Impairment of Stance Control in Children With Sensory Modulation Disorder

Chia-Ting Su, Meng-Yao Wu, Ai-Lun Yang, Mei-Jin Chen-Sea, Ing-Shiou Hwang

OBJECTIVE. To compare stance control between children with sensory modulation disorder (SMD) and typically developing children in various visual and somatosensory conditions.

METHOD. Thirty-one children participated in this study, including 17 children with SMD and 14 matched typically developing children. The Sensory Profile was used to screen for sensory modulation problems, which were further confirmed by measures of electrodermal response and the Evaluation of Sensory Processing. Stance parameters for the assessment of postural stability were obtained with a dual-axis accelerometer on the lumbar area.

RESULTS. The children with SMD presented atypical sensory responses in terms of both electrophysiological and behavioral measures. The results for stance showed a greater body sway in the SMD group than in the control group (p < .05). However, the group difference was not always significant under the conditions of reliable somatosensory input and sway-referenced vision.

CONCLUSION. Our findings first confirmed impaired stance control in children with SMD.


Maintenance of standing balance involves the ability to control the center of mass within the limits of support and is a skill that is especially important for the developing child. A child’s ability to stand unsupported is considered a milestone of gross motor development (Nichols, 2005). Adequate balance is critical for successfully executing many daily activities (Shumway-Cook & Woollacott, 2001), such as getting a book from a shelf. Delayed development of balance impedes subsequent motor development and influences children’s opportunities for engagement in occupations with peers (Parham & Mailloux, 2005; Richardson, Atwater, Crowe, & Deitz, 1992).

A great amount of research has confirmed that stance equilibrium cannot be achieved without continuous sensory feedback, including vestibular, visual, and somatosensory inputs. The brain needs to organize different types of sensory information at the same time so as to perceive the person’s orientation and coordinate the timing, direction, or force level of different limb segments against stance menace (Ayres, 1972; Molloy, Dietrich, & Bhattacharya, 2003; Shumway-Cook & Woollacott, 2001). Before achieving the mature use of sensory strategies, children sway significantly more than adults for maintenance of balance. They are more influenced by visual cues, particularly when inputs from the support surface are not reliable (Woollacott & Shumway-Cook, 1990).

The inability to adequately regulate the degree, intensity, and nature of responses toward sensory information is known as sensory modulation disorder (SMD; Mangeot et al., 2001; McIntosh, Miller, Shyu, & Hagerman, 1999), a problem found in about 5% of the general population (Ahn, Miller,
Milberger, & McIntosh, 2004) and approximately 40%–80% of people with developmental disabilities (Baranek et al., 2002). Although occupational therapists have worked on understanding and improving the daily occupations of children with SMD clinically, empirical research on this population is scarce. The phenomenon can be detected by physiological or parent-report measures (Mangeot et al., 2001; McIntosh et al., 1999; Miller et al., 1999). SMD may co-occur with other medical complications, such as autistic disorders (Mailloux, 2001), cerebral palsy (Blanche & Nakasuji, 2001), and attention deficit hyperactivity disorder (Mangeot et al., 2001).

Children with SMD tend to demonstrate underresponsive responses, overresponsive responses, or both toward sensory inputs (McIntosh et al., 1999; Parham & Mailloux, 2005). Moreover, sensory responses of children with SMD often fluctuate with the types of stimuli and the demands of the situation (Lane, 2002). Children could be overresponsive to a sensory input but become underresponsive to the same sensory stimuli under other circumstances (Parham & Mailloux, 2005). A child with SMD may seek our high-intensity sensory stimulation (sensory seeking) or exhibit fight-or-flight responses to harmless sensory inputs (sensory defensiveness; McIntosh et al., 1999). Because of poor sensorimotor integration after sensory processing problems, children usually look clumsy, and their inadequate control of movement interferes with their daily occupations (Ayres, 1972; Parham & Mailloux, 2005).

Although a few reports on impaired standing balance of children with developmental disorders exist in the literature (Cherng, Su, Chen, & Kuan, 1999; Molloy et al., 2003; Shumway-Cook & Woollacott, 1985), these reports have predominantly focused on children with manifest motor or mental syndromes, such as cerebral palsy (Cherng et al., 1999), Down syndrome (Shumway-Cook & Woollacott, 1985), and autism (Molloy et al., 2003). However, difficulty modulating sensory information should solely influence balance performance. Neither the extent to which stance control is affected nor initial evidence about stance menace of children with pure sensory modulation problems has ever been investigated. Thus, exploring potential stance problems in children with simple SMD (i.e., excluding other medical diagnoses) would be of theoretical and clinical value. The purpose of the study was to contrast the standing balance of children with SMD and typically developing children on application of altered sensory environments using combined visual and somatosensory stimuli in a static upright position.

