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Effect of sensory integration training on executive functions of children with attention deficit hyperactivity disorder

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Abstract

Aim of the study: Sensory integration is the process by which information from our senses (touch, sight, hearing, taste, smell, as well as balance) is interpreted by the brain so that we can respond appropriately to our environment. Attention deficit hyperactivity disorder (ADHD) is a complex neurological condition that is characterized by developmentally inappropriate levels of inattention, hyperactivity, and impulsive behavior. The aim of the current research was to investigate the effect of sensory integration training on executive functions of children with attention deficit hyperactivity disorder.
Material and methods: In order to conduct this study, 20 students with attention deficit hyperactivity disorder were randomly selected from the elementary school student population of Isfahan, Iran, using the random cluster sampling method, and they were assigned randomly to experimental and control groups (each group consisted of 10 students). The design was experimental, and sensory integration training was performed in the experimental group. The research instruments were Conner's Rating Scale (teacher and parent forms) and Conner's Neuropsychology Test. Data were analyzed by multivariate covariance analysis of variance.
Results: The results indicated that sensory integration can improve executive functions of students with ADHD.
Conclusions: Thus, it can be concluded that sensory integration training affects children's executive functions. We suggest that this method can be used in rehabilitation and education of children with attention deficit hyperactivity disorder and it can be recommended to therapists and trainers.

Key words: sensory integration, executive functions, ADHD.

Introduction

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) classifies attention deficit hyperactivity disorder (ADHD) as a neurodevelopmental disorder. This disorder often overlaps with "externalized" disorders such as oppositional defiant disorder and conduct disorder (American Psychiatric Association 2013). On the other hand, it has drawn the attention of neuropsychologists as a childhood disorder with manifest symptoms of inattention and impulsivity so that one of the etiological hypotheses of this disorder is based on functioning failure of the frontal cortex with slow metabolism and less blood flow as well as graft injury in cortical structures and subcortical structures of the brain. From the neuropsychological point of view, executive functions are actions that patients with frontal lobe damage are unable to perform well. In various studies, it has been shown that patients with ADHD have defects in most abilities related to executive functions. In a review of studies related to executive functions in children with ADHD, Pennington and Ozonoff (1996) found that 15 to 18 studies have shown that individuals with ADHD and healthy people have significant differences in one or more measures of executive functions. Executive neurocognitive functions are responsible for controlling consciousness, thought and related actions through psychological processes (Zelazo and Muller 2002). Executive functions are skills that help us decide what kind of activities or objectives should be considered, which one must be selected and how behavior should be organized and planned (Dawson and Guare 2004). In fact, functions such as organization, decision-making, working memory, retention and conversion, motor control, sensation and perception of time, prediction

of future, reconstruction, internal language and problem solving can be considered as the most important executive neurocognitive functions which help humans in life and in learning and mental actions (Barkley 1997).

In addition, early diagnosis and intervention in young children with neuropsychological disabilities has been especially considered by many researchers. Neuropsychological descriptions are crucial in this regard, which requires the investigation of the relationship between mental and cortical processes (Semrud-Clikeman and Teeter 2009). Influenced by these findings, neuropsychological patterns related to attention deficit hyperactivity disorder have been proposed by neuropsychologists in recent decades. Cognitive impairments and specific impairments in attention and executive functions are the main hypotheses proposed in the field of ADHD. Children with this disorder have lower scores and poorer performance in various tasks of alertness, maintaining attention, motor inhibition, executives function and verbal learning and memory. Moreover, these children need to receive mental health services in combination with other ADHD common therapies (Cantwell 1996). Thus, given this fact, using intervention programs to overcome or improve neuropsychological problems of these children is necessary. In addition, different pharmacological, cognitive, behavioral, and complementary and combined treatments are used to treat attention deficit hyperactivity disorder. Since sensory integration problems may overlap with symptoms of attention deficit disorder and hyperactivity, sensory integration makes a noticeable contribution in this regard. Sensory integration therapy includes controlled sensory stimulation as the autonomous and meaningful commands that emphasize the importance of biological needs for motivation of behavior (Davidson 2008). Deep and atrial sensing is used in the sensory integration approach in combination (Ebrahimi *et al.* 2013).

