



## THE EFFECTIVENESS OF PILATES, NEUROFEEDBACK AND MEDICATION IN REDUCING ATTENTION PROBLEMS IN CHILDREN WITH ATTENTION DEFICIT DISORDER

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### ABSTRACT

The present essay attempts to effectiveness of Neurofeedback (NFB), Pilates and Medication in reducing attention problems related to school-age children with Attention Deficit Disorder (ADD). Along with the national preschool children assessment done by the Department of Education of Iran, a set of tests were conducted to detect different types of attention problems in school-age children. To assess children's attention problems, 25 examiners, who had been trained sufficiently, went to different preschool assessment centers in the city of Tehran, Iran. To collect data, a set of attention tracking software such as the Wisconsin Card Sorting Test [1], the Stroop color and word test [2], the Continuous Performance Test [3] and the Digit Span Test [4] were used. Out of the whole population, 4197 children with attention problems were detected. The results showed that out of the whole 18602 school-age children, 4197 had attention problems; the first and the second most common attention problems were Selective Attention Deficits and Sustained Attention Deficit respectively. According to the results, Pilates was the most effective way to reduce attention problems in children, while NFB was the least effective treatment.

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### Introduction

Most brain activities require a lot of attention, whether it is to memorize information, to understand a text, or to find a certain thing. All intellectual activities require attention, either to be generally vigilant, to focus on something in particular, or to divide your concentration among different activities. Attention, as one of the main brain functions, is an essential aspect of cognitive structure that plays an important role in the formation of intelligence, memory and perception. The first step in information processing is related to attention that is defined as the ability to select a portion of the environmental information for further processing based on concentration and awareness [5].

Attention deficit disorders (ADD), which are often diagnosed in children, can also be found in adults. Someone suffering from such disorders (with or without hyperactivity i.e. ADHD) will find it extremely difficult to focus on something; will get constantly distracted by external or internal events, and present compulsive behaviors and difficulties to stand still. These are neurological disorders which are influenced by heredity or environment. ADD is often found in children, especially boys, and can explain certain behaviors that result from a lack of attention in their early school years. However, as mentioned above the diagnosis should be done by a professional since some of those described behaviors may often turn out to be completely normal.

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As conventional treatments offer incomplete benefit for over 33 % of children with attention-deficit/hyperactivity disorder (ADHD) and many refuse to try them, additional treatments are needed. One of the most important, easiest and most cost effective approaches available, especially for attention, is physical activity and exercise and its antidepressant effect has attracted a lot of interest. Research findings related to this field have shown that physical activity and exercise are among the most important strategies for maintaining physical and mental health as well as reducing disease during life. Pilates originally developed by Joseph Pilates after World War I and by physicians as a unique method of fitness in which a combination of strengthening, stretching and breathing muscles are used to develop trunk muscles and restore muscle balance [6,7].

In the present essay, a neurological assessment of attention problems and a new intervention to reduce symptoms of ADD will be presented. Given the importance of attention, many methods have been introduced to improve people's attention and NFB is one of them. NFB is a useful tool to improve cognitive processes. NFB is a safe and painless method to improve self-controlled brain functions. The underlying function of NFB includes strengthening self-regulatory mechanisms required for effective functioning [8]. NFB, also called Electroencephalography (EEG) Biofeedback, is a learning strategy that enables people to change their brain waves through operant conditioning [9]. NFB helps people normalize their brainwaves reactions to stimuli [10]. NFB can be used to stimulate or regulate brain's activities; it can also be used for healthy people [9]. NFB improves attention and increases the capacity of working memory [11]. Attention-deficit/hyper-activity disorder occurs in 3% to 5% of school-aged children, accounts for as many as 30% to 50% of child referrals to mental health services.

Nowadays, medication is the most common treatment method in children suffering from ADHD. However, due to the wide range of heterogeneity in children affected by ADHD, medication is not effective in all clients. Furthermore, even some drugs such as methylphenidate, which has been approved by the U.S. Food and Drug Administration as a first-line treatment for people influenced by ADHD, has different adverse effects. These side effects severely deteriorate patients' ability to manage their cognitive function such as attention and concentration [12]. The aim of this study is to investigate the use of different methods various fields of science to determine the effectiveness of increasing the children's attention with attention deficit. Researchers are looking for answers to their questions Can Neurofeedback improve attention problems in children with attention disorders? Can Pilates improve attention problems in children with attention disorders? Can Medication Pilates improve attention problems in children with attention disorders?

