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Effects of fingertip light touch contact on anteroposterior limits of stability while standing in individuals with bilateral spastic cerebral palsy

Narumi KAWAMATA[1),2)], Sayaka MATSUSHITA[3)], Runa ICHIKAWA[3)], Mikito USUKURA[3)], Honoka ICHIKAWA[3)], Konomi NATSUME[3)], Rena MOCHIZUKI[3)], Hidehito TOMITA[1)] *

1) Graduate School of Health Sciences, Toyohashi SOZO University, Japan
2) Department of Rehabilitation, Geriatric Health Services Facility Jinseien, Japan
3) Department of Physical Therapy, Toyohashi SOZO University, Japan

Abstract

Limits of stability (LoS) while standing are reduced in individuals with bilateral spastic cerebral palsy (BSCP); however, it remains unclear whether therapeutic interventions can increase the LoS. This study aimed to determine whether contacting an external object with fingertip light touch improves stance stability in the LoS among individuals with BSCP. Nine young adults with BSCP (one woman and eight men, mean age: 26.3 years) were included in this study. The position and path length of the center of pressure (CoP) during quiet standing (QS) and the anterior and posterior LoS were measured using a force platform under two touch conditions: no-touch and light-touch conditions. Under the light-touch condition, participants placed the tip of their dominant index finger on a load cell with an applied force of <1 N. In the QS, anterior LoS, and posterior LoS, the CoP positions did not differ significantly between no-touch and light-touch conditions. However, the CoP path lengths were significantly shorter under the light-touch condition than under the no-touch condition. These results suggest that fingertip light touch enhances stance stability in the QS and anteroposterior LoS. Therefore, contacting an

* Corresponding to: Graduate School of Health Sciences, Toyohashi SOZO University, 20-1 Matsushita, Ushikawa-cho, Toyohashi 440-8511, Japan
E-mail address: h_tomita@sozo.ac.jp (H. Tomita)

Present address
Runa Ichikawa: Sato Neurosurgery, Toyohashi, Japan; **Mikito Usukura**: Seiryou Rehabilitation Hospital, Fujieda, Japan; **Honoka Ichikawa**: Kachi Hospital, Toyokawa, Japan; **Konomi Natsume**: Toyohashi Orthopedic Mukaiyama Clinic, Toyohashi, Japan; **Rena Mochizuki**: Shizuoka Kousei Hospital, Shizuoka, Japan

external object with fingertip light touch may be an effective training protocol to increase the stance stability in individuals with BSCP.

Keywords: bilateral spastic cerebral palsy, light touch, stability limit, standing, kinetics

I. Introduction

Cerebral palsy (CP) is a neurodevelopmental disorder defined as “a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain” (Bax et al. 2005). Although many individuals with bilateral spastic CP (BSCP) can stand and walk independently without any assistive device (e.g., forearm crutch or posterior walker), they experience balance problems (Woollacott and Shumway-Cook 2005). In ambulatory individuals with BSCP, balance ability is related to their gross motor function and basic life activities (Chen et al. 2013) as well as physical activity participation (Towns et al. 2022). In addition, improvement in stance balance can promote the physical activity participation and quality of life of such individuals (Silkwood-Sherer and McGibbon 2022). Therefore, enhancing stance balance ability is an important target of physical therapy among individuals with BSCP.

The limit of stability (LoS), an index of stance balance ability, is the maximum distance that an individual can displace the center of pressure (CoP) by leaning the body within the base of support without having to take a step (Melzer et al. 2009). A decreased ability to control CoP displacement within the borders of the base of support limits an individual’ s daily activities that challenge the LoS (Tinetti et al. 1988). Based on previous studies, the anteroposterior LoS is reduced to a greater extent in individuals with BSCP than in those without disability (Tomita et al. 2010; 2024b, 2024c).

