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Comparison of the effects of vestibular stimulation exercises and rotational exercises on cognitive and motor dual balance function of children with attention deficit hyperactivity disorder

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Introduction

Attention Deficit Hyperactivity Disorder is one of the psychological and neurodevelopmental disorders in childhood, which is characterized by three main features: attention deficit, hyperactivity, and impulsivity (1). This disorder often continues until adulthood and causes problems in various aspects of a person's academic, family and social life. The main characteristic of these children is lack of attention, hyperactivity, impulsiveness (2). The American Psychiatric Association states that the prevalence of this disorder among children is 3-7%, that the prevalence of the inattentive type (71%) is higher than the combined type of inattention and hyperactivity (3).

Decreased function of the basal ganglia and cerebellum in children with attention deficit/hyperactivity disorder causes problems in the motor performance of these children (1). If attention-deficit/hyperactivity disorder is not treated, it can lead to academic problems, aggression, difficulty in interpersonal relationships, and other psychological disorders. The treatment of this disorder is divided into two general parts: drug treatment and non-drug treatment. Conventional treatments for children with attention deficit/hyperactivity disorder include drug therapy, although some of these children do not respond well to drugs; Therefore, expensive treatments for them suggest that drugs should be used in combination with non-drug treatments (4). A review of research literature on attention deficit/hyperactivity disorder indicates that the main focus of treatment is on drug therapy (5). And the results indicate its usefulness in reducing the behavioral symptoms of this disorder (6, 7). However, despite these experts and researchers in this field, there are still questions regarding the scope and level of effectiveness and side effects of psychostimulant drugs, as well as the role of these drugs in the treatment of special groups such as very young people with low intellectual function(8). On the other hand, many parents are hesitant about the use of these drugs and do not show much desire to use them to treat their child's disorder(9). The reason for this hesitation in using the drug is probably the concern of long-term use of psychostimulant drugs and its side effects such as anorexia, sleep disorder, irritability, anger, anxiety and in some cases the exacerbation of convulsive disorders and tics. For this reason, the importance of dealing with non-pharmacological treatments for this disorder is revealed, among which we can mention the cognitive rehabilitation treatment approach that focuses directly on improving the structures and functions involved in this disorder and has no side effects of drug therapy.

Daily physical activities and sports require a combination of desired body posture control and specific movement components. Controlling the desired body position or balance is considered one of the indicators of the degree of independence in performing daily activities (10). In many cases, attention deficit/hyperactivity disorder is associated with movement problems (11). Some studies indicate that motor skills of ADHD children are obviously weaker than normal children. These children have problems in balance, movement planning, maintaining control and sensory integration (12). Balance control is one of the important sensory-motor functions that is impaired in ADHD people because it requires the ability to integrate the data of different visual, vestibular, and bodily sensory

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systems as well as trying to produce coordinated movements using sensory messages. (13).

The results of another study showed that sensory integration problems and the inability to control extra movements lead to balance disorders in 7 to 12-year-old children with attention deficit/hyperactivity disorder (14). In another study, it was found that the development of motor skills in children aged 7 to 12 with attention deficit/hyperactivity disorder is weaker than normal children (15). The results of Mokuban et al.'s studies also showed disturbances in static and dynamic balance in children with attention deficit/hyperactivity disorder (16). In addition, the results of another study showed that balance in children with attention deficit/hyperactivity disorder is weaker than normal children (17). In recent years, the use of rotational exercises has increased. Rotating exercises is a new innovative technology in which to provide an interactive environment, upper and lower limb movements are performed for simulation on the game screen (18). An example of rotational exercises that is a product of Microsoft is called Xbox Kinect. In that console, it works through the movement of the player, without the need for a controller. Rotational exercises have become a cheap and reliable program to implement and improve health programs, balance and control neuromuscular coordination (19). Spinning Exercises as a video game is designed to help improve overall health and maintain fitness in the field of physical medicine and rehabilitation. This approach to medicine uses technology and the virtual world to create interventions that are easy to access and cost-effective and enjoyable and fun for the participants (20).

