child's height. The obstacle consisted of a jump rope strung across two cones; cones were placed off the sides of the mat.

Level III: Balance Walk (simple dual task 'walk' condition). Children walked across the instrumented mat while simultaneously balancing a small ping pong ball on a large spoon. The spoon was held in the preferred hand between the thumb and index fingers; the handle of the spoon rested against the palm. The arm was fully extended in front of the body at shoulder height.

Level IV: Combined Obstacle- Balance Walk (complex dual task 'walk' condition). This task combined the Balance and Obstacle Walks. Children walked across the instrumented mat balancing a ping pong ball on a large spoon and stepped over the jump rope obstacle.

Procedures

Prior to beginning each 'walk', the 'walk' condition was explained and demonstrated; this was followed by a practice trial and appropriate test trials. The number of test trials varied depending on task and child; trials were repeated if the ball fell off the spoon, if the child stepped off the mat or simply stopped and lost focus, or if data for a given trial were not recorded, etc. A minimum of two good trials were used for analyses. The score for each gait parameter in all four walking tasks was the average of a minimum of two trials and more often the average of three or more trials. The order of task presentation was the same for all subjects: 'unobstructed' walk, 'obstacle' walk, 'balance' walk, 'combined' obstacle-balance walk.

Research Design

The study was a small group case study design including two groups, children with DCD (n=2) and children without DCD (n=2). Gait variables examined included velocity, cadence, and right and left step and stride length. Step and stride lengths were generally similar on the right and left side, therefore to conserve space, only right step and stride lengths are presented. Mean performance and intra-individual variability of performances were calculated for each dependent variable by group and individual child. Intra-individual variability for each child on each task was determined by calculating the 'within' subject standard deviations across trials for each variable.

Results

Motor Development Assessment

Mean scores of children with and without DCD on the CMSP protocol are given in Table 1 along with individual scores and age-equivalents. Based on total test scores, children with DCD clearly had less well developed gross motor skills than typically developing children. Typically developing children had higher scores on both the 'locomotor' and 'object control' subscales. Differences in scores on the locomotor subscale were small (d=2.5 points), those on the object control subscale larger (d=23.5 points). A major difference between typically developing children and children with DCD in this study was in the level of development of gross motor eye-hand coordination (ball) skills.

Table 1. Individual and group mean performance scores on the CMSP

	TDC		DCD		Group Means	
	Child #1	Child #2	Child #1	Child #2	TDC	DCD
Age	6	7	6	7	-	-
Height cm	131.4	134.6	124.5	130.8	-	-
Locomotor Score (LS)	49	41	41	44	45	42.5
LS Age Equivalent (yrs-months)	6-3	6-0	6-0	6-0	-	-
Object Control Score (OS)	61	60	31	43	60.5	37
OS Age Equivalent (yrs-months)	6-3	7-3	3-0	4-2	-	-
Total CMSP score	110	101	72	87	105.5	79.5

CMSP - CHAMPS Motor Skill Performance Protocol; TDC-Typically developing children, DCD – Children with developmental coordination disorder

Mean Group Performances: Gait Characteristics

Velocity/Cadence. Typically developing children in our small study group walked faster and took more steps than children with DCD under all 'walk' conditions (see Figure 1). Both groups tended to walk more slowly as the level of difficulty of the 'walk' condition increased (unobstructed walk vs combination walk). Importantly typical children appeared to modify the speed at which they walked in a stepwise manner with each increase in level of 'walk' difficulty (e.g. unobstructed, obstacle, balance, combination 'walks'); children with DCD did not. For these children, gait speed was nearly identical in both 'unobstructed' and 'obstacle' walks (single 'walk' tasks) but slowed dramatically in the more challenging 'balance' and 'combined' walks (dual 'walk' tasks; 44.0 cm/s and 37.98 cm/s respectively). The pattern for cadence was similar to that for velocity. In Table Table 2 presented mean performances and intra-individual variability of scores of gait characteristics.