However, it remains unclear whether therapeutic interventions can increase LoS in individuals with BSCP. Light touch contact may improve the LoS. Contacting an earth-fixed external surface with fingertip light touch reportedly stabilizes standing posture (e.g., decrease in postural sway) (Jeka 1997). This effect does not occur due to the mechanical support associated with fingertip light touch contact (Kouzaki and Masani 2008) but rather due to the positive influence of sensory feedback from the finger on stance balance; this sensory feedback provides information about body motion and spatial orientation (Assländer et al. 2018; Jeka 1997; Vérité and Bachta 2021). Previous studies on healthy young adults have revealed an important role of plantar pressure sensation in LoS maintenance (Asai and Fujiwara 2003; Fujiwara et al. 2003). In individuals with BSCP, reduction in anteroposterior LoS is related to sensitivity of the plantar touch-pressure sensation (Tomita et al. 2024c). These findings raise a possibility that additional somatosensory information obtained via fingertip light touch contact may enhance stance stability in the LoS. To the best of our knowledge, no studies have examined this possibility.

This study aimed to determine the effects of contacting an external object with fingertip light touch on the LoS in individuals with BSCP. We hypothesized that light touch contact reduces postural sway in the anteroposterior LoS and increases the LoS.

II. Methods

1. Participants

This study included nine young adults with BSCP (one woman and eight men). Their mean (standard deviation) age, height, weight, and foot length (FL) were 26.3 (5.2) years, 159.1 (6.3) cm, 52.5 (8.1) kg, and 23.8 (1.5) cm, respectively. Participants were included if they (1) were aged 18–35 years, (2) could follow test instructions, (3) were at level II on the Gross Motor Function Classification System (GMFCS) (can walk without an assistive device but have limitations in walking outdoors and in the community) (Palisano et al. 2008), (4) had no history of orthopedic surgery within 2 years before study participation, (5) had no history of any generic or neurological disorders other than BSCP, and (6) exhibited no flexion contracture of the hip or knee joint or no plantar flexion contracture of the ankle joint.

Written informed consent was obtained from all participants before study participation. This study conformed to the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Toyohashi SOZO University (approval number: R4008).

2. Experimental procedures

The experimental protocol to measure the CoP in the quiet standing (QS) and LoS was the same as that in previous studies examining the QS and LoS in individuals with BSCP (Tomita et al. 2024b, 2024c) and healthy young and older adults (Tomita et al. 2021, 2024a). The participants stood barefoot on a force platform (G-6100, Anima, Japan) during all measurements (Figure 1). Through G-6100 software (Anima, Japan), the CoP positions in the mediolateral and anteroposterior directions (CoPx and CoPy, respectively) were recorded with a sampling frequency of 100 Hz on a computer (NJ3900E, Epson, Japan). We instructed the participants to gaze at a fixation point placed 1.5 m straight ahead on their horizontal line of sight. Before each trial, participants' heels were aligned at their comfortable stance width.

First, participants' FL was measured while they maintained the QS. Then, the CoP positions in the QS, anterior LoS, and posterior LoS were measured under two touch conditions: light-touch and no-touch conditions. During LoS measurements, the participants leaned their body forward or backward and placed their weight on the forefoot (anterior LoS) or rearfoot (posterior LoS) as much as possible without having to take a step. The participants verbally reported when they reached the LoS and felt stable. We instructed them to maintain the QS for 10 s and the anteroposterior LoS for 3 s.

Under the light-touch condition, the participants placed the tip of their dominant index finger on a 1 cm-diameter load cell (LMBT-A, Kyowa, Japan) (Figure 1) positioned at approximately 15 cm in front and diagonally to the participants' greater trochanter. During QS and LoS measurements under the light-touch condition, the force applied to the load cell was assessed using an oscilloscope (DS-5105B, Iwatsu, Japan). Based on several previous light-touch studies (Baldan et al. 2014; Tomita et al. 2024a), the QS and LoS measurements with an applied force of <1 N were considered as successful trials. Under light-touch and no-touch conditions, we measured the QS, anterior LoS, and posterior LoS thrice after five practice trials. The order of measurements in the three standing positions (QS, anterior LoS, and posterior LoS) and under the two touch conditions (light-touch and no-touch conditions) was randomized between the participants.

