There is limited evidence to support the use of vestibular stimulation as an intervention for auditory attention for children ages 6-12 diagnosed with ADHD.

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CLINICAL SCENARIO

Client population
Children ages 6-12 diagnosed with attention deficit hyperactivity disorder (ADHD).

Treatment context
Outpatient clinic setting

Condition
Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that is marked by extensive, "developmentally inappropriate levels of inattention, impulsivity, and hyperactivity" (Weyandt, Swentosky, & Gudmundsdottir, 2013, p. 211). While the exact cause of ADHD is unknown, researchers suggest that genetics, environment, and nutritional intake can contribute to the condition (Reiff, 2011).

Problem
Children with ADHD typically experience hyperactivity, inattention, and impulsivity, which leads to several issues during performance in school and home activities (Aminjan, Hosseini & Rostami, 2014). When children with ADHD are engaging in tasks that require focus and attention, they often struggle to participate, as they are constantly seeking sensory stimulation through movement, which can negatively impact performance (Shimizu, Bueno, & Miranda, 2014). In a study conducted by Shimizu et al. (2014), it was found that children with ADHD have significant impairments in sensory processing and modulation, making it challenging for these children to participate appropriately in tasks at home and school. It is crucial to find strategies to address problem areas that impact a child's ability to appropriately function in structured settings, including problems maintaining attention and the need to be in constant motion (Reiff, 2011).

Incidence/Prevalence
According to the Center for Disease Control (CDC), 5.1 million children, and 8.8 percent of children between the ages of 4-17 years old, have a current diagnosis of ADHD. 3.5 million children, and 69 percent of those who are currently diagnosed with ADHD, are taking medication to control symptoms associated with the condition (CDC, 2011). The age when ADHD symptoms typically first appear is between three to six years old, and the average age of an ADHD diagnosis in children is 6.3 years old (Healthline, 2014). Males are two times more likely than females to have a diagnosis of ADHD (CDC, 2011).

Impact of the Problem on Occupational Performance
School performance
ADHD's core symptoms of inattention, hyperactivity, and impulsivity make meeting the required demands at school a challenge. Difficulty sustaining attention to a task may contribute to missing important details, becoming unfocused during schoolwork, and lead to a lack of higher-level cognitive

skills. Hyperactivity may make remaining seated during schoolwork difficult, which can negatively impact school performance, behaviors, and relationships with other students. Impulsivity can lead to careless errors, responding to questions without fully formulating the best answers, and only attending to activities that are entertaining or novel. Overall, students with ADHD may experience more problems with school performance than their nondisabled peers (U.S. Department of Education, 2009).

Relationships/Social Interaction

Children with ADHD experience difficulty in forming and keeping peer relationships due to a combination of symptoms of ADHD, especially impulsivity, inattention, and difficulty reading the social cues of others (Goldstein & Naglieri, 2008). Relationships with parents and siblings are sometimes strained as well (Reiff, 2011). Without positive social connections with others, adolescents with ADHD may experience psychosocial issues such as lacking a sense of belonging, feeling neglected, or demonstrating anxiety.

The following clinical scenario will focus solely on addressing the inattention component of ADHD symptoms, as attention is a key factor of success in school performance and awareness during social interactions.

Intervention

Vestibular stimulation is the input that one's body receives when he or she experiences movement through space (Angelaki, Klier & Snyder, 2009). The intervention used in these studies was specific, structured vestibular stimulation. In order to stimulate the semicircular canals, children in the studies sat and then squatted in a swiveling chair that was rotated both clockwise and counterclockwise. During the seated portion, the participant sat with his or her legs in the tailor position (a cross-legged position where both legs are folded towards the body and crossing at the ankle region), and with his or her arms across the chest. The participant was rotated both clockwise and counterclockwise at various speeds. A blindfold was used during most of the training sessions to help the body remove visual stimulation and attend solely to the vestibular input, but was removed toward the end of the training (Niklasson, Niklasson, & Norlander, 2010). To stimulate otolith organs, the child then participated in linear movement patterns, such as jumping on a trampoline, swinging, or bouncing on a large ball (Haghshenas, Hosseini, & Aminjan, 2014). The typical schedule for this intervention included 30 minute sessions, twice a week, for a duration of 10-12 weeks.