Table 2. Mean and intra-individual variability (IIV) on gait performance in children with and without DCD

Walks		Velocity (cm/s)	Cadence (step/min)	Step LR (cm)	Stride LR (cm)
		Mean (IIV)	Mean (IIV)	Mean (IIV)	Mean (IIV)
Unobstr.	TDC	129.5 (6.1)	137.3 (9.0)	58.0 (3.6)	113.0 (6.6)
	DCD	96.1 (3.3)	105.7 (4.6)	54.7 (2.9)	109.9 (5.8)
Obstacle	TDC	108.9 (14.6)	120.6 (17.7)	54.7 (3.7)	106.1 (7.7)
	DCD	96.1 (5.9)	100.1 (2.7)	60.3 (5.7)	117.1 (11.1)
Balance	TDC	89.8 (34.8)	124.9 (15.8)	49.5 (4.0)	96.5 (11.6)
	DCD	44.0 (21.3)	61.4 (17.4)	48.5 (15.1)	85.6 (19.6)
Combined	TDC	57.7 (5.4)	83.4 (8.8)	41.3 (4.7)	81.7 (11.1)
	DCD	38.0 (4.8)	60.1 (5.6)	38.8 (3.6)	75.7 (6.7)

IIV - Intra-individual Variability, LR – Length Right, Unobstr – Unobstructed, TDC - Typically developing children, DCD - Children with developmental coordination disorder

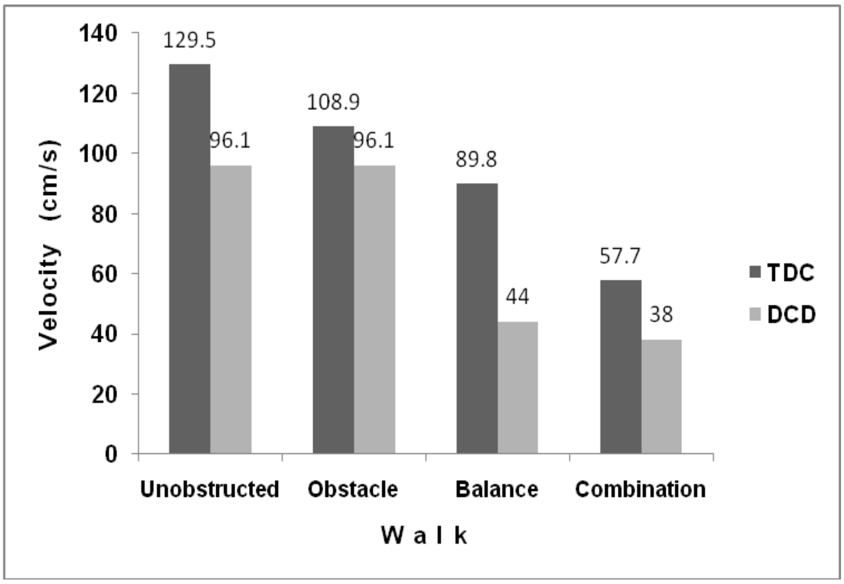

Figure 1. Mean gait velocity in children with and without DCD
TDC - Typically developing children, DCD – Children with developmental coordination disorder

*Step and Stride Length***.** A four cm or greater difference was set as an arbitrary indication of a meaningful difference in stride/step lengths (Chester, Tingley & Biden, 2006). In general, children with DCD tended to walk using shorter stride and step lengths than typical children. Typical children tended to decrease both stride and step lengths as the 'walk' condition increased in difficulty. The exception was the 'balance' walk where the right stride length decreased while the left stride length remained relatively the same as in the 'obstacle' walk. The pattern of change for children with DCD seemed less clear-cut. For example, children with DCD increased stride and step length on the 'obstacle' walk (single task) and decreased them dramatically on 'balance' and 'combination' walks (dual 'walk' condition). Overall the pattern of change was similar in right-left stride and step lengths within each group suggesting a rather consistent right-left symmetry of step/stride length within each group. Thus although the pattern of change in stride/step lengths tended to differ for the two groups across 'walks', there was an observable right-left symmetry in both stride and step lengths for both groups.