Researchers have shown that rotational exercises are a suitable way for students to achieve appropriate physical activity, cognitive stimulation, emotional development and social communication (21). However, research on the physical, emotional, social, and cognitive effects of rotation exercises on people with ADHD is scarce, and there is less research comparing vestibular stimulation exercises and rotation exercises on balance in children with ADHD. . Also, since the defects of these children in balance, movement planning, maintaining control and sensory integration reduce their participation in sports and physical activity and expose them to the risk of health problems related to inactivity and considering the high prevalence of ADHD In children and the issues that this disorder brings with it laterally and involves the individual and his family, and on the other hand, non-pharmacological treatments are an important part of the treatment, and also considering the effect of different methods of exercise on this type of disorder, the study This study was designed and implemented in order to investigate the effect of vestibular stimulation exercises and rotation exercises on the dual cognitive and motor balance function of children with attention deficit/hyperactivity disorder and the difference between these two types of exercise protocols.

Material and methods

The statistical population of the present study included all 8-11-year-old children with attention deficit hyperactivity disorder in Khorramabad city, among whom 24 people were selected voluntarily and randomly, purposefully and available. The subjects were randomly divided into three groups of 8 people, including the rotational exercise group, the vestibular stimulation exercise group, and the control group. The research method was semi-experimental with a pre-test-post-test design and was practical in terms of purpose. After selecting the subjects, at the beginning, in the briefing meeting with the presence of their parents, the purpose of the research and the interventions that were to be applied, as well as the method of evaluating the dependent variables, were explained. Before the beginning of the training session, a training session was held to familiarize the samples of the experimental group with the method

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of performing rotation exercises and vestibular stimulation. At the beginning, in the pre-test phase, dual cognitive and motor balance function and lower limb function were obtained from the subjects. And then the experimental groups were subjected to intervention (rotation exercises and vestibular stimulation exercises) for 6 weeks. The control group had no special intervention during this period. After the completion of six weeks, in the post-test stage, the dual cognitive and motor balance function test and the lower limb function test were taken again from all three groups.

The rotation exercise protocol was such that the intervention included performing active rotation movements of the whole body in 180 degrees and 360 degrees around the vertical axis, complete rotation around oneself and around other people with different number of rounds and at different times. There were more people around, turning while walking, turning in two directions left and right, turning around circles with different radii (22). The intervention was conducted in 18 sessions (6 weeks and three sessions per week) and each session lasted for one hour. In each session, 10 minutes were dedicated to warming up and cooling down, and 40 minutes of complete rotation exercises were performed (23).

The protocol of atrial stimulation exercises was such that atrial stimulation exercises were performed for 6 weeks, three days a week. The exercise program is shown in the following table:

lick	Jumping and sliding in a marked path by moving the arms at the sides of the body
sliding movement	Stepping sideways in a certain direction, while keeping the eyes, face, legs and whole body parallel to the body. Subjects are encouraged to move in one direction, considering one step along the next step. They are also allowed to approach the wall without touching it.
Throwing the bean bag	In a designated path, the subjects throw the beanbag upwards and then receive it. They are required to follow the bean bag with their eyes
eye to eye	The subject is placed at a distance of 14 inches from the examiner and follows the tracing pencil with his eyes 2 times horizontally, 2 times vertically, 2 times in the clockwise direction, 2 times in the anti-clockwise direction and finally 2 times following the convergence practice movement. they do.
to jump	Perform a standing jump between two marked lines on the ground. Subjects are encouraged to jump as much as possible
rolling over	Subjects roll along the length of the mat like a pencil, with their hands up and legs stretched out. They are encouraged to maintain their original position until the end of the rolling path
Cross walking	Subjects raise the knees while alternately touching the opposite elbow while moving slowly in a certain direction.
Balance Bard	Being on the balance board and maintaining the balance of the body as much as possible
Crossing obstacles	Stepping over obstacles with different heights of the balance stick, the subject walks the path of the balance stick, turns in the middle and walks the rest of the way backwards.
Monster step	The subject kicks the markers arranged on the ground with her maximum force
crawling	Crawling on all fours in the designated path
Convergence of the eyes	Subjects hold a string containing three colored beads and focus on each colored bead for ten seconds.
arm strength	Subjects stand facing the wall, then press the wall with the palm of their hand with all possible force
step back	Stepping back on the stairs

