Pediatric Vestibular Rehabilitation: A Case Study

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Background: A 9-year-old child with a 9-month history of complaints of dizziness, headache, and motion sensitivity came to physical therapy. The child complained of difficulties playing on a playground, running, riding in a car, watching "action movies," sitting under fluorescent lights, and making quick head movements.
Methods: An initial evaluation included a clinical oculomotor examination, vergence testing, static and dynamic visual acuity testing, head impulse testing, subjective visual vertical, balance testing, the pediatric vestibular symptom questionnaire, the Dizziness Handicap Inventory—child caregivers version (DHI-PC) and a visual vertigo analog scale. Physical therapy included virtual reality with Xbox games plus adaptation, habituation, and balance exercises. She was seen once per week and given a home program of exercises 2 to 3 times a day.
Results: After 10 treatment sessions, she reported that playing was easier, headaches had reduced, she could travel as a passenger in a car for long distances without complaints, and that she could watch 3-dimensional action movies without symptoms. Her pediatric vestibular symptom questionnaire scores had reduced from 0.7 to 0.1. The DHI-PC had decreased from 22 to 12 points and her visual vertigo analog scale scores were improved.
Conclusions: Vestibular rehabilitation improved this child's quality of life. She was able to return to her daily living activities with fewer symptoms. (Pediatr Phys Ther 2019;31:E14–E19)
Key words: balance, child, dizziness, headache, quality of life, vestibular rehabilitation

INTRODUCTION

Li et al[1] suggested a prevalence of vestibular dysfunction in children of 5.3% (3.3 million children). Prevalence increases with age from 4.1% in children between the ages of 3 and 5 years to 7.5% in children aged 15 to 17 years.[1] Although most children rated their symptoms as a "small problem," 18.6% (600 000 American children) described their symptoms as a "moderate," "large," and even "very large" problem. Approximately 36% of children seek help to solve their dizziness problems and only 29% receive treatment.[1] Migraine is the most common cause of dizziness in children (17%-40%).[2] Dizziness, disequilibrium, and nausea, associated or not with headache, are frequent symptoms.[3] Children with migraine often experience motion sickness.[4] Cuomo-Granston and Drummon[5] report that migraine and motion sickness both involve mechanisms in the brainstem with the headache and motion sickness symptoms sharing the same neural circuitry. The persistence of disturbances in these brainstem pathways increases vulnerability to recurrent attacks of migraine and increases susceptibility to motion sickness. Vestibular tests are often normal in persons with migraine.[6] Anxiety is another symptom frequently found in children who experience dizziness and desequilibrium.[7] According to Tarantino et al,[8] anxiety levels are higher in children with migraine and they experience more anxious feelings in school, social relationships, and separation from parents.

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DESCRIPTION

L.S is a 9-year-old girl referred by her pediatrician to vestibular rehabilitation. She had a history of 9 months of dizziness, headache, and motion sensitivity. The dizziness was described by her as feeling like she was on a boat and it did not always coincide with the headaches. Stomach discomfort was present with some of the events—events that happened 2 to 3 times per week. The child complained of difficulties playing on a playground, running, riding in a car, watching "action movies," sitting under fluorescent lights, and making quick head movements.

L.S's eye examination and magnetic resonance imaging were normal. She denied a history of concussion. Her mother had a history of migraine and reported that her daughter was seen by her family as an anxious child. When her child started to

complain of dizziness, her anxiety got worse. She was taking the following medications at the time of evaluation: Singulair, adera (vitamin D), Sedatif (aconitum napellus 6ch), melatonin, and Dramamine.

A clinical oculomotor examination, vergence testing, static and dynamic visual acuity testing, head impulse testing, subjective visual vertical (SVV), balance testing, functional reach, the pediatric vestibular symptom questionnaire (PVSQ),[9] the Dizziness Handicap Inventory—child caregivers version (DHI-PC),[10] and the visual vertigo analog scale (VVAS) were completed.[11] An informed consent was signed by her mother before starting the examination.