After we initially recognized impairments in sensory modulation for children with SMD by means of Sensory Profile (SP; Dunn, 1999) scores and further confirmed group differences by means of Evaluation of Sensory Processing (ESP; Johnson-Ecker & Parham, 2000) scores and electrodermal response (EDR), we hypothesized that these children would exhibit a greater body sway than their control peers under different sensory conditions because of poorer ability to process sensory inputs. Specifically, we intended to answer the following research questions: (1) Do children with simple SMD have worse stance control than their control peers? and (2) How do the tested sensory conditions influence balance in children with simple SMD?

Method

Participants

Thirty-one children participated in this study: 14 typically developing children and 17 children with SMD. We used convenience sampling to recruit participants from the local community (Tainan city and county, Taiwan). Typically developing children were recruited through advertisements and by schoolteachers and parent volunteers. The children ranged in age from 4 yr 5 mo to 8 yr 11 mo. We found no significant group differences in age, body weight, height, and gender distribution (Table 1). Using clinical observation, SP scores, and parental interviews, experienced occupational therapists (≥2 years in the field of pediatric therapy) categorized children on the basis of the inclusion criteria as having SMD or being typically developing. Also, all participants had a normal range of motion and good to normal muscle strength on manual muscle testing (Hislop & Montgomery, 1995). Children were excluded from this study if they were diagnosed with medical conditions other than SMD, such as orthopedic or neurological diseases or mental retardation. To confirm the group difference, we used two additional examinations, the ESP and EDR, to help with accurately differentiating sensory modulation abilities between the children with SMD and the typically developing children. If the two examinations failed to distinguish the two groups, we excluded the child in the SMD group who demonstrated typical processing of sensory inputs or the typically developing child who had atypical performance.

Measurement of Sensory Modulation

Both behavioral (i.e., SP and ESP) and physiological (i.e., EDR) measurements were made to assess different aspects of sensory modulation. The SP and ESP are sensory
history questionnaires designed to identify specific sensory processing problems in a child’s daily life by gathering information from parents. The SP assesses the frequency of the child’s responses to certain sensory processing, modulation, and behavioral or emotional events as described in its items (Dunn, 1999). The ESP items are distributed among six sensory systems, and for each item, parents report on a 5-point scale for the frequency of the child’s abnormal behavior in response to sensory stimulation. A lower SP or ESP score reflects poorer regulation of responses to sensory inputs. Both questionnaires are valuable for clinical assessment of sensory processing and exhibit satisfactory reliability and validity (Dunn, 1999; Johnson-Ecker & Parham, 2000).

In addition to using behavioral measures, we physiologically assessed the sensory modulation problem by using the Sensory Challenge Protocol (SCP). SCP is a laboratory paradigm designed to gauge a child’s EDR in response to five types of sensory stimuli (Mangeot et al., 2001; McIntosh et al., 1999; Miller et al., 1999), including olfactory (wintergreen extract on a cotton ball), auditory (fire engine siren sounds played at 90 dB), visual (a 20-W strobe light at 10 Hz), tactile (feather gently moved from right ear to chin to left ear), and vestibular (chair tipped backward 30° smoothly and slowly). Each sensory trial of 3 s was administered 8 times on a standard, pseudorandom schedule with 20 s between each sensory modality. The EDR was obtained over the extended time of five different stimulus presentations (McIntosh et al., 1999) by applying a constant current (0.5 V) across a pair of 5-mm electrodes on the palmar surfaces of the middle section of the second and third fingers of the left hand (Dawson, Schell, & Filion, 1990). The electrodes were attached to a skin conductance coupler (SC5 24-bit digitizing skin conductance coupler, Contact Precision Instruments Inc., London, England), and the skin conductance signal was conditioned with a 0.2-Hz low-cut filter before digitization. The sampling rate was set at 50 Hz. As regulated by cholinergic fibers of the sympathetic nervous system, the EDR has been used to characterize the impairment of sensory modulation (Mangeot et al., 2001; McIntosh et al., 1999; Miller et al., 1999).