Sensory integration means coordinating and integrating information received by the brain. Most children with ADHD, children with learning disabilities, and autism lack sensory integration. The child's ability in applying some senses may be high while it might be low in some others. These differences lead to the lack of sensory integration. Most children with considerable differences between their non-verbal intelligence and verbal intelligence lack sensory integration (Clark *et al.* 2008). Approximately half of the children with attention deficit disorder have impaired balance and coordination, and their vestibular system and cerebellum are involved, which is evident in the brain images of these children. Since the cerebellum and basal ganglia influence motor control and cognitive and emotional functions, dysfunction of these brain regions may explain deficits in motor and cognitive levels (Tabrizi *et al.* 2012). On the other hand, the vestibular system is one of the first systems that is formed in the early weeks of fetal life, i.e. about the twentieth week, and various body functions such as coordination in motion, balance, movement in space, setting the level of consciousness, memory, and speech development are related to the proper functioning of this system; as a result, it plays a vital role in the evolution and development of humans (McKeone 1994). Tracy and Williams (2000) examined the effects of training executive function in preschool children. The results of their study indicated that training executive functions influenced the memory of the experimental group. The relationship between the vestibular system and the central nervous system shows this influence. The vestibular system is associated with network formation, which is involved in regulating alertness and selective attention as well as with the thalamus, which is involved in integrating sensory input (Kahle and Frotscher 2003).

Studies by Abedi (2010) indicate that neuropsychological interventions influence academic performance of children with learning impairment. Also, studies by Williamson (1996), Niklasson *et al.* (2009), and Hay *et al*. (2005) show that sensory integration improves progress in social skills and control of children with ADHD (Abedi 2010; Williamson 1996). Hence, considering the above facts and previous studies, it might be inferred that sensory integration training will influence executive functions of students with ADHD. Therefore, the main research question is whether sensory integration training influences executive functions of students with ADHD.

Material and methods

Method

The pretest–posttest experimental research method with a control group was used and the subjects were selected randomly.

Participants

The research population consisted of all male elementary school students with ADHD who studied in elementary schools of Isfahan city

during the academic year of 2014-2015. The research sample included 20 male students (10 in the case group and 10 in the control group) who were selected using multi-stage sampling. Then, for precise diagnosis, Conner's diagnostic test (parent) was administered. Of these, 20 students who had high mean scores and inclusion criteria for the study, namely age, male gender, lack of associated disorders, no medication use for attention deficit hyperactivity, obtaining the required score (higher than 1.5) in Conner's Behavior Rating Scale (parent form), parents' report and the consent of their parents, were randomly selected.

Conner's Scale (parent form) was used for data collection. The parent form of Conner's Scale includes 27 items and is completed by the child's parents. A four-point Likert scale is used for scoring (from not at all to very high). This instrument is used for measuring the severity of ADHD. In the study by Shahaeian *et al.* (2007) for standardization of the short form of Conner's Scale (parent form), the retest reliability coefficient was 0.57 for the whole score, Cronbach's α coefficient was 0.76 and validity was 0.84. Also, reliability of the teacher scale was 0.75 for the whole score using the retest method, and it varied from 0.68 for passivity to 0.82 for conduct problems. Cronbach's α coefficient for the whole questionnaire was 0.82 and varied between 0.74 for hyperactivity and 0.89 for inattention-dreaming (Niklasson *et al.* 2009; Hay *et al.* 2005).

In this study, sensory integration training is the independent variable and neuropsychological skill is the dependent variable. After completing the questionnaire, 20 subjects were selected and assigned to two groups of 10 participants (case group and control group). Then, the "sensory integration" training package, which was adapted from the sensory integration program (Lynn *et al*. 2007), was run individually for each participant. The intervention consisted of 12 sessions, 2 sessions per week. During each session, the subjects were individually trained in sensory integration for 45 min (Shahim *et al.* 2007). The summary of the training program is as follows.

1. Balance skills and spatial awareness: this session includes crawling out of a tire, moving and stopping the tire, jumping in and out of the tire with both feet, standing on the tire and keeping balance.
2. Balancing activities: these activities included walking up and down a ladder to the ground, walking up the ladder to land with the left and right foot, hipping upward on the steps and hipping on the sides within of the ladder steps.
3. Tactile activities: tactile stimulation of the child's fingers by the brush, crawling, moving, crawling while hipping, child stands next to a wall and spins, full rotation in one direction and then in the opposite direction, rolling a ball on the child several times and touching the child with a cloth towel or piece of carpet.
4. Atrial activities: jumping rope, tic-tac-toe, using equipment such as trampolines, rocking chair, slides and swing.
5. Activities to promote the sense of depth: transporting equipment, tug of war, crumpling up paper, throwing a heavy ball, pushing heavy objects and throwing a ball in a basket.
6. Activities to promote planning of movements: blowing ping pong balls, imitation of animal gait, foot jump, rolling a ball back on the wall, shooting forward, climbing ladders and moving in a certain direction.
7. Bilateral motor coordination: riding, jumping rope and hopping aimed at identifying different directions.
8. Strengthening auditory and visual attention: using a nervous system gauge, finding the differences and similarities in pictures, showing objects for 30 seconds to the student and then hiding them and asking the student to explain what he saw.
9. Strengthening auditory memory: making sentences, stating a word, then the child adds another word, and continuing until a complete sentence is made, listening to voices, different recorded voices and voice recognition, using short stories and asking the child about the events of the story.
10. Strengthening visual memory: using word and picture cards, viewing images of children and then recognizing them, finding matching shapes according to their color and size.
11. Hand-eye coordination: catching a ball with the right hand and left hand, opening bolts and nuts with the dominant hand and non-dominant hand, cutting geometric shapes designed by the children themselves, putting matches in a box.

