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Sensory processing disorder and vestibular rehabilitation: A pediatric Case Report

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Abstract

Background: This case report describes changes in postural stability in a patient with sensory processing disorder (SPD) after participating in a vestibular rehabilitation therapy (VRT) program.

Case Presentation: The patient was an 8-year-old male with SPD. Results of the computerized dynamic posturography (CDP) testing suggested vestibular system impairments and postural instability. A specific type of VRT called gaze stability exercises were prescribed as a home exercise program (HEP) and performed for 3 months.

Discussion: Because vestibular system impairments were identified, the patient was evaluated by a physical therapist that specialized in vestibular rehabilitation. Because SPD often includes attention deficits, the HEP was modified to improve task attention and ensure correct performance. The patient was assessed and reassessed over a period of 3 months and CDP revealed marked improvements in vestibular system integrity and postural stability.

Conclusion: This case report describes the vestibular system integrity and postural stability improvements in a patient with SPD after a 3 month VRT HEP. VRT can be easily performed at home with parental or caregiver guidance. Based on our findings, further research is warranted.

Keywords: Sensory processing disorder, vestibular rehabilitation, postural stability

Background

Sensory integration has been described as a framework for how the body processes sensory input from the environment [1]. Optimization of "fit" between patient and environment may help manipulate task demands to improve quality of actions [2]. Ayres theorized that impaired sensory processing may affect function and developed the term sensory integration dysfunction [3,4]. Sensory processing disorder (SPD) "affects the way the brain interprets incoming information and the response that follows, causing emotional, motor, and other reactions that are inappropriate and extreme [5]. "SPD affects approximately 16% of school-aged children involving disruption in their activities of daily living with prevalence estimates of sensory processing disorders based on clinical experience ranging from 5%-10% for children without disabilities [1,4,6-8]. Children with SPD have been described as being "simply wired differently [9]. "Caregiver report measures and standardized assessments, such as the Sensory Profile, are used to classify and describe patient sensory behaviors and deficits [1,7,10,11]. One of the main SPD categories is sensory-based motor disorders with proposed subtypes including postural disorder, which can be characterized by poor balance and postural stability [12,13]. Postural stability provides a stable base for refined movements via integration of vestibular, proprioceptive and visual information [13]. Sensory integration therapy (SIT) was originally designed for children with learning disabilities with SPD or sensory integration dysfunction [3,13,14]. SIT is considered a controversial intervention and research has not clearly demonstrated that SIT is more effective than other interventions [14]. Sensory-based therapies, treatments and interventions

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(SBIs) use sensory modalities (e.g., vestibular, touch, auditory) with passive activities (e.g., weighted vest) to more dynamic activities (e.g., wall climbing) and are considered a component of a comprehensive treatment plan [1,14-16]. Because many children with SPD present with sensory-based motor disorders, the vestibular system and postural stability are often affected [12,17-19]. The purpose of this case report was to describe the effect of VRT on postural stability in a patient with SPD.

Case presentation

The patient was an 8-year-old male whose parents, both of who mare physical therapists and contributing authors of this case report, noticed that age appropriate milestones were not being reached. At approximately 5 months of age, the patient presented with signs of low tone and decreased trunk control and difficulty lifting his head while maintaining a prone position. The patient did not have any co-morbidities or major diseases. The patient could speak single words at age 2 but could not speak full sentences by age 4. Additionally, the patient had difficulty dealing with different environmental sensory inputs including loud sounds, food textures, tight clothing, inability perceiving painful stimuli as expected, inability to focus on tasks in order to complete them, and difficulty focusing visually on a task. Given these signs and symptoms, the patient's parents sought medical consultation. Ultimately, over the course of 4 years, the patient received speech therapy, sensory integration therapies for motor control, visual, smell and auditory stimulation, right hemisphere stimulation exercises (including breathing exercises, smell stimulation, primitive reflexes exercises), and cognitive therapy; with moderate improvements in cognitive, speech and motor control behaviors. The patient was eventually diagnosed with SPD at 8 years old. The SPD diagnosis was based on psycho-educational assessments including cognitive, social/emotional, memory and functioning related to academics, language, reading, spelling, writing, math and visual functioning. Motor assessments revealed sensory processing inefficiencies in body awareness, bilateral coordination, postural stability, visual-motor integration, motor planing and handwriting. Processing of vestibular and visual information was below age level on bilateral coordination and balance tests. Given this information, the parents scheduled a consultation with a physical therapist that specialized in vestibular rehabilitation.

