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Light finger contact concurrently reduces postural sway and enhances signal detection performance in children with developmental coordination disorder

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ABSTRACT

The current study examined the effects of light finger touch on postural sway and signal detection performance in children with developmental coordination disorder (DCD). Children with DCD ($n = 30$; 18 boys, 12 girls; age = 11.87 ± 0.48 years) and typically developing children ($n = 30$; 14 boys, 16 girls; age = 11.73 ± 0.52 years) were recruited from schools in Pintung County, Taiwan. Participants completed a signal detection task under no finger touch (NT) and light finger touch (LT) conditions, while postural sway in both anteroposterior (AP) and mediolateral (ML) axes was recorded. In both conditions, children with DCD exhibited significantly higher levels of postural sway ($p < 0.05$) and lower signal detection performances ($p < 0.05$) than TDC. Additionally, both groups significantly reduced postural sway ($p < 0.05$) and enhanced signal detection performance ($p < 0.05$) when engaged in light finger touch compared with no finger touch. While the effect of LT on postural sway was greater among TDC relative to children with DCD ($p < 0.05$), the effect of LT on signal detection was greater in children with DCD compared with TDC ($p < 0.05$). These results suggest that light finger touch is effective in concurrently reducing postural sway and enhancing signal detection in both groups.

1. Introduction

Approximately 2–6% of school-aged children have motor coordination and motor skill issues that can be diagnosed as developmental coordination disorder (DCD) [1,2]. Children with DCD are usually characterized by fine and gross motor deficits that interfere with daily living and/or academic progress [2]. In particular, impaired control of postural sway is a significant problem because many daily and school activities must be performed in upright standing. In previous studies, children with DCD exhibited a greater magnitude of postural sway than typically developing children (TDC) during upright standing in various environments (stationary or swinging room), visual conditions (eyes open or closed), and postures (two-legged or one-legged stance). In brief, impaired postural control is well documented for children with DCD [3,4].

Furthermore, recent research has indicated that poor control of postural sway in children with DCD affects not only balance itself, but also the performance of concurrent goal-directed tasks, such as counting [5], memory [6], and signal detection [7]. It is worth particular mention that Chen et al. [7] examined the effects of varying demands from a signal detection task while recording postural sway in children with and without DCD. The signal detection task required participants to determine if paired flashing lines differed in length, with different perceptual difficulties. In the low-difficulty condition, lines were black with obvious length disparities. In the high-difficulty condition, lines were grey with minor length disparities. This research indicated that children with DCD and TDC differentiately modulated postural sway between conditions; TDC had reduced postural sway in high-difficulty compared with low-difficulty conditions, whereas children with DCD had increased postural sway. Intriguingly, children with DCD showed a significant degradation in the performance of signal detection from low- to high-difficulty conditions, and at a greater level than their counterparts. The idea of functional integration suggests that postural sway can be adjusted to facilitate the

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performance of other goal-directed tasks [8]. Accordingly, Chen et al. [7] interpreted these results to mean that children with DCD were less capable of adaptively modulating postural sway to effectively accomplish the goal of the signal detection task. This raises an important question about how postural sway is modulated to support performance of the signal detection task in children with DCD. Based on the idea of functional integration, a reduction in postural sway should enhance the performance of signal detection because excessive postural sway can detrimentally affect tasks involved in precise visual control [9].

To test whether reduced sway can indeed enhance the performance of signal detection, the application of light finger contact with a stationary object was used. Bair et al. [10] reported that children with DCD can effectively reduce postural sway when provided with light touch contact relative to a no contact condition. Although this contact force is too small to biomechanically support and stabilize posture, the effects have been widely repeated in many populations, such as Down syndrome [11], diabetes mellitus [12], stroke [13], and Parkinson's disease [14]. The aim of the present study was to investigate how using light finger touch could affect control of postural sway and performance of signal detection in children with DCD and typically developing children. Based on Bair et al.'s [10] study and the idea of functional integration, this study predicted that the magnitude of postural sway would be reduced while applying light finger touch, which would further increase the performance of signal detection in both children with and without DCD.

2. Methods

This study applied a cross-sectional design. Approval to conduct this study was granted by the Institutional Review Board of Antai Hospital in Pingtung County, Taiwan. Written consent was obtained from each participant and his/her guardian before data collection.