3. Data analyses

In each trial, we calculated the mean CoPx and CoPy positions and the CoP path length per second for 10 s in the QS and for 3s in the anterior and posterior LoS. The CoP path length

Figure 1. Experimental setup. This figure represents a measurement in the quiet standing position under the light-touch condition. Under this condition, the participants placed the tip of their dominant index finger on a load cell.

per second was derived from both the mediolateral and anteroposterior directions combined (i.e., CoPx and CoPy). To minimize interparticipant differences in stance width and FL, we normalized the mean CoPx and CoPy positions in the three standing positions by calculating the percentages of the participants' stance width between the feet' s lateral borders (% of stance width) and FL (%FL), respectively. CoPx values of 0% and 100% of stance width indicate that the CoPx position is at the lateral borders of the left and right feet, respectively. Regarding CoPy, 0 and 100 %FL indicate that the CoPy position is at the heel and tip of the toe, respectively.

The Shapiro–Wilk test confirmed that all calculated CoP positions and path lengths were normally distributed. Therefore, differences in the CoP positions and path lengths under no-touch and light-touch conditions were assessed using paired *t*-test. A *p*-value of <0.05 was considered to indicate statistical significance. All statistical data were analyzed using IBM SPSS Statistics for Windows, Version 25 (IBM, USA).

III. Results

Figure 2 shows representative data for the CoP path in the anterior LoS under NT and LT conditions in a participant with BSCP. In this participant, although the CoP positions in the anterior LoS were almost the same between the NT and LT conditions, the CoP path tended to be smaller under the LT condition than under the NT condition.

Table 1 shows the CoPx and CoPy positions in each standing position. The CoPy positions

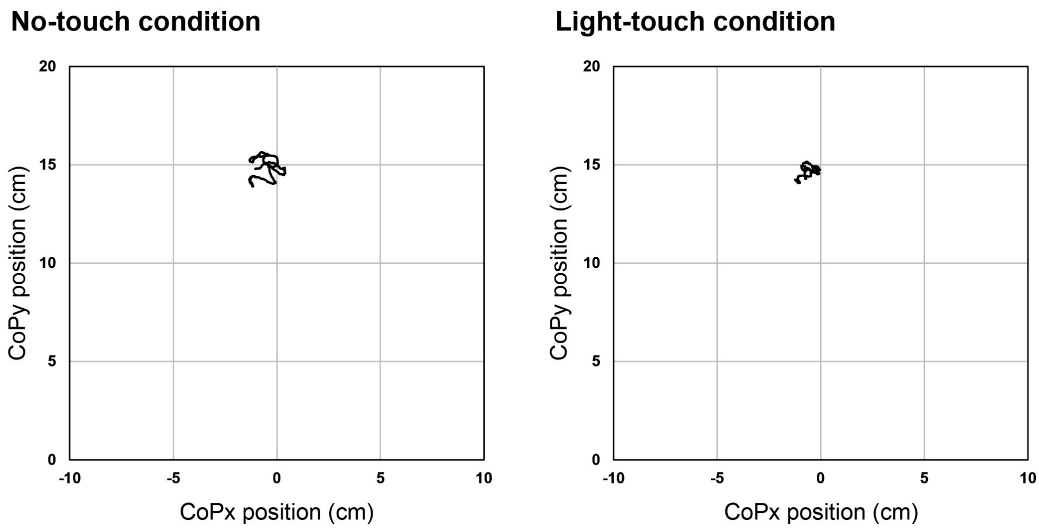

Figure 2. Representative data for the center of pressure path in the anterior limit of stability under no-touch and light-touch conditions in a participant with bilateral spastic cerebral palsy. The zero values of x- and y-axes are the midpoint of both feet and the heel, representatively. Note that the center of pressure path was smaller under the light-touch condition than under the no-touch condition.

Table 1. The CoP positions in the QS, anterior LoS, and posterior LoS in NT and LT conditions.