OT Theoretical Basis

We hypothesize that the sensory integration frame of reference supports vestibular stimulation as an intervention for inattention. This frame of reference can be applied to children in a variety of settings, including home and school. Jean Ayres describes sensory integration as "a neurobiological process that refers to the detection, assimilation, organization, and use of sensory information to allow an individual to interact effectively with the environment in daily activities at home, school, or in other settings" (Roley et al., 2003, pg. 653). When taking a sensory integration approach in occupational therapy, practitioners can gain information about the client's sensory processing abilities and perception, and use that information to determine how it impacts their planning and functioning in various occupations (Roley et al., 2003). As children with ADHD struggle to maintain attention during activities due to their tendency to seek sensory stimulation, it is necessary to use a sensory integration frame of reference when creating an intervention plan.

Science Behind the Intervention

According to Goldstein and Naglieri (2008), a key issue for children with ADHD involves issues with executive functioning; individuals with ADHD may have difficulty sustaining attention, have problems with organization, and may struggle to avoid distractions from stimuli in the environment. Vestibular connections with the cerebral cortex and subcortical brain structures are involved in the role of the

vestibular system in executive function (Haghshenas et al., 2013). Mays (2011) suggests that vestibular stimulation of the child's system, involving spinning or various positioning strategies of the head, can be beneficial for children with ADHD, as this type of stimulation activates inhibitory nerves in the brain that helps calm the child, while at the same time, helps the brain focus on organizing information.
The vestibular system, which is centered in the inner ear, plays an important role in both balance and movement. Inside the inner ear, three semicircular canals on each side of the body help a person determine how his or her head is rotating in a three-dimensional plane; utricle and saccule organs on each side of the body then help determine how the body is positioned while moving through gravity (Angelaki et al., 2009). When an individual moves his or her head, the fluid in these organs shifts and provides information about the position of the head and body in space. When the vestibular system is disrupted, cognitive or psychological changes occur, disrupting executive functions (Vestibular Disorders Association, 2015).
Stimulation of the vestibular system activates the auditory system, as it is located in the inner ear. Therefore, it may be beneficial to stimulate the vestibular system when attempting to improve a child's auditory attention (Haghshenas et al., 2013). The studies incorporated both rotational and linear movement into vestibular stimulation interventions, as rotational movement stimulates the semicircular canals and linear acceleration stimulates the otolith organs, which are main components of the vestibular system (Clark et al., 2008). It is believed that stimulating the vestibular system will improve the child's awareness of his or her head in space and increase focus of attention to auditory input.

Why is this intervention appropriate for OT?
The intervention of vestibular stimulation addresses the ICF levels of body structure, body function, and impairment. This intervention is used as a preparatory method to stimulate the vestibular system, helping to prepare the client in processing skills, such as attending and regulating, during any given task. By helping the child to attend to his or her environment more appropriately, he or she will be able to participate more effectively in occupations such as education and social participation, thus improving his or her occupational performance and overall quality of life.

FOCUSED CLINICAL QUESTION: Is vestibular stimulation more effective than clinical exercises in increasing auditory attention of children ages 6-12 with attention deficit hyperactivity disorder (ADHD)?

SUMMARY: This CAT investigates the effects of vestibular stimulation on auditory attention for children with ADHD. We searched seven databases and located five articles on this topic. Of those, we selected three articles to review based on their rigor, strength, year published, and relevance to our PICO question. Two of our articles had moderate rigor, and one article demonstrated poor rigor. All three articles were randomized controlled trials (RCTs), indicating a level 1b for design strength. Based on the three articles we reviewed, there is limited evidence to support the use of vestibular stimulation as an intervention for auditory attention with children ages 6-12 diagnosed with ADHD.