### Procedures

Before participant recruitment, the local institutional review board approved this study. We obtained written informed consent from each participant.

After impairments in sensory modulation were initially recognized by SP scores and further confirmed for group difference by ESP scores and EDR, we contrasted stance control. We adopted the Clinical Test of Sensory Interaction and Balance (CTSIB; Shumway-Cook & Horak, 1986) to provide information about the ability to stand upright comfortably under the following six sensory environments: (1) eyes open and fixed-foot support (all sensory modalities enabled), (2) eyes closed and fixed-foot support (visual input absent), (3) sway-referenced vision and fixed-foot support (visual input inaccurate), (4) eyes open and compliant-foot support (somatosensory input inaccurate), (5) eyes closed and compliant-foot support (visual input absent, somatosensory input inaccurate), and (6) sway-referenced vision and compliant-foot support (visual and somatosensory inputs inaccurate; Figure 1).

Three kinds of visual inputs were used during the CTSIB. During Conditions 1 and 4, eyes were open, providing full visual input. During Conditions 2 and 5, eyes were closed, and visual input was occluded. Conditions 3 and 6 required children to wear a dome that partially blocked peripheral vision and moved with head movement so that sway-referenced visual input was achieved (Cherng, Chen, & Su, 2001; Cherng et al., 1999).

Two kinds of somatosensory inputs were used during the CTSIB. During Conditions 1–3, children stood on a hard surface with fixed support for the feet (i.e., reliable somatosensation). Conditions 4–6 required children to stand on soft foam (i.e., a medium-density foam block: 50 cm × 50 cm × 10 cm) that offered compliant support for the feet (i.e., unreliable somatosensation). Except for Conditions 1 and 2, children experienced sensory conflict in the other four conditions (Cherng et al., 2001).

Each stance condition was repeated 3 times. For each time, the children were asked to stand barefoot with feet together and arms hanging by the sides, still, for 30 s. We used the Latin square method to arrange the sequence of

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**Table 1. Demographic Data for the Groups With and Without Sensory Modulation Disorder (SMD)**

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Group Without SMD</th>
<th>Group With SMD</th>
<th>Statistics</th>
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<tbody>
<tr>
<td>Gender (n)</td>
<td></td>
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<tr>
<td>Male</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td>6.8 ± 1.2</td>
<td>6.5 ± 1.2</td>
<td>t(29) = 0.696, p = .492</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>122.0 ± 8.1</td>
<td>123.2 ± 7.7</td>
<td>t(29) = −0.407, p = .687</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>24.8 ± 4.2</td>
<td>23.1 ± 5.3</td>
<td>t(29) = 1.018, p = .317</td>
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the 18 trials to preclude the possibility of learning, carry-over, and order effects on performance.

**Measurement of Stance Control**

During CTSIB examination, body sway was recorded for 30 s. We adopted a convenient approach to measure body sway by placing a dual-axis accelerometer (Model ADXI.202, Analog Device, Norwood, MA) around the center of mass in the lumbar region (L3; Moe-Nilssen & Helbostad, 2002). Accelerometer recording has been shown to be a reliable method with which to study standing balance in the clinic and to have good test–retest reliability (Moe-Nilssen & Helbostad, 2002). The outputs of accelerometer data contained two orthogonal acceleration components in the anterior–posterior (AP) and medial–lateral (ML) directions. The recorded data of body sway were conditioned with low-pass filters (cutoff frequencies were set at 4 Hz) and digitized at 400 Hz using a specific computer program constructed on a Labview 6.1 platform (National Instruments, Austin, TX).

**Data Analysis**

The EDR was represented by the mean magnitude of reactions across five sensory domains (McIntosh et al., 1999) to characterize the capacity of sensory modulation. We defined significant changes in EDR to sensory stimuli as electrodermal activities that (1) were ≥0.05 micromhos in amplitude above the baseline, (2) occurred ≥1 s after each stimulus and 0.6 s before the subsequent stimulus, and (3) occurred ≥0.6 s after a previous peak (Dawson et al., 1990). The local maximum after the presence of sensory stimulation was determined (Figure 2a). For each participant in the SMD and control groups, the average of the maximum amplitude of five different stimulus presentations represented the mean magnitude of reactions (Mangeot et al., 2001; McIntosh et al., 1999; Miller et al., 1999).