Vestibular rehabilitation

One of the main sensory systems affected by SPD is the vestibular system. SBIs primarily aim to provide stimulation to these systems where vestibular-based interventions can be provided with therapy balls, therapy cushions, therapeutic horse back riding, and swings [16,20,21]. Because the vestibular and visual systems are closely related, some of the primary goals of VRT include improving gaze and postural stability [22,23]. SPD includes challenges related to sensory-based processing and often affects motor planning and/or postural stability [24]. During the initial physical therapy consultation, sensory organization testing was performed using the Bertec Balance Advantage™ Dynamic Computerized Dynamic Posturography (CDP) under six conditions (in the following order) [25]:

Condition 1: Stable platform with stable visual scene
Condition 2: Stable platform with eyes closed
Condition 3: Stable platform with unstable visual scene
Condition 4: Unstable platform with stable visual scene
Condition 5: Unstable platform with eyes closed
Condition 6: Unstable platform with unstable visual scene

Each condition included three 20-second trials and the average was calculated.

CDP can identify non-specific vestibular system deficits and provide information about a person's ability to properly integrate vestibular system information with information from other sensory systems [26]. The Bertec CDP calculates postural stability and generates an equilibrium score. Signals from the participant's efforts to maintain his/her balance are sampled and analyzed at 1,000 Hz, and the sway path is computed. The testing protocol calculates the sway path from the equilibrium scores, quantifying how well the participant's sway remains within the expected angular limits of stability under each testing condition. The following formula was used to calculate the equilibrium score (ES):

$12.5°–(taMAX – taMIN)]/12.5°)\times100$. ES uses 12.5° as the normal limit of the anterior–posterior sway angle range; taMAX is the theta maximum and taMIN is the theta minimum. The sway angle was calculated with the following formula: sway angle $=\arcsin(COGy/[0.55 \times h])$, where y=anterior–posterior sway axis and h=participant's height in centimeters or inches. The inverse sine of the center of gravity (COG) was divided by 55% of each person's height. Participants showing little sway will have equilibrium scores near 100, whereas subjects whose sway approaches their limits of stability will have scores near zero [25].

Results of the CDP testing suggested vestibular system impairments and postural instability (Figure 1). Based on the findings, a specific type of VRT called gaze stability exercises were prescribed as a home exercise program (HEP) to directly stimulate the vestibular system. The HEP was performed with the patient sitting upright and parent holding an optotype at eye level approximately 3 feet away. The HEP was modified in order to improve task attention by including16 different 48-font capital letters on flash cards as optotypes. The patient then rotated his head smoothly from side to side for 30 seconds. The HEP modification included changing the letter every couple of seconds and having patient read the letter out loud to keep him focused for the 30-second duration. The patient performed 3 sets of the exercises with rests of 30 seconds between sets 1 time per day. The patient was compliant with the HEP performing an average of 4-5 times per week.

Results

The physical therapy follow-up visit was conducted 3 months

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later. The results of the CDP demonstrated marked improvement in vestibular system integrity and improved postural stability. The CDP re-examination demonstrated changes in overall equilibrium scores. The CDP condition 5 best represents vestibular system integrity as eyes are closed and platform is unstable. The composite score represents the overall equilibrium score across all testing conditions. The pre-treatment composite equilibrium score was 51 (**Figure 1**) and the post-treatment was 68 (**Figure 2**), representing a 25% increase in postural stability. The pre-treatment average for 3 trials of CDP condition 5 (C-5) was 19 (**Figure 1**) and the post-treatment average was 53.3 (**Figure 2**), representing a 64% increase in vestibular system function.

Discussion

This case report describes the impact of VRT on postural stability and vestibular system integrity in a child with SPD. There is no universal framework for diagnosing SPD and sensory-related behaviors; sensory deficits are based on parents or caregivers' reports and assessments [1,7]. The patient in this case report was diagnosed with SPD after several years of receiving treatments for sensory integration difficulties. Because vestibular system impairments were identified, the patient was evaluated by a physical therapist that specialized in vestibular rehabilitation. Because SPD often includes attention deficits, the HEP was modified to improve task attention and ensure correct performance by providing a variety of different optotypes that the patient read out loud during the exercise [6,7,9]. The patient was assessed and reassessed over a period of 3 months and CDP revealed marked improvements in vestibular system integrity and postural stability.