Table 1: Program of atrial stimulation exercises

Every week, changes were made in some stations in order to increase their skill and intensity. If no changes were made, the basic movements of the first week continued (24).

Assessment of dual cognitive and motor balance function

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Balance assessment was done using the timed stand up and move test. The timed stand-up and move test is designed as a quick method to determine balance problems affecting daily life movement skills (25). The timed getting up and moving test includes 3 steps: getting up from a chair, walking, turning and returning. Subjects should perform this test in the least possible time. Subjects had to perform the timed stand up and move test under 2 different conditions. The implementation of the timed standing up and moving test along with the performance of the movement task (dual movement-balance task) and the implementation of the timed standing up and moving test together with the cognitive task (dual cognitive-balance task) were performed by the subjects:

1- The dual movement task includes the implementation of the timed stand-up and move test, while holding a cup of water in the hand.

2- The dual cognitive task, the execution of the timer test of getting up and moving, was simultaneously with counting down 15 numbers randomly, so the subjects were evaluated as a pre-test. The results of these evaluations were recorded in order to determine the pattern and amount of changes (25).

Data analysis method

Data analysis was done using descriptive and inferential statistics. In the descriptive statistics section, the average and standard deviation, tables and graphs are used to describe the characteristics of the research samples, and in the analytical statistics section, the Shapiro-Wilk test (to determine the normality of the data distribution), Levin's test (to check the homogeneity of variances), Dependent t-test (to examine intra-group changes of variables), one-way analysis of variance test and Tukey's post hoc test (to analyze research hypotheses) were used. The significance level was also considered by considering the first type error, α = 5%.

Results

The descriptive information of the subjects [mean and standard deviation (SD ± X)] obtained from the data are presented in Tables 1-4.

Variable	Control	vestibule	rotary
age (in years)	١,١٩ ± ٩,٥	١,١٩ ± ٩,٥	١,٢٨ ± ٩,٧٥
height (cm)	٢,٣ ± ١٣٠,٤	٢,٧ ± ١٣٠,٧	٢,٩ ± ١٣١,٣
weight (kg)	١,٦ ± ٣١,٥	١,٦ ± ٣١,٣٧	٢,٥ ± ٢٩,٢٥

Table ١–۴: Mean and standard deviation related to research variables

Inferential analysis of research findings

Shapiro-Wilk test was used to check the normality of data distribution. The results of this test are presented in Table 2-4.

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Variable	the level	Control		vestibule		rotary	
		Significance level	statistics	Significance level	statistics	Significance level	statistics
Movement task	pre-test	۰/۹۹	۰/۹۸۹	۰/۶۹	۰/۹۴۸	۰/۳۷	۰/۹۱۲
	post-test	۰/۹۴	۰/۹۷۶	۰/۰۸	۰/۸۴۵	۰/۳۶	۰/۹۱۱
Cognitive task	pre-test	۰/۸۷	۰/۹۶۷	۰/۲۳	۰/۸۸۸	۰/۳۲	۰/۹۰۵
	post-test	۰/۶۵	۰/۹۴۳	۰/۱۴	۰/۸۶۶	۰/۹۷	۰/۹۸۱

Table 2-4: Test of normality of sample distribution (Shapiro-Wilk test)

Following the analysis of the research variables with the Shapiro-Wilk test, regarding all the research variables, in the tested groups, according to the significance level (significance level) obtained (which was above 0.05 in all cases), the distribution of the data was normal, therefore from Parametric statistical tests such as dependent t and analysis of covariance were used to analyze the hypotheses.