### **Literature review**

Executive functions are a set of cognitive processes including planning, flexibility, inhibitory control, attentional control, working memory, verbal memory, visual memory, and spatial memory that work independently of each other, but are simultaneously related. Attention is one of the key elements of executive functions. The existence of ADD in children has confirmed functions are functions are a neuroimaging-based studies [13].

The most important subcategories of attention are selective attention, attention shifting, sustained attention and attention capacity. Alder and et al [14] have shown that children with ADD have slower responses, verbal problems and poor sustained and selective attention; these children have also self-regulation problems. Adults with ADD have many problems in using their attention capabilities in the optimal manner, but children with ADD are inattentive in doing their activities. There is no compelling evidence regarding strong interactions between attention and EF structures in children. Attention is the main factor during the learning process; as Bandura (1989) emphasized, the initial stage of learning begins with attention and inattention results in major flaws in learning. As mentioned by Bandura, attention is one of the essential aspects of cognitive structure that plays an important role in the structures of intelligence, memory, and perception. Sustained attention deficit prohibits processing, storing and recalling information. Attention deficits are among the main causes of learning disabilities [15]. Studies conducted by Hadassah Medical Center (2011) have shown that attention deficits are sustainable in older age groups and make people face serious problems in doing their personal/social duties. Accordingly, early diagnosis and treatment of ADD is very essential, especially in younger students [15,16]. Learners' attention to the subject matter is also important in learning process; herefore

Bandura emphasizes that the initial stage of learning is attention, while inadequate attention results in flawed learning [17]. Selective attention refers to the ability to avoid interfering information unrelated to the task at hand or the ability to absorb information selectively [18]. Mechanisms of selective attention allow us to select relevant information from large amount of data. Selective attention is one aspect of inhibitory control. Distraction, defined as the lack of ability to concentrate on a specific stimulus or to understand complex stimuli effectively, is another attention problem commonly observed among children [19].

Attention-related problems can also cause intelligence problems among children. Barkley [20] puts special emphasis on the fact that attention deficit is a dysregulation disorder characterized by unstable and changeable behaviors due to biochemical imbalances in the brain. Barkley defined changeable behaviors as a set of general regulation deficits and biochemical imbalances that make it difficult to control the onset of a task and its completion. (ADD) is usually characterized by Sluggish Cognitive Tempo (SCT), drowsiness, confusion, slow responses, reticence, anxiousness, inactivity, self-absorption and ignorance of the details [21].

Attention deficit is the most obvious children's problem with (ADHD), being regarded as the first diagnostic and statistical feature of mental disorders [22]. Children with ADHD do not have the ability to focus on the details and are usually careless in doing their homework or daily duties. Selective attention plays an important role in executive functions and is simply defined as focusing on a set of information selectively [23]. Attention deficits, as a wide range of disorders, can be manifested through hyperactivity, impulsivity, inattentiveness, hearing or visual processing problems, learning disorders or emotional illnesses. ADD has become a recognized problem; however, there is no proper test, based on its actual components, to measure it, especially among children. ADD is currently diagnosed based on its behavioral components; nevertheless, there is a need for a neurological diagnostic tool to assess it [13,26]. In this study, we tried to compare scientific foundations and different theoretical reduction exercise, attention problems, and evaluated the technology and drug therapies. All research on reducing the problems have argued that the child has strengths and weaknesses. However, maybe that is very important for parents when the normal side effects of therapeutic interventions and practices are available. According to research conducted by studies sought to find the best effective that has the least damage to the child and her family.