Intra-Individual Variability: Gait Characteristics

Intra-individual variability in gait characteristics is shown in Table 2. The scores are based on standard deviations of performance across trials for individual children and averaged by group.

Velocity/Cadence. The speed with which typical children walked was, in general, more variable than that of children with DCD for all 'walk' conditions. See Figure 2. The pattern of change in variability across tasks, however, was similar for both groups. With one exception ('combined' walk), variability of walking speed tended to increase with increases in 'walk' condition difficulty. Interestingly, variability of gait speed tended to increase more

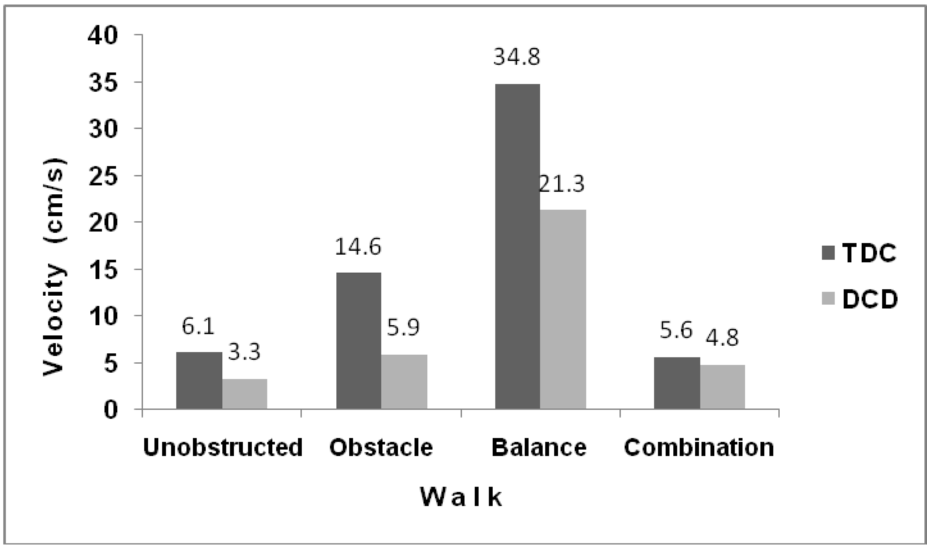

Figure 2. Intra-Individual Variability of Gait Velocity in Children with and without DCD
TDC - Typically developing children, DCD – Children with developmental coordination disorder

dramatically for typically developing children than for children with DCD. Variability of walking speed was large for both groups in the 'balance' walk and considerably reduced in the 'combined' walk. With regard to cadence, typical children tended to be more variable in number of steps taken; the exception was in the 'balance' walk.

Step and Stride Length. For typically developing children, variability of step length was similar in the 'unobstructed' and 'obstacle' walks (single task conditions) but increased in 'balance' and 'combined' walk conditions (dual task conditions). In contrast variability in stride length tended to be relatively stable across 'walk' conditions. The exception was on the 'combined' walk where it increased dramatically. For children with DCD, variability of both stride and step lengths tended to increase as difficulty of 'walk' condition increased (exception~~'combined' walk). The two groups, however, were similar in the tendency to maintain a right-left symmetry in variability of both stride and step length. Thus when right stride/step length increased in variability, it was accompanied by an increase in variability in left stride/step length. This symmetry was present across all 'walk' conditions.