Oculomotor Testing

There was no spontaneous nystagmus in room light or with infrared goggles.[12] Saccadic and smooth pursuit eye movements were normal. Her vergence score was 3 cm, which was also normal.[13,14]

Clinical Tests of the Peripheral Vestibular System

She had a negative head impulse test (HIT) to the right and to the left. The HIT is considered positive if at least 2 corrective saccades are observed to the right and/or to the left.[15,16] She had no nystagmus with the head shake test.[17] Her dynamic visual acuity testing was normal. A dynamic visual acuity test is considered positive if 10 optotypes (ie, 2 lines are lost).[16] L.S.'s SVV score was 0.6°. Scores of 2° or less are considered normal for the SVV test.[18]

Balance Testing: Static and Dynamic

During the Modified Clinical Test of Sensory Interaction on Balance, L.S. stood for 120 seconds during 4 timed conditions: eyes open on a stable surface, eyes closed on a stable surface, eyes open on a foam pad, and eyes closed on a foam pad. Each trial was 30 seconds for a total of 120 seconds. Her arms were crossed on her chest and her shoes were off.[16] She had some small oscillations with eyes closed on foam but the total score was normal. Her functional reach score was 21 cm.[19]

Pediatric Vestibular Symptom Questionnaire

The PVSQ[9] is an 11-question tool that asks the children about how often they experience various vestibular-related symptoms such as feeling that things are spinning or moving around, unsteadiness so bad that they fall, or feeling sick. The PVSQ questionnaire is useful for children between the ages of 6 and 17 years. Each item is rated on a 0 (never) to 3 (most of the time) scale. A "don't know" category is also included. The score is based on the equation: total score/(total number of questions asked—"don't know" replies). Higher scores indicate greater symptom severity. A cutoff score of less than 0.68 out of 3 distinguished between children with and without vestibular diagnoses with a sensitivity and specificity of 95% and 85%, respectively.[9] Her PVSQ score was 0.7 and is considered normal, yet she was close to the cut score.

Vanderbilt Pediatric DHI-PC

The DHI-PC[10] has 21 questions and was developed for parents or caregivers to comment on their children's dizziness symptoms. The aim is to have a better understanding how dizziness or balance issues are affecting life. Some examples of the questions include the following: Does your child's problem make him or her feel tired? Is your child's life ruled by his or her problem? Does your child's problem make it difficult for him or her to play? The responses are scored from "yes" (4 points), "sometimes" (2 points), or "no" (scored as 0). The DHI-PC total score of 0 to 16 is classified as no participation and activity limitation. A score of 16 to 26 indicates participation and activity limitation and a score of 26 to 43 is moderate participation and activity limitation. The DHI-PC instrument has high internal consistency for the total scale (Cronbach $a = 0.93$) and a high test retest reliability ($r = 0.98$, $P \leq .001$).[10] Parent report of her Vanderbilt score was 22.

Visual Vertigo Analogue Scale

L.S. was asked to rate from 0 to 10 the dizziness that she experiences in each of 9 situations (eg, walking in a supermarket, or riding in a car) on an analogue scale by drawing a line on a 10-cm anchored line. The number 0 is no dizziness and the number 10 the most dizziness that she ever experienced. The Cronbach α index indicated that the VVAS is internally consistent and reliable (Cronbach $\alpha = 0.94$) in adults.[11] There is no study published using VVAS in children but we decided to use this in this child to have some indication about her vertigo perception before and after vestibular rehabilitation. The child reported that riding in a car (score of 5.7 at VVAS), being under fluorescent lights (score of 3 at VVAS), walking through a shopping mall (score of 7.8 at VVAS), watching a movie at the movie theatre (score of 0.7 at VVAS), and watching action television (score of 0.7 at VVAS) made her symptomatic.