CLINICAL BOTTOM LINE: There is limited evidence to support the use of vestibular stimulation as an intervention for auditory attention for children ages 6-12 diagnosed with ADHD.

Limitation of this CAT: This critically appraised topic has been reviewed by occupational therapy graduate students and the course instructor.

SEARCH STRATEGY:

Table 1: Search Strategy

Databases Searched	Search Terms	Limits used	Inclusion and Exclusion Criteria
UW System Databases APA PsycNET OT Search OTseeker Cochrane Google Scholar ResearchGate	"Vestibular stimulation" "Vestibular stimulation and ADHD" "Vestibular stimulation and attention deficit hyperactivity disorder" "Vestibular stimulation and attention" "Vestibular stimulation and auditory comprehension"	No articles prior to 2005 were included Participants had to be under the age of 18 (children)	English only; full text; peer reviewed

RESULTS OF SEARCH

Table 2: Summary of Study Designs of Articles Retrieved

Level	Study Design/ Methodology of Articles Retrieved	Total Number Located	Data Base Source	Citation (Name, Year)
Level 1a	Systematic Reviews or Metanalysis of Randomized Control Trials	0		
Level 1b	Individualized Randomized Control Trials	4	1.ResearchGate 2. Cochrane Database of Systematic Reviews 3. APA PsycNET 4. Sage Premier	1. Aminjan, A.S., Hosseini, S.A., Haghgoo, A., & Rostami, R. (2014). 2. Arnold, L.E., Clark, D.L., Sachs, L.A., Jakim, S., & Smithies, C. (1985) 3. Haghshenas, S., Hosseini, M.S., & Aminjan, A.S. (2014). 4. Clark D.L., Arnold, L.E., Crowl, L., Bozzolo, H., Peruggia, M., Ramadan, Y., Bornstein, B., Hollway, J.A., Thompson, S., Malone, Kr., Hall, K.L., Shelton, S.B., Bozzolo, D.R., & Cook, A. (2008).
Level 2a	Systematic reviews of cohort studies	0		
Level 2b	Individualized cohort studies and low quality RCT's (PEDro ≤4	0		
Level 3a	Systematic review of case-control studies	0		
Level 3b	Case-control studies and non-randomized controlled trials (quasi experimental or clinical trials)	0		

Level 4	Case-series and poor quality cohort and case-control studies	0		
Level 5	Expert Opinion	1	Ammons Scientific	Niklasson, M., Niklasson, I., & Norlander, T. (2010)

Table 3: Studies Included

	Study 1	**Study 2**	**Study 3**
Author	Aminjan, A.S., Hosseini, S.A., Haghgoo, A., & Rostami, R. (2014).	Clark, D.L., Arnold, L.E., Crowl, L., Bozzolo, H., Peruggia, M., Peruggia, M., & Cook, A. et al. (2008).	Haghshenas, S., Hosseini, M.S., & Aminjan, A.S. (2014).
Design	RCT	RCT	RCT
Level of Evidence	1b	1b	1b
Rigor Score	PEDro 4/10	PEDro 6/10	PEDro 6/10
Purpose of Research	To investigate the correlation between vestibular stimulation and auditory perception in children with ADHD.	To examine whether rotary stimulation of semicircular canals and combined stimulation of canals and otolith system will improve learning deficits in children with ADHD. Also to examine whether or not a placebo effect in the control group will have an impact.	To examine auditory comprehension in children with ADHD who were treated with vestibular stimulation.
Population	Participants in this study included 30 children ages 7-12 years old diagnosed with ADHD based on the diagnostic and statistical manual of mental disorders (DSM-IV-TR).	Participants in this study included 50 children ages 6-12 years old with a diagnosis of ADHD. In addition to a diagnosis of ADHD, participants were required to have a mean rating on the parent's or teacher's SNAP-IV of 1.7 or more on the 0 to 3 scale. All participants also had to be	Participants in the study included 20 children ages 6-9 years old with a diagnosis of ADHD. Participants in the study could not be undergoing any additional treatments during the time of the study.