Levine's test was used to determine the similarity and homogeneity between the variances of the research variables. The results of Levin's test are given in Table 3-4.

post-test		pre-test		Variable
Significance level	statistics	Significance level	statistics	
۰,۷۱	۰,۳٥۳	۰,٦٥	۰,٤٤	Movement task
۰,٦۸	۰,۳۹٥	۰,۹٦	۰,۰۳٦	Cognitive task

Table 3-4: Examining homogeneity of variances (Levin's test)

According to the results in Table 3-4, the analysis of research variables with Levin's homogeneity of variance test showed that the variance of the variables is homogenous.

Dependent t-test was used to examine the intra-group changes of the research variables in the studied groups. The results are given in Table 4-4.

Significance level	dependentt	rate of (%) change	Mean and standard deviation		group	Variable
			post-test	pre-test		
۰,۰۰۱	٥/٦۳	-۲۳/٤	۰,۸٦ ± ۱٤,٥	۱,۰۱ ± ۱٥,۱٤	rotary	Movement task

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۰,۰۰۱	٥/٧٩	-٣٧/٢	۰,٧٩ ± ١٤,۰٤	۰,٨٤ ± ١٤,٧٥	vestibule	
۰,٦٥	۰,٤٧٥-	+۰,٢٥	۰,٨٤ ± ١٥,٩٩	۰,٨٩ ± ١٥,٩٦	Control	
۰,۰۰۰١	٦/٥٦	-٦/٥٤	۰,٦٣ ± ١٢,٤٤	۰,٥٣ ± ١٣,٣١	rotary	Cognitive task
۰,۰۰١	٥/١٩	-٩/٥	۰,٨١ ± ١٣,۰٧	۰,٤٨ ± ١٣,٨٩	vestibule	
۰,٦٣	۰,٥۰٩	-۰,٢١	۰,٥٢ ± ١٤	۰,٦٢ ± ١٤,۰٣	Control	

Table 4-4: Intragroup changes of research variables in two experimental and control groups

As the information in Table 4-4 shows, regarding motor-balance function, there is a significant improvement of (4.23%) following rotation exercises, and a significant improvement of (2.37%) following vestibular stimulation exercises. observed (P=0.001). Regarding the cognitive-balance function, a significant improvement of (6.54%) was observed after rotation exercises, and a significant improvement of (5.9%) was observed after vestibular stimulation exercises (P=0.001). On the contrary, in the control group, no significant change was observed in any of the above variables ($P \leq 0.05$). In order to investigate the effect of vestibular stimulation exercises and rotational exercises on the dual motor-balance function of children with attention-deficit-hyperactivity disorder, one-way analysis of variance was used. The results are given in Table 5-4

.

Significance level	F	mean square	Degrees of freedom	sum of squares	
۰,۰۰۰١	١٦/١	١/٣٢	٢	٢/٦٤	between groups
		۰,۰٨٢	٢١	١/٧٢	Intergroup
		------	٢٣	٤/٣٦	Total

Table 5-4: Analysis results of the fifth hypothesis using the one-way analysis of variance test (P≤0.05)

According to the information in Table 5-4, the comparison of the changes in the dual motor-balance function in the three groups showed a significant difference (P=0.001).

Tukey's post-hoc test was used to compare the difference in the average of the dual movement-balance

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function in the three studied groups, and the results are shown in Table 6-4.

Control	Atrial stimulation exercises	Groups
** ۰,٦٦٣ ۰,۰۰۱ *	** ۰,۰۷٥ ۰,۸٦ *	Rotational exercises
Average difference ** Significance level *	** ۰,۷٤ ۰,۰۰۱ *	Control

Table 6-4: Comparison of the mean difference of the dual motor-balance function using Tukey's post hoc test

According to the information in Table 6-4, there is no significant difference in the average group of rotation exercises and vestibular stimulation exercises (P=0.86). On the other hand, a significant difference was observed between the mean of the control group and the two groups of vestibular stimulation exercises and rotation exercises (P=0.001). Therefore, it can be concluded that there is no significant difference between the effect of vestibular stimulation exercises and rotational exercises on the dual motor-balance function of children with attention deficit hyperactivity disorder.