INTERVENTION

The child was seen once a week for 10 weeks with the goal of reducing her feelings of dizziness and improving her quality of life. Therapy sessions lasted for 60 minutes and were adaptation, habituation, and balance exercises plus Xbox Kinect games complemented the therapy program but only after the sixth session. A home exercise program was also given with similar exercises lasting for about 20 minutes each session. The child performed 3 times a day for 2 weeks, then 2 times per day for 2 months, and then at the end of care, she did her exercises 1 time per day.[20]

Adaptation Exercises

The primary goals of adaptation exercises are to improve gaze stability and balance ability and to diminish symptoms.[21] Because of this, we introduced this type of exercises even though her HIT was normal.

She started with VOR X 1 with the child asked to look to a stationary sticker and move the head in the yaw and pitch planes at 2 Hz according to a metronome while seated for

1 minute. L.S. was asked to stop when she started to feel uncomfortable (started to feel a headache, to see unclearly, or started to have stomach discomfort). She was advised that dizziness could occur after the end of the session but could last only 20 minutes. If it lasted more than 20 minutes, she was asked to slow her head velocity or decrease her amplitude of head movement.

After 1 week, we started to do X1 in the standing position and at the third week, she stood on an unstable surface using the Airex (Airex AG, Industrie Nord 26, Switzerland) balance pad (19.7 × 16.1 × 2.4 in). She started to use high-contrast backgrounds, and then the X2 exercise was added. On the VOR X2 exercise, the sticker was not stationary, as the sticker (target) moves in the opposite direction as of the head movement. L.S. was also asked to perform VOR X1 while looking at a book (Figure 1) where there were small figures and letters that the child had to identify while she moved her head in the horizontal and vertical plane. She was asked to jump on a trampoline, jump rope, or move from one side to the other while identifying figures in a book or "flashcards."

Habituation

Habituation refers to the reduction of a response by repeated exposure to a provocative stimulus. The primary goal would be reduction of vertigo and dizziness symptom.[21] L.S. was asked to stand and hold a ball. She then was asked to pass the ball backward while rotating her trunk. The exercise dose was 3 sets of 5 repetitions to each side. The speed of trunk rotation increased as the level of dizziness and stomach discomfort decreased. A disco ball was used in a dark room while standing in Romberg eyes open on foam, modified tandem Romberg eyes open on foam, and while jumping on a trampoline. She used the disco ball initially for 5 minutes with 1 color. Later, different colors were added, and the time of the visual exposure was lengthened.

Balance

Balance exercises have the goal to improve postural control, helping the child feel more stable during his or her daily living activities, thereby reducing fall risk. L.S. started balance exercises in the Romberg position, eyes open on a stable surface, modified tandem Romberg eyes open on a stable surface, and single leg stance on a stable surface. Later, she was progressed to eyes closed for the exercises. When exercises with eyes closed on a stable surface became easier, she started to do those with eyes open on a foam pad and later on the trampoline progressing to a Bosu Ball (Figure 2). She started jumping on the trampoline doing clockwise rotations with eyes open. The last stage was the Romberg, modified tandem Romberg and single leg stance with eyes closed on a foam pad and the trampoline.

Xbox Kinect Games

The Boom Ball and Rivals games from Xbox Kinect (Microsoft Co, Redmond, Washington) were used as a complement to the therapy program but only after the sixth session when she was not so symptomatic with motion images and lights (Figure 3).

OUTCOMES

After 10 sessions of vestibular rehabilitation, L.S. reported that playing was easier, headaches had reduced, and she could ride in a car for long distances without complaints. She watched 3-dimensional action films with no symptoms and walked in a

Fig. 1. A book with small figures and letters. She was asked to find a figure or letter on the page of the book as she moved her head either up or down while keeping the target in focus.

Fig. 2. Performing balance exercises on the top of a Bosu Ball.

shopping mall with slight symptoms. At the end of therapy, she met her and her parent's goals.

Spontaneous nystagmus, saccades, smooth pursuit, ocular vergence, the HIT, post–head shake nystagmus, static and dynamic visual acuity, and SVV were normal at the onset and did not change. The tests that changed after the 10 sessions are listed in the Table.