To ensure stable stance recording, we analyzed the accelerometer data from only the middle 20 s of a total of 30 s. The magnitude of body sway in each sensory condition was represented by averaging the three trials of the values of the mean root-mean-square (RMS) of L3 accelerometer data. To contrast performance in the two groups of children under different sensory conditions, we examined mean RMS values of accelerometer data in the ML and AP directions for each condition by using repeated-measures analysis of variance (ANOVA) using a 2 (group) × 3 (type of visual input) × 2 (type of somatosensory input) factorial design. Group was a between-subjects factor, and type of visual and somatosensory inputs were within-subjects factors. Post hoc analysis included a comparison of L3 acceleration RMS between the two groups using an independent t test for each sensory condition. We
compared group differences in sensory responses, including EDR and ESP, using an independent t test. All statistical analyses were performed using Version 14 SPSS software (SPSS Inc., Chicago). The level of significance was set at \( p < .05 \).

Results

Examples of representative EDR measurements of the children with SMD and the typically developing children are shown in Figures 2a and 2b. We noted evident larger amplitudes and more frequent EDR with less evidence of habituation over repeated exposure to sensory stimulus for the child with SMD in contrast to the typically developing child. In addition, sensory stimulation elicited rapid recovery of skin potential for the child with SMD, whereas the typically developing child presented slow recovery of skin potential. The results of the independent t tests indicated that the SMD group presented a significantly greater peak amplitude of EDR and a lower total ESP score than the control group \( (p < .05, \text{Table 2}) \). These findings suggest that children with SMD had atypical behavioral and physiological responses in the presence of sensory stimuli.

Figure 3 shows representative accelerometer recordings in the AP direction from a child with SMD and a typically developing child while standing upright in different sensory conditions. A greater body sway was observed in the child with SMD during the tested conditions. For both the AP and ML directions, the results of the three-way ANOVA showed a significant group difference in L3 acceleration RMS with greater body sway in the group \( (F[1,29] = 6.605, \text{ML direction: } F[1,29] = 8.564, p < .05) \). In addition, a main effect of the type of visual and somatosensory inputs on body sway was significant \( (\text{AP direction: } F[1,29]_{\text{visual}} = 46.955; F[1,29]_{\text{somatosensory}} = 109.087, p < .05; \text{ML direction: } F[1,29]_{\text{visual}} = 61.321; F[1,29]_{\text{somatosensory}} = 172.176, p < .001; \text{Table 3}) \).

With respect to body sway in the AP direction, two-way interactions were statistically significant \( (\text{Type of Children} \times \text{Type of Visual Input: } F[2, 58] = 3.880, p < .05; \text{Type of Visual Input} \times \text{Type of Somatosensory Input: } F[2, 58] = 10.484, p < .05) \). Post hoc testing showed that children with SMD had poorer stance control than typically developing children for all visual input types \( (p < .05) \), except for the condition of reliable somatosensory input with sway-referenced vision \( (p > .05; \text{first half of Table 3}) \). In the ML direction, the two-way interaction was only significant between the type of somatosensory input and the type of visual input \( (F[2, 58] = 21.721, p < .001) \). Results revealed that body sway of the child with SMD was greater than that of the typically developing child for all visual input types under the condition of unreliable somatosensory input \( (p < .05) \). In the case of reliable somatosensory input, only visual occlusion resulted in a significant difference in body sway of the two groups \( (p < .05; \text{second half of Table 3}) \).

Discussion

The current study appears to be the first work to validate stance menace in children with simple SMD, who demonstrated manifest sensory modulation problems without inferior muscle power or range of motion. The children with SMD had poorer stance control than their typically developing peers in most of the tested sensory conditions, except for the conditions of reliable somatosensory input and sway-referenced vision \( (\text{AP and ML directions}) \) and of reliable somatosensory input and normal vision \( (\text{ML direction only}) \). The findings highlight a deterioration of standing balance that might cause falling in children with SMD under altered sensory environments in daily occupations.