2.1. Participants

Thirty children with DCD aged 11–12 years (18 boys and 12 girls; age = 11.87 ± 0.48 years) and 30 age-matched TDC (14 boys and 16 girls; age = 11.73 ± 0.52 years), were recruited from a screening sample of 585 children in five primary schools in Pingtung County, Taiwan. Children with DCD were included if they meet the following criteria: (1) a score ≦5th percentile on the second edition of the Movement Assessment Battery for Children (MABC-2) [15] to identify motor coordination disorder; (2) a score ≧95th percentile on the MABC-2 checklist to confirm functional motor impairments while performing movement activities in daily home and school life; (3) a score of >80 on the second edition of the Kaufmann Brief Intelligence Test (KBIT-2) [16] to rule out intellectual disability; (4) a score of <70 on Conners' ADHD DSM-IV Scales (CADS) [17] to exclude attentional problems; and (5) no medical conditions that explain their difficulties in motor coordination (i.e. muscular dystrophy or cerebral palsy). In addition, TDC were randomly recruited from the sampling pool if they scored ≥50th percentile on the MABC-2, and did not have intellectual or attentional problems. There were no group differences for age, weight, height, intelligence, or CADS scores. In contrast, the DCD group exhibited significantly lower scores for MABC-2 percentiles than the TDC group (Table 1). All participants were right-side dominant and reported normal or corrected-to-normal vision.

2.2. Apparatus

2.2.1. Force platform

Kinematic data for postural sway was obtained from ground reaction force at a sampling rate of 100 Hz using a force platform (model 9260AA6; Kistler Instrumente GmbH, Ostfildern, Germany). Consistent experimental setup was ensured by setting the force platform at marked positions on the floor.

Table 1
Demographic data and scores for MABC-2 percentile, KBIT-2, and Conner's ADHD DSM-IV scale for children with DCD and TDC.

	Children with DCD (n = 30; 18 boys, 12 girls)	TDC (n = 30; 14 boys, 16 girls)	t	p
Age	11.87 ± 0.48	11.73 ± 0.52	1.072	0.288
Height	147.211 ± 8.819	148.292 ± 9.326	−0.462	0.646
Weight	48.973 ± 9.476	46.783 ± 8.073	0.964	0.339
MABC-2 percentile	1.863 ± 1.583	77.893 ± 14.946	−24.468	0.000
KBIT-2	106.530 ± 10.415	108.250 ± 10.571	−6.270	0.533
CADS	50.374 ± 5.196	48.523 ± 5.619	1.336	0.187

2.2.2. Touch plate

Finger contact force was measured by a customized device, which comprised of a load cell (LSB 200, Futek Advanced Sensor Technology, Inc., Irvine, CA) attached on a 5 cm × 5 cm plate, and mounted on a tripod (for details, see [18]). Kinetic data for finger contact force in the vertical direction was obtained at a frequency of 100 Hz. The height and position of the tripod was adjusted so that participants flexed the dominant elbow to about 90° and slightly flexed the index finger naturally/comfortably to contact at the centre of the touch plate (Fig. 1A). The threshold of finger contact force was set at 1 N. If the contact force was over the threshold, the trial was repeated. Additionally, a video camera was used to capture the index finger movements of the dominant hand. Once fingertip slippage was observed, the trial was performed again.

2.2.3. Signal detection task

The high-difficulty condition in Chen et al.'s [7] signal detection task was used in the current study, as children with motor coordination disorder displayed greater postural instability and lower levels of signal detection in this condition. The visual signals were composed of two paired lines shown on a laptop screen placed 1 m ahead at the level of participants' eyes. In the non-target signals, both lines subtended 1.95° of visual angle vertically (Fig. 1B). In the target signals, the left and right lines subtended 1.95° and 2.12° of visual angle, separately (Fig. 1C). Participants were instructed to identify if briefly flashed lines were equal in length. Participants did not have to respond to non-target signals, but had to click the left button of a computer mouse using the dominant index finger as soon as possible. In each trial, there were 60 non-target and 30 target signals. The duration of each signal lasted 444 ms, and the inter-signal duration was set to 888 ms. Thus, the frequency of the signal detection task was 0.75 Hz, and each trial was 120 s long.

2.2.4. Procedure

Participants performed the signal detection task in both no finger touch (NT) and light finger touch (NT) conditions while standing barefoot with feet shoulder-width apart on a force platform in a quiet room at their school. The position of the heel was marked so that stance width was kept identical across trials for each participant. In the NT condition, participants naturally hung their arms down by their sides. In the LT condition, participants lightly and precisely contacted a fixed point of the touch plate with a finger. All participants performed six trials (three for each condition) in a random order. Additionally, a practice trial was provided for the NT and the LT condition. The rest time between