	No-touch condition	Light-touch condition	Significance
QS			
CoPx position (%SW)	51.1 (2.5)	51.0 (2.7)	n.s.
CoPy position (%FL)	44.1 (8.5)	46.6 (6.5)	n.s.
Anterior LoS			
CoPx position (%SW)	51.5 (2.8)	51.1 (2.5)	n.s.
CoPy position (%FL)	70.8 (4.8)	71.5 (4.0)	n.s.
Posterior LoS			
CoPx position (%SW)	51.7 (2.7)	51.0 (2.7)	n.s.
CoPy position (%FL)	31.2 (7.6)	28.9 (8.1)	n.s.

Mean (standard deviation). CoP, center of pressure; CoPx center of pressure in the mediolateral direction; CoPy center of pressure in the anteroposterior direction; FL, foot length; LoS, limit of stability; LT, light-touch; n.s., not significant; NT, no-touch; QS, quiet standing; SW, stance width.

in the anterior LoS (no-touch condition vs. light-touch condition: 70.8 ± 4.8 vs. 71.5 ± 4.0 %FL) and posterior LoS (31.2 ± 7.6 vs. 28.9 ± 8.1 %FL) tended to slightly shift forward and backward under the light-touch condition, respectively. However, the CoPy positions in the QS, anterior LoS, and posterior LoS did not differ significantly between no-touch and light-touch conditions (QS: t_8 = 1.53, p = 0.081, d = 0.51; anterior LoS: t_8 = 0.79, p = 0.455, d = 0.26; posterior LoS: t_8 = 1.48, p = 0.089, d = 0.22). The CoPx positions in the three standing positions also showed no significant differences between the two conditions (QS: t_8 = 0.19, p = 0.855, d = 0.06; anterior LoS: t_8 = 1.72, p = 0.124, d = 0.57; posterior LoS: t_8 = 1.48, p = 0.178, d = 0.49).

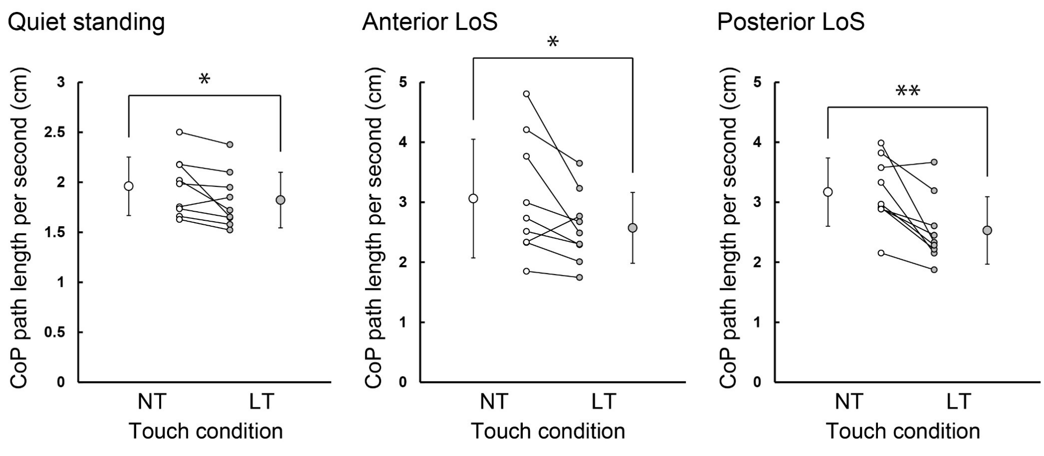

Figure 3. Means and standard deviations of the path lengths of the center of pressure (CoP) per second in the quiet standing and anteroposterior limits of stability (LoS). Individual data are also shown. Open and gray circles represent the CoP path lengths under no-touch (NT) and light-touch (LT) conditions, respectively. * $p < 0.05$, ** $p < 0.01$.

Figure 3 shows the CoP path length in each standing position. The CoP path lengths in all three standing positions were significantly shorter under the light-touch condition than under the no-touch condition (QS: $t_8 = 2.34$, $p = 0.047$, d = 0.78; anterior LoS: $t_8 = 2.41$, $p = 0.043$, d = 0.80; posterior LoS: $t_8 = 3.69$, $p = 0.006$, d = 1.23).