Case Studies: Individual differences within Typically Developing and DCD Groups.
Gait characteristics of children with and without DCD are given in Table 3 and 4; values are the average of a minimum of 2 trials on each 'walk' condition. There were observable differences in gait characteristics between the two children within each group which were often related to 'walk' condition. Gait characteristics of the two typically developing children were nearly identical on the unobstructed walk (e.g. similar speed, cadence, step and stride lengths; simple single 'walk' condition); there were more noticeable differences on other 'walks'. For example, on both 'obstacle' and 'combined' walks, the same child tended consistently to take longer steps and strides and walk faster than the other child. There was little or no consistency in gait characteristics between the two children on the 'balance' walk. Generally there was evidence of rather consistent right-left symmetry in step/stride lengths for both typically developing children.

Table 3. Velocity and cadence in children with and without DCD

Walks	Velocity (cm/s)		Cadence (step/min)	
	TDC #1 TDC #2	DCD #1 DCD #2	TDC #1 TDC #2	DCD #1 DCD #2
Unobstr.	129.20	91.7	136.97	102.8
	129.83	100.6	137.70	108.7
Obstacle	130.28	95.6	126.40	95.6
	87.53	96.6	114.73	104.7
Balance	94.85	47.8	115.92	52.6
	84.67	94.2	133.97	70.1
Combination	63.68	31.0	88.95	47.4
	51.65	45.0	77.85	72.8

TDC - Typically developing child, DCD – Child with developmental coordination disorder, Unobstr. – Unobstructed

There were also observable differences in various gait characteristics between the two children with DCD. For all ‘walks’, the same child with DCD consistently walked faster and took more steps to complete all ‘walks’ than the other. As with typically developing children, gait characteristics of the two children with DCD were more similar in the ‘unobstructed’ walk than in other ‘walks’ (simple single ‘walk’ vs more complex dual task ‘walks’). There were variations in right-left symmetry of step lengths that tended to be related to was evidence of symmetry in right-left step length for these children on ‘unobstructed’ and ‘combination’ walks. In contrast to step length, right-left symmetry in stride length was present on all ‘walks’ for both DCD children.

Table 4. Velocity and cadence in children with and without DCD

Walks	Step LL (cm)		Step LR (cm)		Stride LL (cm)		Stride LR (cm)	
	TDC #1 TDC #2	DCD #1 DCD #2	TDC #1 TDC #2	DCD #1 DCD #2	TDC #1 TDC #2	DCD #1 DCD #2	TDC #1 TDC #2	DCD #1 DCD #2
Unobstr.	55.4	52.7	57.7	52.7	113.8	107.6	112.8	106.6
	58.4	54.8	58.4	56.6	113.8	111.6	114.3	113.2
Obstacle	62.3	55.0	60.9	65.3	125.0	122.4	123.1	121.6
	42.3	56.1	48.5	55.3	90.7	112.7	89.2	112.7
Balance	48.8	47.8	49.0	51.6	98.3	99.1	97.9	100.4
	51.2	36.6	50.1	45.3	122.1	69.9	95.2	70.8
Combin.	52.1	36.7	41.7	41.6	92.6	79.6	86.5	76.8
	39.1	38.4	40.9	35.9	80.1	74.9	76.8	74.5

LL – Length Left, LR – Length Right, TDC - Typically developing child, DCD – Child with developmental coordination disorder, Unobstr. – Unobstructed, Combin. - Combination

Discussion

There is considerable agreement that the most important variables in describing gait patterns in both children and adults are speed, cadence, stride length and in some instances step length (Hillman, Stansfield, Richardson, & Robb, 2009; Huang, Mercer, & Thorpe, 2003). Overall our data indicated that, on average, our typical children walked faster and took more steps than children with DCD regardless of walk condition. They also tended to take longer steps and strides. Differences in gait characteristics between the two groups were smaller under the simple walk condition than under more challenging ‘walks’. Cherng et al also report (a) little or no difference between children with and without DCD in gait parameters under a ‘free’ walk condition similar to ours and (b) greater differences under dual walk or more challenging task conditions (Cherng et al., 2009). Others have reported qualitative based differences in gait characteristics between children with DCD and comparison groups similar to those we observed (Larkin & Hoare, 1991; Woodruff, 2002). In contrast, Deconinck et al (2006) reported that children with DCD used shorter steps than children without DCD when they walked on a treadmill. It is possible that treadmill walking requires different strategies to adapt to the constantly moving bed of the treadmill than does walking on a non-moving land surface and thus we might expect differences in how the two groups adapt to these very different environments; this awaits future inquiry.