Although the effectiveness of sensory integration treatments

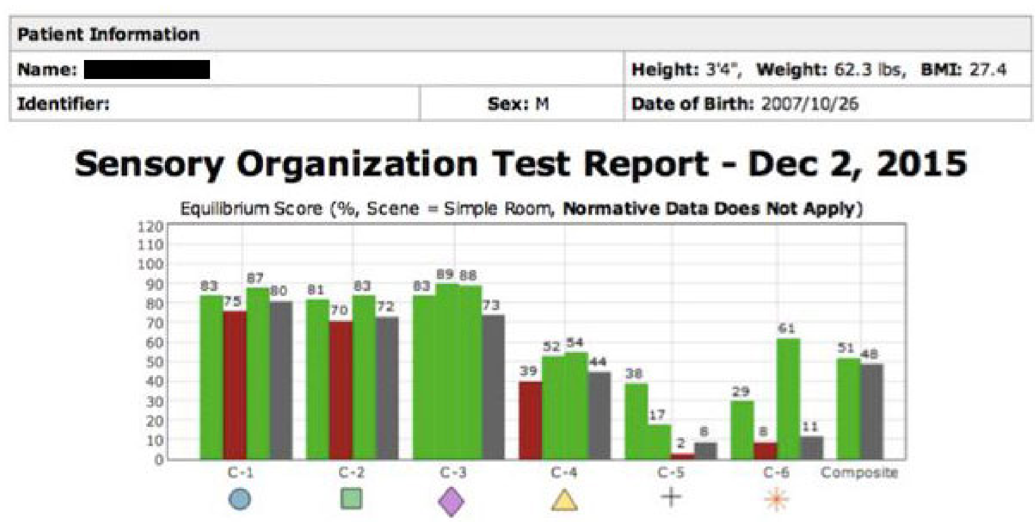

Figure 1. Sensory Integration Initial Examination.

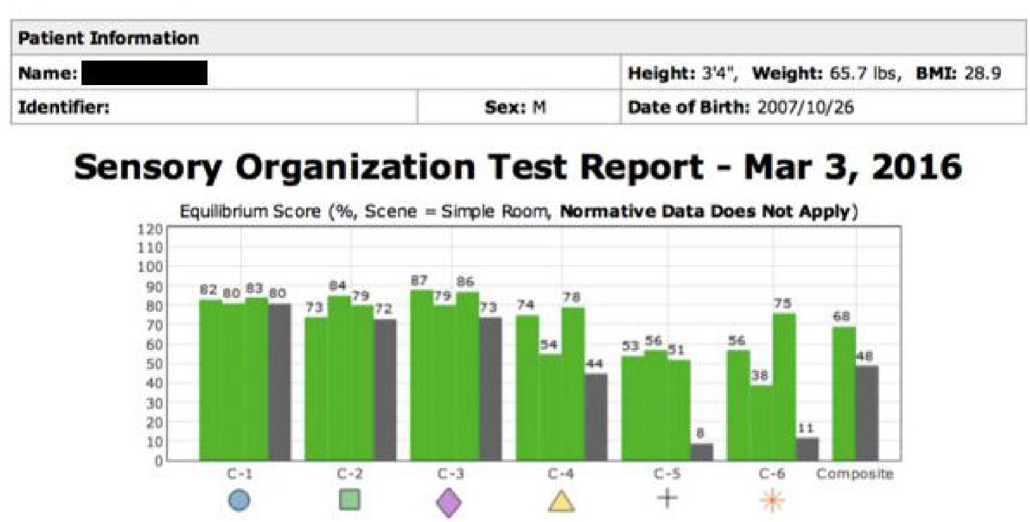

Figure 2. Sensory Integration Re-Examination.

have been questioned in the literature; the patient in this case report improved his postural stability after a HEP of specific VRT progressive gaze stability exercises were prescribed [17]. Early intervention is important once SPD has been diagnosed in order to provide the "just right challenge" based on the child's skill level [12,27,28]. Providing opportunities for processing sensory information is important for adaptive responses to occur and often requires modifying the child's environment [19,29]. Sensory integration treatment uses multisensory environments that involve activities including vestibular sensory input [12,30]. Repetition can help the child's brain process sensory stimulation more normally and begin to interact effectively within sensory environments [12,31]. It has been hypothesized that repetition of normal responses to sensory stimuli creates new neural pathways and provides a stable surface for participating in real-world environments [30,32]. A HEP of gaze stability exercises with specific modifications to maintain task attention were used to provide repetitive vestibular stimulation. The results suggest improved sensory stimulation processing and postural stability.

Conclusion

This case report describes the postural stability and vestibular system integrity improvements, as measured by CDP, in a patient with SPD after a 3 month VRT program. Vestibular exercises can be easily performed at home with parental or caregiver guidance. Based on our findings, further research is warranted in this area of clinical research.

List of abbreviations

SPD: Sensory processing disorder
VRT: Vestibular rehabilitation therapy
CDP: Computerized dynamic posturography
HEP: Home exercise program
SIT: Sensory integration therapy
SBI's: Sensory-based therapies treatments and interventions
taMAX: Theta maximum
taMIN: Theta minimum
ES: Equilibrium score
COG: Center of gravity

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Authors' contributions	PM	LJM	EGJ
Research concept and design	✓	✓	✓
Collection and/or assembly of data	✓	✓	✓
Data analysis and interpretation	✓	✓	✓
Writing the article	✓	✓	✓
Critical revision of the article	✓	✓	✓
Final approval of article	✓	✓	✓
Statistical analysis	--	--	--

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