



Short communication

Children with Autism Spectrum Disorder, Developmental Coordination Disorder, and typical development differ in characteristics of dynamic postural control: A preliminary study

Haylie L. Miller^{a,*}, Priscila M. Caçola^b, Gabriela M. Sherrod^a, Rita M. Patterson^c, Nicoleta L. Bugnariu^a

^a Department of Physical Therapy, University of North Texas Health Science Center, 3500 Camp Bowie Blvd., Fort Worth, TX, 76107, USA

^b Department of Kinesiology, University of Texas at Arlington, 701 S. Nedderman Dr., Arlington, TX, 76019, USA

^c Department of Family Medicine, University of North Texas Health Science Center, 3500 Camp Bowie Blvd., Fort Worth, TX, 76107, USA

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ABSTRACT

Background: Autism Spectrum Disorder (ASD) and Developmental Coordination Disorder (DCD) are developmental disorders with distinct definitions and symptoms. However, both conditions share difficulties with motor skills, including impairments in postural control. While studies have explored postural sway variables in children with DCD and ASD as compared to typical development (TD), few have used kinematic data to assess the magnitude of differences between these two neurodevelopmental conditions. There are few sensitive and specific measures available to assess balance impairment severity in these populations.

Research question: Do individuals with ASD, DCD, and TD differ in dynamic postural control?

Methods: We quantified postural control differences between ASD, DCD, and TD during a dynamic balance task. 10 ASD, 10 DCD, and 8 TD age-matched children completed a dynamic postural control task in a virtual environment. They leaned to shift their center of pressure (CoP) to match a user-controlled object to an oscillating target (0.1 Hz–0.8 Hz).

Results: The DCD group had higher CoP accelerations compared to ASD or TD. While the DCD and TD groups did not differ in their medial-lateral velocity, the ASD group had low medial-lateral velocity and acceleration as compared to DCD and TD. ASD group velocity and acceleration did not differ from that of the TD group in the anterior-posterior direction. Higher accelerations in the DCD group reflected non-fluid movements; by contrast, the ASD group had slower, more fluid movements. Results may reflect differences in how children with ASD and DCD plan, execute, and modify motor actions.

Significance: This study demonstrates the potential utility of CoP acceleration and velocity as a sensitive and specific means of differentiating between ASD, DCD, and TD. Results indicating group differences between ASD and DCD in velocity and acceleration profiles represent an important step toward understanding how these populations modify motor plans during dynamic tasks.

1. Introduction

Autism Spectrum Disorder (ASD) and Developmental Coordination Disorder (DCD) share similar behavioral and motor symptoms, but are not commonly studied together [1]. Children with ASD and DCD have poor postural control compared to TD children [2,3], and are at higher fall and injury risk [4,5]. Postural control depends on visuomotor integration—the use of visual information to guide motor action [6,7]. Here, we examined differences in dynamic postural control in children with ASD and DCD. We used a novel task [8] that requires online use of

visual feedback to support dynamic postural control.

This study provides a starting point for a new line of work using kinematic data to discriminate between the specific profiles of ASD, DCD, and TD. We compared acceleration and velocity of center of pressure (CoP), in these three groups. We expected differences in stability between the clinical groups and TD, and also that ASD and DCD would differ significantly from TD.

* Corresponding author.

E-mail address: Haylie.Miller@unthsc.edu (H.L. Miller).

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2. Method

2.1. Participants

This study was approved by the Institutional Review Board at the University of North Texas Health Science Center, and all parents gave informed consent prior to their children participating. We tested 10 children with ASD (9 male; $M_{age} = 13.00$, $SD_{age} = 2.54$, $range = 9–16$), 8 age-matched controls (4 male; $M_{age} = 10.20$, $SD_{age} = 3.41$, $range = 7–18$), and 10 children with DCD (9 male; $M_{age} = 9.30$, $SD_{age} = 1.25$, $range = 6–14$). ASD and DCD participants carried a prior diagnosis based on DSM-IV or DSM-V criteria [9,10] and these were confirmed by the research team. The groups did not differ in mean full-scale IQ (ASD = 98.30, DCD = 104.40, TD = 114.13, $F(2, 25) = 2.76$, $p = 0.08$). Participants had IQ scores > 69 and no history of seizure disorders, neurological abnormalities, or current use of medications known to impair motor function. Those with a first-degree relative with ASD were ineligible for the TD group.