The comparison of the changes in the dual motor-balance function in three groups (rotation exercises, vestibular stimulation exercises and the control group) is shown in Figure 1-4.

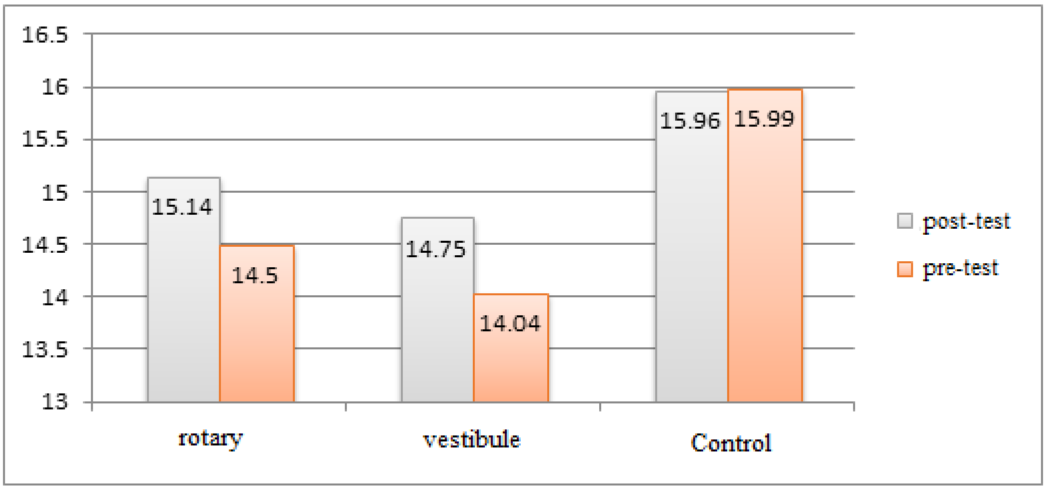

Chart 1-4: Comparison of pre-test and post-test changes in the dual motor-balance function in three groups

In order to investigate the effect of vestibular stimulation exercises and rotational exercises on the dual cognitive-balance function of children with attention deficit hyperactivity disorder,

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one-way analysis of variance was used. The results are given in Table 7-4.

Significance level	F	mean square	Degrees of freedom	sum of squares	
٠,٠٠١	١٥/٠٩	١/٧٩	٢	٣/٥٩	between groups
		٠,١٢	٢١	٢/٤٩	Intergroup
		------	٢٣	٦/٠٩	Total

Table 7-4: Analysis results of the fifth hypothesis using one-way analysis of variance test (P≤0.05)

According to the information in Table 7-4, the comparison of the changes in cognitive-balance dual function in three groups showed a significant difference (P=0.001).

Tukey's post hoc test was used to compare the difference in the average cognitive-balance dual function in the three studied groups, and the results are shown in Table 8-4.

Control	Atrial stimulation exercises	Groups
** ٠,٨٥ ٠,٠٠١ *	** ٠,٠٦٣ * ٠,٩٣	Rotational exercises
Average ** difference Significance level *	** ٠,٧٩ ٠,٠٠١ *	Control

Table 8-4: Comparison of the mean difference of cognitive-balance dual function using Tukey's post hoc test

According to the information in Table 8-4, there is no significant difference in the average group of rotational exercises and vestibular stimulation exercises (P=0.93). On the other hand, a significant difference was observed between the mean of the control group and the two groups of vestibular stimulation exercises and rotation exercises (P=0.001). Therefore, it can be concluded that there is no significant difference between the effect of vestibular stimulation exercises and rotational exercises on the cognitive-balance dual function of children with attention deficit hyperactivity disorder.