Consistent with previous studies, the children with SMD in this study exhibited lower total ESP scores \( (\text{Johnson-Ecker & Parham, 2000}) \) and larger EDR peak amplitudes than did the typically developing children \( (\text{McIntosh et al., 1999}) \). These facts validated that the children with SMD had difficulty in grading responses to sensory inputs \( (\text{Miller, Reisman, McIntosh, & Simon, 2001}) \). The children with SMD in our study were mostly hyperresponsive in light of larger amplitudes of EDR \( (\text{Table 2}) \) and less habituation over sensory exposures than the typically developing children \( (\text{Figure 2; McIntosh et al., 1999}) \). EDR hypersensitivity with large amplitudes and fast recovery has also been found in children with autism, but children with autism were found to be nonresponsive to initial stimulus more often (van

<table>
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<tr>
<th>Measure of Sensory Modulation</th>
<th>Group Without SMD</th>
<th>Group With SMD</th>
<th>Statistics</th>
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<tbody>
<tr>
<td>ESP score</td>
<td>317.1 ± 13.0</td>
<td>259.7 ± 13.8</td>
<td>t(29) = 11.914, ( p &lt; .001 )</td>
</tr>
<tr>
<td>EDR (micromhos)</td>
<td>0.040 ± 0.022</td>
<td>0.066 ± 0.028</td>
<td>t(29) = -2.968, ( p = .003 )</td>
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Note: SMD = sensory modulation disorder.
Engeland, 1984). For children with SMD, the physiological overresponsivity of EDR is considered to be a request for greater allocation of central resources for processing sensory information (Filion, Dawson, Schell, & Hazlett, 1991). It is rational to assume that the attentional load to deal with balance threats could be greater for the children with SMD under sensory conflicts (Lane, 2002). In fact, body sway in terms of L3 acceleration of children with SMD was generally greater than that of typically developing children except under the conditions of reliable somatosensory input and sway-referenced vision (AP and ML directions) or of reliable somatosensory input and normal vision (ML direction only; Table 3). The poorer stance control detected in children with SMD supports the assumption that inappropriate sensory modulation would interfere with the maintenance of balance (Ayres, 1972; Parham & Mailloux, 2005).

The most interesting finding of the study was that the difference in stance control between the children with SMD and the typically developing children varied with the nature of the sensory conditions. When somatosensory input was unreliable (Conditions 4, 5, and 6), the children with SMD increased sway much more than did the typically developing children, which could be contributed by the sensory conflict. When somatosensory input was reliable, body sway did not differ between the two groups under the condition of inaccurate visual input and fixed-foot support (Condition 3). The results might suggest that (1) children with SMD had problems in reweighing their preferential dependence on somatosensory input to vestibular information, which plays an important role under conflicted sensory conditions (Conditions 3–6; Hirabayashi & Iwasaki, 1995; Shumway-Cook & Woollacott, 2001); (2) the posture control of the children with SMD was relatively robust when inaccurate visual information conflicted with reliable somatosensory information; and (3) children with SMD appeared to be capable of resolving less intensive sensory conflicts.

Figure 3. Representative accelerometer data on the lumbar area for the six conditions of the Clinical Test of Sensory Interaction and Balance (CTSIB) for (A) a child with sensory modulation disorder and (B) a typically developing child.

Note. CTSIB conditions: (1) fixed-foot support with eyes open, (2) fixed-foot support with eyes closed, (3) fixed-foot support with sway-referenced vision, (4) compliant-foot support with eyes open, (5) compliant-foot support with eyes closed, and (6) compliant-foot support with sway-referenced vision.
sensory conflict (Condition 3) but failed to cope with more challenging sensory conflicts (Conditions 4–6) as competently as did their control peers. Sway-referenced vision is designed to provide orientationally inaccurate visual cues (Shumway-Cook & Horak, 1986) and is supposed to provide participants with a greater challenge to balance maintenance than full vision and occluded vision (Cherng et al., 2001; Shumway-Cook & Horak, 1986). However, input during sway-referenced vision with reliable somatosensation did not result in a greater postural threat to children with SMD, as we expected it to. Because children with SMD are used to increasing reliance on visual processing in compensation for frequent conflicting vestibular and somatosensory information in daily occupations (Ayres, 1972; Parham & Mailloux, 2005), we speculate that they might tactically develop a unique strategy for interpreting inaccurate visual cues during upright stance when limited sensory conflicts are presented. In fact, the dependence on visual processing during stance control for children with SMD could exist because the group effect on body sway in the AP direction was subject to the type of visual input rather than the type of somatosensory input (first half of Table 3). However, further research is needed to clarify this speculation.