Findings

Average age of subjects in the case group was 8.60 and the standard deviation was 1.07. Age and standard deviation in the control group were 8.60 and 0.52, respectively. Parents' level

Table 1. Mean and standard deviation scores of pretest and posttest in case and control group

Research component	Group	Pretest			Posttest		
		No.	Mean	SD	No.	Mean	SD
executive functions	case	10	28.70	1.49	10	24.40	2.99
	control	10	29.10	1.29	10	28.30	1.25

Table 2. Results for covariance analysis of effects of group membership on executive function scores

Variable	Sum of squares	Degrees of freedom	Mean of squares	F	Sig.	Level of effect	Statistical power
pretest	18.675	1	18.675	2.808	0.122	0.203	0.334
group membership	64.044	1	64.044	9.628	0.001	0.467	0.806
error	73.170	11	6.628	–	–	–	–

of education in the present study varied by high school diploma and MA level, with the highest frequency of high school diploma. The participants mostly were from single child families and most of them were the first child of the family.

According to the results of the Wilk-Shapiro test, presupposition of normal distribution of scores in pretest and posttest in both groups is supported. Also, according to the results of Levene's test, presupposition of equality of variances in scores of case and control groups in the pretest stage is supported. Considering observation of the normality presupposition and random selection of samples and identicalness of variances, covariance analysis was performed for obtaining inferential results.

As observed in Table 2, following the elimination of the effect of Sync variables on the dependent variable and considering the calculated F coefficient, a significant difference between adjusted means of executive function scores of the participants in terms of group membership (case and control groups) was observed in the posttest ($p < 0.01$). Thus, the research hypothesis is supported. Therefore, sensory integration training influences increasing executive functions scores of subjects in posttest in the case group. This influence in posttest is 46.7%.

Discussion and conclusions

The current work was conducted aimed at determining the effect of sensory integration training on executive functions of male elementary school students with ADHD. The results of the statistical analysis indicate that sensory integration training influences the performance of students.

The findings of the current study are consistent with the findings of Soortigi *et al*. (2005) on the influence of sensory integration on motor skills of agility in motions and motor planning, Sabet (2010) on the sensory integration treatment effect on the reduction of hyperactivity, Dehghan (2009) on the sensory integration effect on improvement of motor functions and skills, and Rogers *et al*. (2006) on the sensory integration treatment effect on improvement of touch and movement skills. Moreover, Hay *et al*. (2005) studied the effect of sensory integration on 6-12 year old children with ADHD and found the influence of these simulations on the reduction of behavioral problems, alertness, speed of response to stimuli, and changing ability (Niklasson *et al*. 2009).

The above findings can be explained through the deficiency of the ADHD children in executive functions. Thus, appropriate training programs should be designed which lead to the improvement of these skills. One such is sensory integration training, which can directly improve executive functions, which, in turn, indirectly leads to the reduction of ADHD symptoms. Executive functions are significant abilities helping children to evaluate their performance as well as to identify and remove possible barriers of their improvement. Thus, by enriching and preparing the environment through sensory integration methods, the growth and development of executive functions in children will be fostered. One of the major findings of this study is that these skills are acquired through education and learning. Most children apply these skills automatically, whereas children with attention deficit hyperactivity disorder encounter problems in these skills; consequently, they need to be taught how to apply them. Therefore, sen-

sory integration can be effective in developing these basic skills, and learning can be improved by nurturing and developing these basic skills.

Attention deficit is the most evident and is a major problem in these children which leads to difficulty in controlling different stimuli and responding to only one stimulus. Sensory integration influences higher levels of the brain which are responsible for higher processes including attention, and improves organization of the senses from stimuli which children receive from the surrounding environment, so that spatial and temporal aspects of sensory input are processed, interpreted, and integrated and the brain selects, enhances, manages and compares information in the form of a flexible and variable pattern.

Attention deficit covers a wide area of academic problems of students. If attention deficit and hyperactivity problems of children are left unrecognized, children will probably encounter emotional and social problems. Thus, applying appropriate intervention methods can improve this disorder in children. This method can be used for the improvement of executive functions of students with ADHD. Furthermore, using this intervention method is recommended to psychologists and teachers to tackle the problems in children with ADHD.

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