As important as the foregoing differences (if not more so) are observed differences in how the two groups of children adapted their gait to different ‘walk’ demands. For example typically developing children appeared to adapt to different ‘walk’ conditions by modifying speed/cadence with each change in ‘walk’ demands. Thus with increasing ‘walk’ challenge, both speed and cadence were reduced. In contrast, the method of adapting to increasing ‘walk’ demands by children with DCD was linked to whether or not the ‘walk’ involved ‘single’ vs ‘dual’ task conditions. Speed/cadence remained essentially unchanged under the two single ‘walk’ conditions (unobstructed/obstacle walks) but was reduced under ‘dual’ walk conditions. This same strategy was also manifested in stride and step. Cherng et al reported that compared to a ‘free’ walk condition, children with DCD reduced speed, cadence and stride length more than typically developing children when a second current task (e.g. carrying an empty tray or a tray with marbles) was added; however no data were reported on whether or not different strategies were used in adapting to various task conditions by the two groups. Overall our typically developing children appeared to adapt to changing ‘walk’ demands by modifying major gait characteristics in finer increments than children with DCD. Whether this is related to lack of refined perception of the need for modifying movements, an inability of the motor system to make those modifications or a combination of the two is not clear. There is some evidence that sensory-integration processes are less well developed in children with DCD (Bonifacci, 2004; Piek & Dyck, 2004) and that timing of movements and the onset of muscular responses are also problematic for these children (Williams & Woollacott, 1997; Williams et al., 1992). These could be important contributing factors. There is also the potential influence of increased demands on attentional resources (diverting attentional capacity to other task demands) thereby affecting gait characteristics in different ways for the two groups (Bonifacci, 2004; Schmidt & Wrisberg, 2004; Wickens, 1984; Woollacott & Shumway-Cook, 2002).

With regard to variability of gait characteristics, our observation that typically developing children were more variable in speed/cadence than children with DCD was unexpected. Most research suggests greater variability in children with DCD in a variety of motor functions including gait (Estil, Ingvaldsen & Whiting, 2002; Laufer et al., 2008; Rosengren et al., 2009; Williams & Woollacott, 1997; Williams et al., 1992). Is it possible that children with DCD due to their difficulties with processing visio-spatial inputs are less responsive to alterations in the walking path? It is interesting, however, that the pattern of change in variability of speed/cadence with changes in ‘walk’ demands was similar for both groups. Both groups were less consistent in the speed with which they walked as ‘walk’ condition became more challenging (one exception). Still the change in variability of gait speed tended to be greater for typically developing children than for children with DCD. Again one could speculate that gait speed/cadence became less consistent for both groups, in part, because attentional resources needed to be focused on meeting the additional demands of the more challenging ‘walks’ (e.g. the more challenging single task ‘walk’ in the form of the ‘obstacle’ course and/or the more demanding dual task ‘walk’ in the form of the ‘balance’ walk). This would not be unexpected for children with DCD but why would gait speed be more variable for typically developing children? According to dynamic systems theory, variability of action is often greater when the individual is undergoing a transition from a familiar, stable form of movement (e.g. the unobstructed ‘walk’) to a more challenging and less stable form of movement (e.g. ‘balance’ or ‘obstacle’ walks) (Corbetta & Vereijken, 1999; Haehl, Vardaxis & Ulrich, 2000; Whitall & Getchell, 1995). Since a number of aspects of motor skill performances undergo change in typically developing children at this age, it may be that the systems underlying balance and locomotor control are adapting to these changes and thus are simply less able to consistently organize and execute these actions (Williams, 2002; Williams & Monsma, 2007). Is it possible that our children with DCD were simply less mature in terms of motor skill development than the comparison children and thus did not manifest the same degree of change in variability of gait characteristics under increasing task demands? In either case our data suggest as other data have that gait efficiency may be reduced in both groups when task demands are more challenging (Cherng et al., 2009).