DISCUSSION

The child in this case report had improvements in her quality of life after 10 sessions of vestibular rehabilitation. There are no case reports to our knowledge published related to improvement in children with visual vertigo complaints[22] after rehabilitation.

Vestibular rehabilitation in adults is effective in the reduction of the symptoms of dizziness and improvement of postural control.[20]

Rine et al[23] reported the efficiency of vestibular exercises in children with vestibular hypofunction. Braswell and Rine[24] described improvements in their subjects' activities of daily living in one of their subjects who was a child with vestibular hypofunction. There are also reports of improvements in symptoms and postural control in children with concussion.[25]

In adults, persons are typically treated with adaptation, habituation, and optokinetic or substitution exercises.[20] The challenge is to make the exercises interesting and fun for the child. The exercises must be challenging and need to be modified over time to enhance recovery. The use of balls, colored stickers, children's books, toys and flashing lights, balance boards with sounds and lights, and a trampoline are important tools when working with children. The treatment program should be centered on patient's functional limitations plus his or her activity and participation restrictions. According to Rine,[21] when developing the rehabilitation program, rehabilitation specialists must consider several factors: (1) the type and nature of the vestibular lesion, (2) the mechanisms of recovery, and (3) the factors affecting behaviors of interest (ie, gaze stabilization, balance ability, and vertigo).

Vestibular exercises were combined with some Xbox Kinect (XbK) games starting in the sixth session (Boom-Ball game and the Rivals—mini-game tennis and Jet Ski). Studies support the beneficial effect on balance with the use of virtual reality games including the Wii-Fit and the Xbox Kinect.[26-30]

Parental cooperation is critical in working with children and finding time to exercise before or after school can be challenging. In our case study, the child cooperated with performing her exercise program.

Fig. 3. Child playing the Boom Ball Game from the Xbox Kinect.

TABLE

Outcomes

Test/Questionnaire	Results From the First Evaluation	Results After 10 Treatment Sessions
mCTSIB[1]	120 s, but with oscillation mainly with eyes closed	120 s, almost no oscillation even with eyes closed
FR[2]	21 cm	35 cm
PVSQ[3]	0.7 score	0.1 score
DHI-PC[4]	22 points	12 points
VVAS[5]	Riding in the car (score of 5.7), being under fluorescent lights (score of 3), walking through a shopping mall (score of 7.8), watching a movie at the movie theatre (score of 0.7), and watching action television (score of 0.7) were the most symptomatic situations for her.	The only situation that still brought slight discomfort after 10 sessions of treatment according to the patient was walking through a shopping mall (prerehabilitation was 7.8 and after rehabilitation was 0.8). Others improved and even though some did not reach 0, the amount was not relevant for her. Riding in the car (score of 0.1), being under fluorescent lights (score of 0.2), watching a movie at the movie theatre (score of 0.2), and watching action television (score of 0.3).

Abbreviations: DHI-PC, Dizziness Handicap Inventory—child caregivers version; FR, functional reach; mCTSIB, Modified Clinical Test of Sensory Interaction on Balance; PVSQ, pediatric vestibular symptom questionnaire; VVAS, visual vertigo analog scale.

It was unclear what her medical diagnosis was. There were several possible medical diagnoses including childhood migraine and motion sickness that may have limited her ability to participate. Regardless of the pathology, the child improved and was less functionally impaired.

CONCLUSIONS

In this case, a child with motion sensitivity was treated over 10 sessions with vestibular rehabilitation and her motion sensitivity decreased. Her mother and the child reported that she was able to tolerate movement at play and could tolerate motion-provoked symptoms with less headache.

WHAT THIS CASE ADDS TO EVIDENCE-BASED PRACTICE BEYOND THE RESEARCH LITERATURE

This is the first case report that suggests that children with visual vertigo symptoms can improve with vestibular rehabilitation.

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