		unmedicated for 2 weeks prior to randomization and stay unmedicated during treatment.	
Intervention Investigated	Vestibular stimulation: child was seated with his or her legs in a tailor position (a cross-legged position where both legs are folded towards the body and crossing at the ankle region) and with his or her arms across the chest. The participant was rotated both clockwise and counterclockwise at various speeds. A blindfold was used during most of the training sessions to help the body remove visual stimulation and attend solely to the vestibular input. The blindfold was removed toward the end of the training. Auditory perceptual stimulation complemented vestibular stimulation training, in order to strengthen the dominance of the right ear. Participants listened to headphones with custom-made music playing for ten minutes during their rest breaks.	Vestibular stimulation: child sat in a reclining chair which rotated with programmed gradual acceleration accompanied by rocking and tilting. Both the amplitude and direction of linear acceleration changed as the chair rotated, rocked, and tilted. The programmed movement was completed in a quiet darkened room for 30 minutes. Participants wore eye shields as well as well as an acoustic headset to block vision and sound. Immediately following treatment, each participant received 20 minutes of a typing tutorial.	Vestibular stimulation: child sat and then crouched in a rotating chair, spinning both clockwise and counterclockwise for 20 seconds. The child then rolled forwards, backwards, and sideways 20 times on a line. The child then walked on a balance beam, jumped 10 times on a trampoline while rotating, and bounced on a ball in a prone position with arms above head and feet flat on ground
Comparison Intervention	The control group completed clinical exercises during occupational therapy treatment sessions. These exercises included basic gross motor movements such as rolling, and sports-related gross motor skills, such as skipping	The control group was designed as a sham of the intervention, differing by an accompaniment of white noise, and post-session computer typing tutorial. Participants listened to the same white noise, broken in the middle by a 10 minute	The control group completed clinical exercises, including a memory card game, massage, visual attention training and rolling a ball over the child while the child was lying prone.

		entertaining video	
Dependent Variables	Auditory attention	Parent ratings of 9 inattentive symptoms and 9 hyperactive impulsive symptoms. Both parent and teacher ratings of 18 ADHD symptoms.	Auditory attention
Outcome Measures	Integrated Visual and Auditory – Continuous Performance Test (IPA-CPT)	-Integrated Visual and Auditory Continuous Performance Test (IVA-CPT) - Wisconsin Card Sorting Test (WCST) -The Multidimensional Anxiety Scale for Children (MASC) - Columbia Impairment Scale (CIS) - Conner's Scales (CPRS and CTRS)	Integrated Visual and Auditory – Continuous Performance Test (IVA-CPT)
Results (p value and effect size)	The results of the study indicate that the intervention group scored significantly higher compared to the control group for auditory attention in the pre and post-test IVA-CPT (p=0.033). The effect size was not able to be calculated due to the lack of standard deviations. Vestibular stimulation showed to have a significant effect on increased auditory attention.	The results of the study indicate that there was no difference in the intervention group from baseline to treatment end. However, results show there was an improvement from treatment to follow up. The effect size (Cohen's d) of this comparison of the mean difference in auditory comprehension/ attention between groups for the following components of the CPT at follow-up for include: -Number of omission errors: .01 -Number of commission errors: .56 -Mean hit reaction time overall: -.14	The results of the study indicate that the mean difference between the pre- and post-test IVA-CPT scores of the intervention group were significantly higher than in the control group for auditory attention (p = 0.033). The effect size of this comparison of the mean difference in auditory attention between groups was Cohen's d: 2.1104 and r = 0.725852.
Conclusion	Vestibular stimulation can	Vestibular stimulation	Vestibular stimulation

	increase comprehension and attention in children with ADHD, by provoking the autonomic nervous system, which gradually calms the child. As a result, vestibular stimulation along with other common trainings in occupational therapy, help to relieve the symptoms of ADHD.	resulted in an improvement in auditory comprehension after completion of the study, however, it is unclear whether or not additional stimulation of the semicircular canals (using the CMA approach) is beneficial for auditory comprehension.	might have an impact on the improvement of auditory comprehension in children with ADHD.