IV. Discussion

1. LoS characteristics in participants with BSCP

Compared with a previous study examining the CoP position and path length in the anteroposterior LoS in 27 individuals with BSCP (Tomita et al. 2024b), our study revealed slightly wider anteroposterior LoS and longer CoP path length in the LoS in participants with BSCP. In general, an increased CoP path length represents stance instability, especially in the QS (Cherng et al. 1999; Donker et al. 2008; Özal et al. 2022; Rojas et al. 2013; Rose et al. 2002). However, the abovementioned study demonstrated that the CoP path length in individuals with BSCP was longer in the QS but shorter in the anteroposterior LoS than that in individuals without disability (Tomita et al. 2024b). In their study, a wider LoS in individuals without disability indicates that the larger postural sway in the LoS in healthy controls did not occur due to an instability in the LoS but rather due to their higher ability to control a large postural sway in the LoS compared with individuals with BSCP (Tomita et al. 2024b). Therefore, the slightly wider anteroposterior LoS and longer CoP path length in our study participants with BSCP suggest that their stance balance ability is greater than that of individuals in the previous study. Although our study included participants with BSCP classified as level II on the GMFCS, the abovementioned study (Tomita et al. 2024b) included those with a more severe disability [level III: can walk using a hand-held mobility device (Palisano et al. 2008)], which may have caused differences in the CoP positions and path lengths in the anteroposterior LoS.

2. Effects of fingertip light touch contact on the QS and LoS in individuals with BSCP

The significantly shorter CoP path lengths in the QS and anteroposterior LoS under the light-touch condition than under the no-touch condition clearly indicate that stance stability in individuals with BSCP can be increased with fingertip light touch contact. The decrease in the CoP path tended to be observed in both the mediolateral and anteroposterior directions (Figure 2). The perception of anteroposterior LoS positions is reportedly related to somatosensory information from the lower limbs [e.g., plantar pressure sensation (Asai and Fujiwara 2003; Fujiwara et al. 2003) and patellar movement perception (Asai et al. 2017)]. Although sensory functions are often reduced in individuals with BSCP (Damiano et al. 2013; Wingert et al. 2009; Zarkou et al. 2021), sensory impairments in ambulatory individuals with BSCP are milder in the upper limbs than in the lower limbs (Minear 1956). Improvements in stance stability through light touch might be explained by the positive effects of augmented sensory feedback on stance balance control (Assländer et al. 2018; Jeka1997; Jeka and Lackner 1994). Additional somatosensory information arising from the upper limb with fingertip light touch contact may compensate for sensory deficits in the lower limbs in individuals with BSCP. Therefore, these individuals could perceive the CoP position while standing more precisely under the light-touch condition than under the no-touch condition, resulting in an increase in stance stability (i.e., decreased postural sway) in the QS and LoS with light touch contact.

A previous study examining LoS in healthy younger and older adults reported a decrease in the CoP path length and an increase in the anteroposterior LoS with light touch contact (Tomita et al. 2024a). However, our participants did not exhibit an increase in the LoS with light touch contact. Dual task (e.g., performing cognitive task while standing and walking) reduces the performance of standing and walking in individuals with BSCP (Roostaei et al. 2021). Fingertip light touch contact (e.g., <1 N) while standing is considered as a dual task with precise demands (Lee et al. 2019). Although the anteroposterior LoS was measured after several practice trials, maintaining LoS while contacting an object with fingertip light touch is challenging for individuals with BSCP; therefore, the light touch contact may have no effect on the anteroposterior LoS positions.

3. Study limitations

This study had several limitations. First, this study examined only anteroposterior LoS; therefore, the effects of light touch contact on the LoS in the mediolateral and oblique directions remained unclear. Second, the number of participants was relatively small, and their GMFCS level was limited to level II. Third, we did not assess impairments in body function and structure (e.g., sensory deficits in the lower limbs). Fourth, we measured the participants' FL while they maintained the QS and normalized the CoPy position by calculating the percentages of the FL. In healthy young adults, toe flexion is apparent in the anterior LoS (Aoki et al. in press). We did not observe toe conditions during the measurements; therefore, the CoPy position especially in the anterior LoS might be influenced by the toe flexion. Last, although several previous studies have demonstrated that stance stability is improved by light touch not only to an earth-fixed external surface but also to a cane (Jeka 1997). Although no previous studies have examined the effects of contacting a cane on the LoS in individuals with BSCP, performance of the Functional Reach Test is improved by lightly gripping a cane in healthy young adults (Oshita and Yano 2015), raising a possibility that light touch to a cane increases the LoS in individuals with BSCP. Thus, further research is warranted to incorporate our findings into physical therapy programs for improving stance balance in individuals with BSCP.

