Original Article

Vestibular Stimulation and Auditory Perception in children with Attention Deficit Hyperactivity Disorder

Azin Salamati Aminjan
Tabriz medical science University, Tabriz, Iran
Seyed Ali Hosseini, PhD.; Hojjat Allah Haghgoo, PhD.
University of Social Welfare and Rehabilitation Sciences, Tehran, Iran
Reza Rostami, PhD.
University of Tehran, Tehran, Iran

Objectives: Rehabilitation strategies play a pivotal role in reliving the inappropriate behaviors and improving children's performance during school. Concentration and visual and auditory comprehension in children are crucial to effective learning and have drawn interest from researchers and clinicians. Vestibular function deficits usually cause high level of alertness and vigilance, and problems in maintaining focus, paying selective attention, and altering in precision and attention to the stimulus. The aim of this study is to investigate the correlation between vestibular stimulation and auditory perception in children with attention deficit hyperactivity disorder.

Methods: Totally 30 children aged from 7 to 12 years with attention deficit hyperactivity disorder participated in this study. They were assessed based on the criteria of diagnostic and statistical manual of mental disorders. After obtaining guardian and parental consent, they were enrolled and randomly matched on age to two groups of intervention and control. Integrated visual and auditory continuous performance test was carried out as a pre-test. Those in the intervention group received vestibular stimulation during the therapy sessions, twice a week for 10 weeks. At the end the test was done to both groups as post-test.

Results: The pre-and post-test scores were measured and compared the differences between means for two subject groups. Statistical analyses found a significant difference for the mean differences regarding auditory comprehension improvement.

Discussion: The findings suggest that vestibular training is a reliable and powerful option treatment for attention deficit hyperactivity disorder especially along with other trainings, meaning that stimulating the sense of balance highlights the importance of interaction between inhabitation and cognition .

Keywords: vestibular training; auditory comprehension; attention deficit hyperactivity disorder

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Introduction

Attention deficit hyper activity disorder (ADHD) is a neuro-behavioral disorder affecting 3-7% of school age children. Despite its high prevalence and growing clinical researches, some symptoms may have persisted into adulthood. rehabilitation strategies play a pivotal role in reliving the inappropriate behaviors and improving children's performance during school (1). It was reported the inattentive symptoms were usually ignored by parents before starting school, while these behaviors led to noticeable problems including the child's learning during school (2). Today, concentration and visual and auditory comprehension in children are crucial to effective learning and have drawn interest from researchers and clinicians. About 30-50 percent of children with ADHD have poorly balanced and effective interplay of movement and actions (3). Moreover, brain imaging studies in ADHD children in comparison with those of normal children demonstrated that cerebellum, prefrontal cortex and the striatum are smaller; methylphenidate increase regional brain metabolism in the cerebellum, frontal and temporal lobes; vestibular caloric stimulation of the labyrinth in the inner ear activates the limbic system and neo cortex supporting a connection between the vestibular stimulation and dopaminergic modulation of the limbic system (4). It has been

∗All correspondences to: Azin Salamati Aminjan, email: <salamat.ot@gmail.com>

postulated that basal ganglia and cerebellum are involved in regulating motor control, as well as cognitive and emotional function, suggesting that the differences in these structures of the brain between ADHD and normal children may explain many general performance deficiencies on cognitive and motor levels in ADHD (5). Vestibular function deficits usually cause high level of alertness and vigilance, and problems in maintaining focus, paying selective attention, and altering in precision and attention to the stimulus (6).

Integrated visual and auditory continuous performance test (IVA-PLUS-CPT) is a continuous performance test commonly used by neuropsychologists to measure inattention, executive function impairment and impulsivity problems in ADHD children with higher diagnostic accuracy than other CPTs (7,8). This test has various types including geometric shapes, words and numbers from which the numbers version (reliability coefficient ranged from 0.53 to 0.93) was employed in this study to test auditory Comprehension and sensitivity by stimulating the vestibular system and clinical movement exercises.

Methods

Thirty children were diagnosed based on diagnostic and statistical manual of mental disorders (DSM-IV-TR) criteria in a comprehensive psychiatric center of Atieh, in Tehran. Wechsler intelligence test and IQ test were carried out after ADHD diagnosis. In addition, informed consent and demographic questionnaire (age, drug usage and laterality in upper limb) were completed by parents and children. Participants were randomly divided into intervention group and control group. The IVA-PLUS-CPT test was done for all participants by psychiatrist. Errors of omission, errors of commission, and reaction time were used to evaluate comprehension characteristics. Participants were seated at a distance up to about 60 cm in front of a computer (15-inch screen monitor). Target stimulus was presented randomly on the computer screen among untargeted stimulus. These stimuli were verbally broadcasted through the headphone by the examiner during administrations. Examinees were asked to listen during the broadcasts, and then use the mouse to respond. The number of true and false responses, missed targets, and the response speed were calculated and recorded in the computer. Both groups spent ten weeks (twice a week) on therapy sessions. The intervention group received vestibular stimulation based on the common exercise in occupational therapy clinics and special protocol (9-12). After completion of therapy sessions, each subject was tested by IVA-PLUS-CPT. Data analysis was performed by SPSS 16.0 by using t-test between the two groups. All legal guardians consented to participate in the research.