Another interesting finding was that body sway in the ML direction of the children with SMD did not differ significantly from that of the typically developing children under the condition of reliable somatosensory and visual inputs (Condition 1; second half of Table 3). On the contrary, a group difference in body sway was present in the AP direction during Condition 1 (first half of Table 3). When facing a smaller postural threat, such as during Condition 1, ankle strategy was preferentially adopted for maintaining stance (Horak & Nasher, 1986), in which body sway would be more apparent in the AP direction. By contrast, when the challenge for balance increased, such as standing on fixed-foot support with occluded vision (Condition 2), additional hip strategy in control of horizontal sway (Winter, Parla, Prince, Ishac, & Gielo-Perczak, 1998; Winter, Prince, Frank, Powell, & Zabjek, 1996) might be adopted by children, in which body sway would also become more detectable in the ML direction and a group difference would emerge. Thus, the directional-dependent difference in body sway between groups could be a result of different stance strategies being adopted when facing different degrees of postural threat, and therefore, we could not find significant group difference in body sway in the ML direction under Condition 1.

Although most of the children with SMD in this study tended to be overresponsive (their mean amplitudes of EDR were larger), the participant selection criteria should consider sensory overresponsivity, sensory underresponsivity, and sensory seeking or craving to be different subtypes of SMD (Miller, Anzalone, Lane, Cermak, & Osten, 2007). It appears that different sensation strategies (such as seeking or avoidance) may lead to different predictions for postural sway. However, confirmation for the consistent dimension of SMD
with sensory overresponsivity, underresponsivity, or sensory seeking or craving is not simple in practice. People with SMD, particularly those with overresponsivity to sensation, frequently fail to meet a fixed criterion for medical or psychological diagnoses (Reynolds & Lane, 2007) because children’s neurological threshold and behavioral responses to incoming stimuli often fluctuate with the demands of the situation (Lane, 2002) and anxiety level. Miller, Coll, and Schoen (2007) adopted stringent criteria and expected to recruit a homogeneous group of children with SMD; however, recruitment resulted in a heterogeneous sample (such as overresponsivity combining with underresponsivity). Thus, in this study we generalized from samples with global problems in sensory modulation, without contrasting stance control among typically developing children and subgroups with SMD. In fact, regardless of subtypes, our study suggested that children with SMD had poorer stance control.

For clinical application, this study’s findings provide occupational therapists with evidence to support their clinical observation and concerns regarding motor difficulties, especially impaired standing balance, in children with SMD. We hope the results will bring new insight into the unique balance strategy or difficulties of children with SMD regarding their stance performance under various sensory conditions. Some findings could inspire different perspectives in clinical reasoning in the treatment of children with SMD. Specifically, our study indicates that the group difference in stance control varied with the nature of the sensory conditions, which suggests that a change of sensory environment can either increase the challenge in clinical treatment or improve the adaptation of daily occupations for children with SMD. For instance, we found that the children with SMD always demonstrated poorer stance control than did the typically developing children when standing during the conditions of unreliable somatosensation. This finding could imply that the activities conducted on the support surface of unreliable somatosensation may be particularly challenging or effective for training children with SMD in standing balance ability. However, if the primary goal of intervention is to help children to adapt better in daily life, we suggest that occupations that require stance control be executed on a support surface of reliable somatosensation.

As another example, our results indicate that the processing of visual input seemed particularly important for the balance strategy of children with SMD, and they might even develop a unique strategy for interpreting inaccurate visual cues. This result implies that the appropriate application of visual cues could effectively influence the execution of daily occupations for children with SMD. Also, directional-dependent difference (AP and ML) in body sway between groups suggests that different stance strategies be adopted when facing different degrees of postural threat. Thus, in addition to our traditional sensory interventions, motor strategy training might also influence children’s performance in daily occupations. As noted, although these implications were in part supported by our findings, future studies are necessary to further explore these speculations.

Moreover, regarding clinical assessment, our study supported use of the accelerometer on the lumbar region as a convenient and successful measure to detect body sway for identifying balance problems in children with SMD. Also, our data from either ESP or EDR (as seen in Table 2) supported use of the SP to successfully identify children with SMD. Before finding an accessible method for clinicians to test electrodermal responses, we suggest that the SP be applied clinically for screening for SMD.

In summary, as a consequence of impairment in sensorimotor integration and an inferior capacity to settle intersensory conflicts, the children with SMD exhibited a lower degree of stance control under altered sensory conditions. The findings validate theoretical assumptions and clinical observations from occupational therapists about postural disturbance in children with SMD. A consequence of developing unique compensatory strategies in the face of sensory conflicts may contribute to the clumsiness of some children with SMD. Our findings may justify therapeutic intervention to ameliorate potential postural menace for children with SMD.

**Acknowledgment**

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**References**