V. Conclusions

This study is the first to demonstrate that fingertip light touch contact can increase stance stability in the QS and anteroposterior LoS in individuals with BSCP.

CRediT authorship contribution statement

Narumi Kawamata: Formal analysis, investigation, writing – original draft, visualization. **Sayaka Matsushita**: Formal analysis, investigation, and writing – review & editing. **Runa Ichikawa**: Formal analysis, investigation, and writing – review & editing. **Mikito Usukura**: Formal analysis, investigation, and writing – review & editing. **Honoka Ichikawa**: Formal analysis, investigation, and writing – review & editing. **Konomi Natsume**: Formal analysis, investigation, and writing – review & editing. **Rena Mochizuki**: Formal analysis, investigation, and writing – review & editing. **Hidehito Tomita**: Conceptualization, methodology, and writing – review & editing, and supervision.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

References

Aoki Y, Tomita H, Kawaguchi D (2024). Using visual observation of the feet to estimate the center of pressure position during standing in healthy young adults: Part 1. Forward-leaning standing posture. *J Wellness Health Care*, 48(2), 75-80.

Asai H, Fujiwara K (2003). Perceptibility of large and sequential changes in somatosensory information during leaning forward and backward when standing. *Percept Mot Skills*, 96(2), 549–577.

Asai H, Hirayama K, Azuma Y, et al. (2017). Perception of leaning backward while standing and patellar movement. *J Phys Ther Sci*, 29(9), 1670–1674.

Assländer L, Smith CP, Reynolds RF (2018). Sensory integration of a light touch reference in human standing balance. *PLoS One*, 13(6), e0197316.

Bax M, Goldstein M, Rosenbaum P, et al. (2005). Proposed definition and classification of cerebral palsy, April 2005. *Dev Med Child Neurol*, 47(8), 571–576.

Baldan AM, Alouche SR, Araujo IM, et al. (2014). Effect of light touch on postural sway in individuals with balance problems: a systematic review. *Gait Posture*, 40(1), 1–10.

Chen CL, Shen IH, Chen CY, et al. (2013). Validity, responsiveness, minimal detectable change, and minimal clinically important change of pediatric balance scale in children with cerebral palsy. *Res Dev Disabil*, 34(3), 916–922.

Cherng RJ, Su FC, Chen JJ, et al. (1999). Performance of static standing balance in children with spastic diplegic cerebral palsy under altered sensory environments. *Am J Phys Med Rehabil*, 78(4), 336–343.

Damiano DL, Wingert JR, Stanley CJ, et al. (2013). Contribution of hip joint proprioception to static and dynamic balance in cerebral palsy: a case control study. *J Neuroeng Rehabil*, 10(1), 57.

Donker SF, Ledebt A, Roerdink M, et al. (2008). Children with cerebral palsy exhibit greater and more regular postural sway than typically developing children. *Exp Brain Res*, 184(3), 363–370.

Fujiwara K, Asai H, Miyaguchi A, et al. (2003). Perceived standing position after reduction of foot-pressure sensation by cooling the sole. *Percept Mot Skills*, 96(2), 381–399.

Jeka JJ (1997). Light touch contact as a balance aid. *Phys Ther*, 77(5), 476–487.

Jeka JJ, Lackner JR (1994). Fingertip contact influences human postural control. *Exp Brain Res*, 100(3), 495–502.

Kouzaki M, Masani K (2008). Reduced postural sway during quiet standing by light touch is due to finger tactile feedback but not mechanical support. *Exp Brain Res*, 188(1), 153–158.