2.2. Apparatus & procedures

The apparatus is represented in Fig. 1, and procedures are described in detail elsewhere [8]. We used a visual tracking task requiring participants to shift their center of pressure (CoP) to match the dynamic position of a user-controlled object. The target oscillated right and left at 8 frequencies (0.1–0.8 Hz) in a fixed randomized sequence. Each frequency was presented twice, for 5 s each time, and target frequency changed without warning. The task lasted 1 m 20 s in total. We calculated CoP—the point at which ground reaction force is applied on the force plate—velocity and acceleration in the medial-lateral (side-to-side) and anterior-posterior (front-to-back) directions at each frequency. Higher velocity indicated fast movement; higher acceleration indicated less-fluid movement.

3. Results

3.1. Multivariate model

We used multivariate analysis of variance (MANOVA) to test group differences in CoP accuracy (deviation from target), velocity (medial-lateral and anterior-posterior) and acceleration (medial-lateral and anterior-posterior). There was a significant effect of Group, $F(8, 46) = 5.93$, $p < 0.001$, $\eta_p^2 = 0.51$, observed power = 0.99 in the multivariate model (see Table 1 for means and standard deviations). The between-subjects effect of group was significant for medial-lateral and anterior-posterior velocity and acceleration (all univariate $ps <$

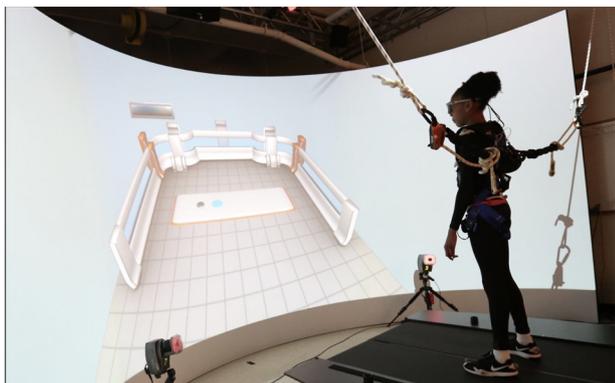


Fig. 1. Participant completing the study task in the CAREN system, with the blue disc representing the target object, and the silver disc representing the participant's user-controlled object. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Means (M) and Standard Deviations (SD) for Center of Pressure (CoP) Velocity and Acceleration by Group.

	Group	Medial-Lateral		Anterior-Posterior	
		Mean	SD	Mean	SD
CoP Velocity	TD	0.26	0.07	0.25	0.09
	ASD	0.13	0.03	0.14	0.06
	DCD	0.35	0.12	0.47	0.18
CoP Acceleration	TD	43.66	16.84	43.98	17.76
	ASD	16.37	7.34	23.20	12.27
	DCD	65.61	25.75	91.65	34.56

0.001).

3.2. CoP velocity

The between-subjects effect of Group was significant for CoP velocity in both the medial-lateral and anterior-posterior directions, $F_s(2, 25) = 16.01$ and 19.93 , $ps < 0.001$, η_p^2 s = 0.56 and 0.62. The ASD group had lower medial-lateral CoP velocity than the TD ($p = 0.02$, $M_{Diff} = 0.12$, $SE = 0.04$) or DCD ($p < 0.001$, $M_{Diff} = 0.22$, $SE = 0.04$) groups. The DCD and TD groups did not differ ($p = 0.09$). For the anterior-posterior direction, both the TD ($p = 0.002$, $M_{Diff} = 0.23$, $SE = 0.06$) and ASD ($p < 0.001$, $M_{Diff} = 0.33$, $SE = 0.05$) groups had higher CoP velocity than the DCD group, but did not differ from each other ($p = 0.22$).