Results

Auditory comprehension data is reported in table (1). And also the average of auditory attention in intervention and control group in pre and posttest is indicated in figure (1). The presence of vestibular stimulation showed a significant effect on the increase of auditory attention.

Table 1. Auditory attention data

Mean difference	Average	N	Group	t	P value
17.37	17.5	15	Intervention	2.247	0.033
19.31	2.4	15	Control		

P<0.05

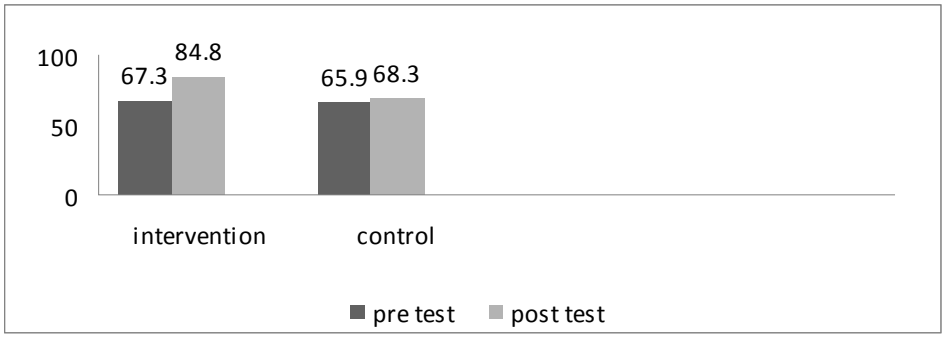

Fig 1. Average of auditory attention in intervention and control group in pre test and post test

The auditory impulse control data is reported in table (2). And the average of impulse control in intervention in intervention and control group in pre and posttest is indicated in figure (2). The presence of vestibular stimulation showed a significant effect on the increase of impulse control in intervention.

Table 2. Auditory impulse control data

P value	t	mean difference	average	N	group
0.004	3.165	13.81	22.3	15	intervention
		14.22	6.1	15	control

* *P<0.05, P<0.01*

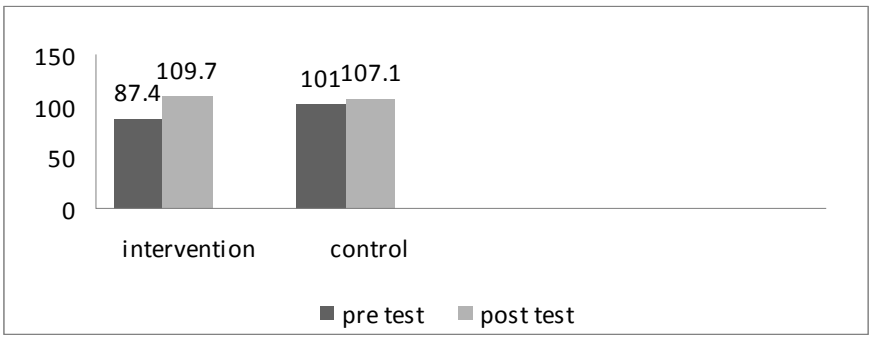

Fig 2. Average of auditory impulse control in intervention and control group in pre test and post test

Discussion

In this study further efforts have been done to investigate the effect of vestibular stimulation on auditory comprehension in children with ADHD. As vestibular stimulation significantly alters level of consciousness, it also expects to increase comprehension and focus in ADHD (11). Instructions and practices in a regular and steady rhythm, used in this study, were designed to meet most of emotional needs of ADHD children and be effective in alteration of consciousness level, and subsequently comprehension level. Vestibular stimulation gradually calms children by provoking uniformly the autonomic nervous system, leading to a significant impact of therapy sessions on the children's comprehension (13). Vestibular connections with cerebral cortex and subcortical brain structures such as thalamus could describe the role of vestibular system in the executive functions of the human. On the other hand, anatomical connections between vestibular and auditory systems make a hypothesis that these two systems work as one. Therefore, stimulation of vestibular system will activate auditory system. This could be another reason for increased level of auditory comprehension in the intervention group in comparison with the control group. The inhibitory role of vestibular stimulation in the ADHD children respond speed to the test was influenced by auditory processing (14, 15).

Previous studies have indicated that the movement-based instructions increase the process of listening comprehension (16,17). Interestingly, body movement affect auditory rhythm processing of music, therefore, posterior parietal cortex integrate auditory information with balance information (11,18). Here, results proved that vestibular stimulations provoked and then activated auditory comprehension. Changing level of consciousness and modulating alertness as vestibular stimulation received, children's attention to environmental stimuli was increased and led to correct and impulsive responds.

An exercise protocol for vestibular stimulation was based on counting the number of practice times which was an auditory stimulus. Surprisingly, when first round of exercises was done (ten times), and the direction or type of practice was changed, the impulse control of auditory for intervention children was enhanced more than the control group. Moreover, findings suggest increasing the time under vestibular stimulation as well as applying other sensory stimulations and exercises is helpful to get better results. In conclusion, vestibular stimulation along with other common trainings relieves the symptoms of ADHD.

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