Lee IC, Pacheco MM, Newell KM (2019). Postural coordination and control to the precision demands of light finger touch. *Exp Brain Res*, 237(5), 1339–1346.

Melzer I, Benjuya N, Kaplanski J, et al. (2009). Association between ankle muscle strength and limit of stability in older adults. *Age Ageing*, 38(1), 119–123.

Minear WL (1956). A classification of cerebral palsy. *Pediatrics*, 18(5), 841–852.

Oshita K, Yano S (2015). The effect of lightly gripping a cane on the dynamic balance control. *Open Biomed Eng J*, 9, 146–150.

Özal C, Aksoy S, Kerem Günel M (2022). Postural control alterations in children with mild forms of spastic cerebral palsy. *Pediatric Health Med Ther*, 13, 367–376.

Palisano RJ, Rosenbaum P, Bartlett D, et al. (2008). Content validity of the expanded and revised Gross Motor Function Classification System. *Dev Med Child Neurol*, 50(10), 744–750.

Rojas VG, Rebolledo GM, Muñoz EG, et al. (2013). Differences in standing balance between patients with diplegic and hemiplegic cerebral palsy. *Neural Regen Res*, 8(26), 2478–2483.

Roostaei M, Raji P, Morone G, et al. (2021). The effect of dual-task conditions on gait and balance performance in children with cerebral palsy: A systematic review and meta-analysis of observational studies. *J Bodyw Mov Ther*, 26, 448–462.

Rose J, Wolff DR, Jones VK, et al. (2002). Postural balance in children with cerebral palsy. *Dev Med Child Neurol*, 44(1), 58–63.

Silkwood-Sherer DJ, McGibbon NH (2022). Can hippotherapy make a difference in the quality of life of children with cerebral palsy? A pragmatic study. *Physiother Theory Pract*, 38(3), 390–400.

Tinetti ME, Speechley M, Ginter SF (1988). Risk factors for falls among elderly persons living in the community. *N Engl J Med*, 319(26), 1701–1707.

Tomita H, Asai H, Ogawa Y, et al. (2024a). Fingertip light touch contact increases anteroposterior limits of stability in healthy young and older adults. *Gait Posture*, 114, 28–34.

Tomita H, Fujiwara K, Fukaya Y (2010). Body alignment and postural muscle activity at quiet standing and anteroposterior stability limits in children with spastic diplegic cerebral palsy. *Disabil Rehabil*, 32(15), 1232–1241.

Tomita H, Kawaguchi D, Takahashi S, et al. (2024b). Quiet standing and anteroposterior limits of stability in adolescents and young adults with bilateral spastic cerebral palsy. *Hum Mov Sci*, 95, 103215.

Tomita H, Kuno S, Kawaguchi D, et al. (2021). Limits of stability and functional base of support while standing in community-dwelling older adults. *J Mot Behav*, 53(1), 83–91.

Tomita H, Takahashi S, Kawaguchi D, et al. (2024c). How does standing anteroposterior stability limits correlate to foot/ankle functions in bilateral spastic cerebral palsy? *Pediatr Phys Ther*, in press.

Towns M, Lindsay S, Arbour-Nicitopoulos K, et al. (2022). Balance confidence and physical activity participation of independently ambulatory youth with cerebral palsy: An exploration of youths' and parents' perspectives. *Disabil Rehabil*, 44(11), 2305–2316.

Vérité F, Bachta W (2021). Cognitive processes and a centre-of-pressure error-based moving light-touch biofeedback. Neurosci Lett, 749, 135743.

Wingert JR, Burton H, Sinclair RJ, et al. (2009). Joint-position sense and kinesthesia in cerebral palsy. *Arch Phys Med Rehabil*, 90(3), 447–453.

Woollacott MH, Shumway-Cook A (2005). Postural dysfunction during standing and walking in children with cerebral palsy: What are the underlying problems and what new therapies might improve balance? *Neural Plast*, 12(2-3), 211–219.

Zarkou A, Lee SCK, Prosser L, et al. (2021). Foot and ankle somatosensory deficits in children with cerebral palsy: A pilot study. *J Pediatr Rehabil Med*, 14(2), 247–255.