The comparison of the changes in cognitive-balance dual function in three groups (rotation exercises,

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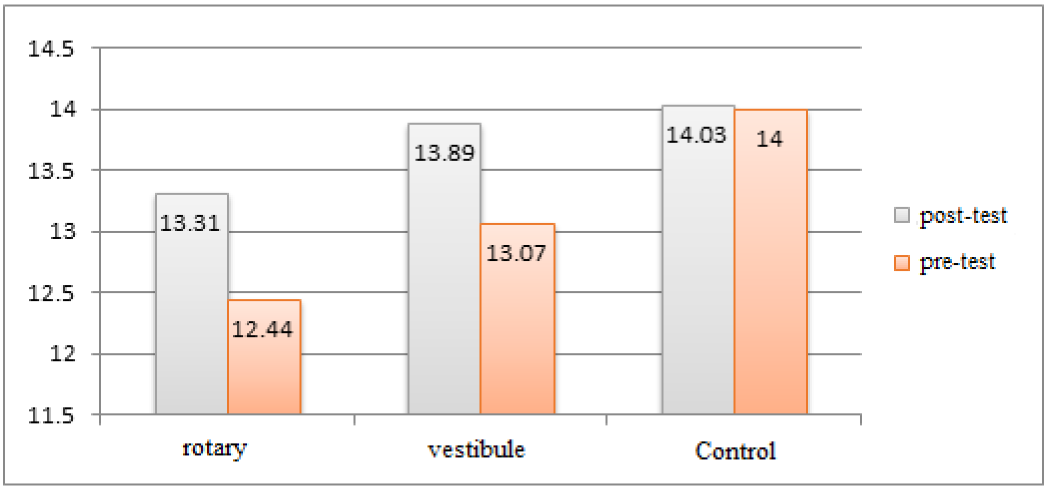

Vestibular (stimulation exercises and control group) is shown in Figure 1-4.

Discussion

Examining intra-group changes in cognitive and motor dual function indicated that vestibular stimulation exercises improved motor-balance dual function by 2.37% and improved cognitive-balance dual function by 5.9%.

In line with the present study, Gholami and Sabzi, in a research titled the effect of perceptual-motor and vestibular exercises on static and dynamic balance of children with developmental coordination disorder, concluded that both exercise programs, i.e. vestibular and perceptual-motor exercises, improve balance Static and dynamic had an effect on children with developmental coordination disorder compared to the control group, but no difference was found between their effects (26). Shukti et al. investigated the effect of vestibular stimulation exercises on motor skills of children with Down syndrome and concluded that balance, bilateral coordination and other fine and gross motor skills of experimental group subjects improved significantly after vestibular stimulation exercises (24). . The findings of Ankit et al.'s research, entitled the effect of vestibular stimulation on the stability and postural mobility of the elderly, indicated that vestibular stimulation exercises significantly improve the stability and postural mobility of the elderly (27). Tramontano et al., in a research titled the effect of vestibular stimulation exercises on the motor function of children with cerebral palsy, observed a significant improvement in the motor function of subjects after neurodevelopmental treatment and vestibular exercise (28).

Studies show that the brain mechanisms for the integration and integration of visual, vestibular and sensory-body inputs may become very strong with long-term training and cause less swaying of the body in the standing position. Different sports exercises stimulate different sensory systems and increase body posture control. Several studies have been done on different sensory and movement adaptations that result from continuous participation in different sports activities. Each sport requires different levels of sensory-motor processes to execute skills and maintain the neuromuscular system (29, 30). The skill and environmental requirements of different sports cause the sensory-motor systems to be involved in each one differently; For example, swimmers use information from the vestibular system to maintain balance in the water, while gymnasts and football players use more information from the sensory-body system, and basketball players use more information from the visual system to maintain balance during training (31).