SYNTHESIS SECTION:
IMPLICATIONS FOR PRACTICE, EDUCATION and FUTURE RESEARCH

PICO Question: Is vestibular stimulation more effective than clinical exercises in increasing auditory attention of children ages 6-12 with Attention Deficit Hyperactivity Disorder (ADHD)?

Key Terms:

Vestibular stimulation: Vestibular stimulation is the input the body receives in the inner ear when one's head experiences movement or gravity.

Clinical exercises: Clinical exercises involve a variety of visual training (i.e. reading a book and tracking a light), cognitive activities (i.e. memory games), proprioceptive practices (i.e. massage), and gross motor activities (i.e. skipping).

Auditory attention: Auditory attention is one's ability to concentrate on specific sounds and process the sounds to understand their meaning.

IVA-CPT: The Integrated Visual and Auditory- Cognitive Performance Test (IVA-CPT) is the outcome measure used in all three studies. The IVA-CPT is a performance test that measures inattention, executive function impairments, and impulsivity in children with ADHD (Haghshenas et al., 2014).

Results: Similar Findings

- Auditory attention was investigated across all studies, measured at pretest and at the termination of the study.
- The IVA-CPT was the outcome measure used to determine auditory attention.
- Treatment did not have to be terminated early due to ill effects, meaning there were no negative symptoms reported from participants.
- Rotational vestibular stimulation was used during interventions to activate the semicircular canals in the inner ear.
- Linear vestibular stimulation was used during interventions to activate the otoliths in the inner ear.
- Results indicated that vestibular stimulation produced statistically significant outcomes immediately following treatment in two studies, while one study had statistically significant results for vestibular stimulation that had a lasting effect of 18 weeks.

Results: Different Findings

- There was a variation of vestibular stimulation provided during interventions; the variations included rolling on a straight line, bouncing on a large ball, jumping on a trampoline, and a typing tutorial.
- One of the studies did not find a statistically significant difference from pretest to termination of treatment between intervention and control groups. However, the study proved statistically significant effects of vestibular stimulation only in the intervention group 18 weeks after termination of treatment.

Boundaries

A total of 100 children ranging from ages 6 to 12 years old at the start of the intervention participated in these three studies. All participants were diagnosed with ADHD, as classified by the DSM-IV. Participants were excluded from the studies if they were on medication or receiving other treatments from occupational therapy.

Implications for Practice

Based on the results of the three articles, it can be concluded that vestibular stimulation can improve auditory attention, compared to clinical exercises alone in children ages 6-12 with a diagnosis of ADHD. These studies demonstrated statistically significant effects on auditory attention with 15-30 minutes of vestibular stimulation, at least two times a week for ten weeks or more. Vestibular stimulation was seen to be an effective individual therapy intervention in an outpatient setting, as opposed to group therapy sessions. Vestibular stimulation had an effect on auditory attention, however, it is still unclear whether or not there is an impact on the child's performance at school or in the home setting.
In addition, it should be noted that in one of the studies, 7 participants complained of nausea and headaches, which led one to drop out of the trial altogether. The other two studies failed to report on whether ill effects occurred or not.

Overall Conclusions

Although limited evidence supports vestibular stimulation as an intervention for auditory attention, effectiveness of vestibular stimulation was statistically significant across all three studies. In one study, effects persisted for an additional 18 weeks.

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