3.3. CoP acceleration

The between-subjects effect of Group was significant for CoP acceleration in both the medial-lateral and anterior-posterior directions, $F_s(2, 25) = 18.03$ and 21.37 , $ps < 0.001$, η_p^2 s = 0.59 and 0.63 (Fig. 2).

The ASD group had lower medial-lateral CoP acceleration than the TD ($p = 0.01$, $M_{Diff} = 27.30$, $SE = 8.71$) or DCD ($p < 0.001$, $M_{Diff} = 49.25$, $SE = 8.22$) groups. The medial-lateral CoP acceleration of the DCD group was marginally higher than the TD group ($p = 0.056$, $M_{Diff} = 21.95$, $SE = 8.71$). For the anterior-posterior direction, both the TD ($p = 0.001$, $M_{Diff} = 47.68$, $SE = 11.35$) and ASD ($p < 0.001$, $M_{Diff} = 68.45$, $SE = 10.70$) groups had lower CoP acceleration than the DCD group, but did not differ from each other ($p = 0.24$).

4. Discussion

Our preliminary results suggest that children with ASD and DCD

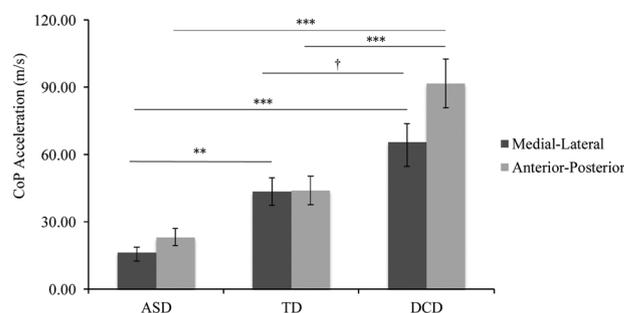


Fig. 2. Mean medial-lateral (M-L) and anterior-posterior (A-P) center of pressure (CoP) acceleration differs by group. For both the M-L and A-P directions, DCD group accelerations were significantly higher, and ASD group accelerations were significantly lower. Vertical bars show standard errors. Note: ASD = Autism Spectrum Disorder, TD = Typical Development, DCD = Developmental Coordination Disorder; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p = 0.056$.

differ in the speed profile of their movement during a dynamic postural control task. Consistently higher accelerations in the DCD group reflected a lack of fluidity to their movements. Non-fluid movements require greater energy expenditure and more corrections to over- and under-shoots than micro-accelerations used to make smaller, more fluid adjustments to CoP.

Movement patterns observed in our DCD group seem to support the *poor internal modeling hypothesis* [11]—that children with DCD can produce motor plans, but not effectively modify them. When tasks require rapid adaptation, slower feedback mechanisms are insufficient [12], and anticipatory control of CoP is necessary to overcome response latency.

In contrast, the ASD group had lower medial-lateral accelerations, reflecting slower, more fluid patterns of movement. This is equally inefficient, but may stem from different mechanisms than those impaired in DCD. Prior work identified increased signaling latencies in sensory networks [13] perhaps due to decreased white matter integrity [14]. This may slow motor network signaling in ASD (e.g., [15]), rendering anticipatory *and* feedback mechanisms inefficient in motor plan modification.

CoP acceleration and velocity may be a sensitive and specific means of differentiating between ASD, DCD, and TD. While the small sample size limits generalizability and complex statistical modeling, clear patterns of group differences can inform future work. The patterns observed in our study highlight the potential utility of kinematic data from dynamic tasks in lieu of traditional quiet standing. Demands on visuomotor integration inherent to this type of task may illuminate an aspect of motor difficulty not previously explored in DCD and ASD.

Our preliminary findings lay new groundwork for an alternative approach to assessing postural control in DCD and ASD. These data represent an important step toward understanding how children modify motor plans during dynamic tasks, which more closely mirror everyday tasks demands. If future studies can establish that CoP acceleration patterns identified in our data are defining characteristics of postural control in DCD and ASD, these findings could inform development of more targeted diagnostic and therapeutic approaches.

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Declarations of interest

None.

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