In contrast to gait speed, the pattern of change in variability of stride and step length was different for the two groups. Variability in both, step and stride length tended to increase with each increase in ‘walk’ demands for children with DCD. Thus both stride and step link were less and less consistent as ‘walk’ demands increased. For typically developing children, while variability in step length was linked to whether the ‘walk’ involved single or dual task conditions, variability of stride length remained relatively stable across ‘walk’ conditions (one exception). It appeared that for typically developing children, stride/step length were not tightly coupled and modifying step length was the strategy used to adapt to major increases in ‘walk’ demands. This is congruent with other evidence that changes in step length are a common strategy used in adapting to or acquiring a new skill (Akram & Frank, 2009; Lowrey, Reed & Vallis, 2007; Yang, Chew, Zielinska & Poo, 2007).

For children with DCD, step and stride length appeared to be more tightly coupled and the strategy for meeting task demands seemed to be to change both in tandem in response to increases in ‘walk’ demands. It is possible that the motor system of typically developing children is characterized by a greater ‘flexibility’ (more choices) in responding to changing environmental demands, that is it has the capacity to hold one variable constant (stride length) while modifying another (step length). If holding stride length constant and modifying step length to meet task demands is a more challenging but efficient strategy for adapting to changes in ‘walk’ demands (than linking stride/step length and modifying the two parallel), it is possible that a part of the motor impairment associated with DCD is a motor system with less ‘flexibility’ in terms of choices of how to respond to varying ‘walk’ challenges. In such a system, the degrees of freedom of the action would be reduced, and the strategy would be to link stride and step length and modify them in parallel. The more ‘flexible’ strategy exhibited by typically developing could be a sign of the developmental process of evolving refined motor control and suggests that our children with DCD have not yet reached that point in development. Since children with DCD tend not to outgrow their motor coordination difficulties, the use of more conservative strategies may be an enduring characteristic of their motor system.

A significant characteristic of both children with and without DCD was the presence of a generally consistent right-left symmetry of mean and consistency of stride length under various ‘walk’ conditions (also true for step length). We believe these data point to identifiable linkages between right and left sides in walking and although the stride parameters change with ‘walk’ condition, the linkage itself remains intact. The observation that a right-left symmetry was present for several gait characteristics in both groups of our children in all ‘walks’ suggests that it may be a basic, automatic or inherent feature of the motor control system integral to the act of walking and thus not a part of the coordination issues associated with developmental coordination disorder. Rosengren et al (2009) used phase portraits of shank/hip movements and also reported no differences in the overall pattern of right-left symmetry for children with and without DCD (although they did find inconsistencies between the two signs which were not right-left related). If some aspects of gait are carried out at lower levels of the nervous system (e.g. spinal pattern generators) (Guertin & Steuer, 2009; Mandadi et al., 2009; Rabe, Gezelius, Vallstedt, Memic, & Kullander, 2009), this suggests that at least some aspects of the motor coordination difficulties of children with DCD involve higher level processes.

Given the small study sample and the limitations that accompany it, we realize that it is important to interpret our data conservatively. We have attempted to do so while still drawing attention to what may be important differences and similarities between the two groups of children that may lead to and guide future research in identifying underlying processes and mechanisms associated with DCD. Although the foregoing data are interesting and potentially informative, more careful and controlled scientific work needs to be undertaken to confirm or negate these outcomes. Studies that involve larger samples of both boys and girls and include appropriate measures of brain activity must be completed to provide evidence for and greater insight into possible mechanisms associated with the motor coordination difficulties experienced by children with DCD. The goal of this report is to promote and facilitate such research. We are currently planning further exploratory study of this issue using fMRI techniques.

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