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In the game of football and basketball, the accuracy in determining the distance or path of the ball and the correct judgment about the distance from teammates and opponents are among the determining factors in success, and these are dependent on the health of the visual system. Also, soccer players use the lower limbs more to perform techniques, which seems to have a more effective role for the visual and sensory-body system in maintaining their balance. Swimmers use the vestibular system to balance their movements and techniques in the water; Therefore, the vestibular sense of these people may be more effective in maintaining balance (32). In other words, participating in sports activities, depending on the conflict it creates for the visual, vestibular and sensory-body systems, strengthens the balance, which can somehow explain the findings of the current research.

On the other hand, since vestibular stimulation exercises effectively reduce weakness in the vestibular system, changes in white matter can be introduced as a neural mechanism for this rehabilitation (33). So, in a study, a significant decrease in FA (Fractional Anisotropy) and changes in gray and white matter were observed in professional ballet dancers. It is possible that vestibular stimulation exercises performed after weakness in the vestibular system affect white matter plasticity, which can help coordinate different sensory systems for balance and maintaining posture, and thus may be a physiological mechanism for balance exercises as a rehabilitation method. be introduced (34).

The findings of the present study showed that rotation exercises improved the dual motor-balance function by 4.23% and improved the cognitive-balance dual function by 6.54%. In another study, researchers investigated the effect of rotational exercises on balance by manipulating the sense of vision and proprioception and concluded that rotational exercises bring better results in improving balance in the X axis, and this results in people's reliance on the visual and sensory system. It reduces the depth (35). The results of the research by Derakhshan Nejad et al showed that rotation exercises improve the physical performance of elderly women (36). Choi et al., in a research entitled the effect of head rotation exercises on postural balance, muscle strength and walking in elderly women, showed that head rotation exercises significantly improve postural balance, muscle strength and walking in elderly women (37). Systems theory researchers believe that in evaluating balance, effective systems in maintaining balance and controlling posture should be examined separately; So that by changing the information of the sensory systems, the ability of a person to maintain balance in a standing position is measured by measuring the amount of body sway; Because, the body is not completely stationary in a standing position and the center of gravity on the support surface is associated with fluctuations that are maintained (38). The active rotation of the whole body is a combination of the rotation of the spine and the rotation of the pelvis, and the evaluation of the movement of the pelvis at the sagittal level is very important in the evaluation of the movement during the rotation; So, rotation exercises have become so useful that they have a positive effect on the proprioception receptor in the pelvis, which is consistent with the theory of dynamic systems (39).

In this regard, studies show that vestibular exercises only with head rotation (extension and hyperextension) improve balance in conditions of proprioceptive manipulation. Also, it has been found that wrestling practitioners performed better than semi-skilled people in the conditions of body sense manipulation, which of course could be the reason for continuous training on the wrestling mat, which is an unstable surface and continuously affects the sense of proprioception and adapts the body sense system to it. conditions lead to Rotational exercises, which are a combination of rotation in the spine and pelvis, have strengthened the proprioceptive sense in the pelvis, so that the participants were able to maintain their balance even in the condition of proprioceptive manipulation using the pelvic strategy (40-42). Vestibular input information is obtained through both vision and head movement. The vestibular system is able to detect the lack of stability through head movement, which can be a reason for reducing the speed of information transmission to the central nervous system and transmitting information to the lower centers of the joints to respond to the lack of stability. When accurate visual and bodily information cannot be used, people only use vestibular sense information for balance stability (38).

In general, the results of the present study showed that vestibular and active rotational stimulation exercises lead to the improvement of motor and cognitive double balance almost equally, and at any moment, the sensory systems participate in maintaining balance according to the situation and adapt according to the conditions. which probably indicates the effect of the exercises of this research in confirming the theory of dynamic systems. Also, the current research is probably partially consistent with the issue of controlling the degrees of freedom of the body; Because, in the conditions of manipulation of sensory systems, rotational exercises have led to balance control at anatomical and biomechanical levels. However, it is likely that conducting similar research on children with various disorders, such as mental retardation and brain damage, and comparing the results with the results obtained in healthy people can lead to a greater understanding of the effectiveness of these types of interventions.

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