### **Pilates**

Pilates has been developed in the early twentieth century by a German athlete, Joseph Pilates. He actually invented a new style of gymnastics. His method achieved a tremendous success in America in 1920s. Today, Pilates is a combination of yoga and gymnastics techniques that are known worldwide. Joseph Pilates tested his method on his fellow prisoners and wounded soldiers during the World War I. He used available tools, such as bed springs to move up and control people's muscles. He essentially developed Pilates to enhance resistance. Pilates exercises are done on the ground, with or without its tools. Pilates is developed based on six principles that are essential for performance quality and successful outcomes with regard to Pilates, the quality is more important than the quantity. Unlike other training systems that include excessive repetition of the movements, movements are done completely and accurately in Pilates; therefore, the athletes achieve the desired results in a short period of time. The development of a balanced body position is an important issue with regard to Pilates. Pilates' movements require proper breathing. In fact, Pilates' movements are a combination of balanced body position, movement and breathing. Pilates movements that are done on the ground have their own characteristics and special tools (such as ball, spring and bands). These tools create imbalances and thereby move a variety of balancing muscles. Pilates includes 500 movements. All muscles need to be in unusual positions in order to become stronger. Pilates' exercises are commonly completed in 60-minute sessions. Pilates might be used as a main sport, a supplement to other sports or even as a rehabilitation strategy. The modern approach to Pilates can be regarded as a comprehensive method of enhancing mind's and body's functions. The main goal of this modern view of Pilates is the improvement of attention that eventually enhances executive functions [25,26]. Pilates has three key components that reduce ADD symptoms: coordination of movements, complex movements and coherent breathing. Biochemical imbalances seen in individuals with ADD reduce their ability to focus and do their tasks. Exercise is always useful; but, controlling ADD symptoms is only possible by treating biochemical imbalances in the brain [27].

Pilates exercises can greatly help people with ADD. When performing Pilates movements, blood flow increases in the brain and makes it more efficient. These exercises increase blood flow and oxygen in the brain leading to a better survival of nervous system; they also lead to the construction of new neural connections and the increased number of neurotransmitters in parts of the brain responsible for learning, memory and critical thinking. The complexity and coordination of movements in Pilates increase connections between nerve cells and improve brain functions. Two main principles of Pilates are quality and accuracy. With regard to Pilates, body movements are controlled by the brain; attention and concentration improve; sleep quality increases; negative thoughts decrease; body rests; and memory processing speed increases. Furthermore, coherent breathing in Pilates stabilizes the automatic nervous system and improves brain functions. Using Pilates, as a part of an intervention for the treatment of ADD, reduces ADD symptoms and improves attention and life quality of the patients [28].

ADD patients have difficulties in selecting relevant information and ignoring irrelevant information; these patients have also difficulties in functional asymmetry that lead to problems in internal control and positioning of attention. Complications, such as problems related to functional asymmetry, represent the position of defects in the neural mechanism of attention that is lateralized on the right hemisphere.

Further studies must be conducted to confirm the effectiveness of Pilates in reducing symptoms of ADD [29]. Attention, learning, planning, delaying needs, emotional regulation, avoiding risky situations and performing dangerous deeds are related to a part of the brain that allows making the right decisions. Most of the problems associated with ADD are due to frontal lobe disorder; thus, future studies are required to determine how Pilates can activate this part of the brain. Improved mood, increased vitality, high level of energy, satisfaction of basic psychological needs, competence, independence, communication, improved mental health and self-confidence decrease the levels of anxiety, stress and mental pains [28].

### **Neurofeedback**

Brain waves are divided into four bandwidths that are able to describe their functions: delta waves (1 to 3 HZ); theta waves (4 to 7 HZ); alpha waves (8 to 13 HZ); and beta waves (14 to 30 HZ). Alpha waves are dominant during quietly flowing thoughts or in meditative states; beta waves are dominant when attention is directed towards cognitive tasks or solving problems; delta waves are dominant in dreamless sleep; and theta waves are dominant when dreaming [30].

In the same line, in another study, 32 medical students were trained to increase either their sensory motor rhythm (SMR) (12 to 15 HZ) or their theta rhythm (4 to 7 HZ). Based on the results, concentration and working memory of those who increased their SMR were improved significantly and after 8 sessions of NFB therapy, those students could increase their SMR selectively (that increase was determined by raising the ratio of SMR to theta/beta waves) [11].

NFB is a treatment method that is able to alter or modify cognitive, emotional and physiological processes. Research results show that NFB makes the brain compatible with proper activities. Many studies have been conducted to evaluate the effectiveness of NFB in treating learning disorders. For example, Kouijzer and colleagues [31] examined the effectiveness of NFB in improving executive functions of autistic children and reported positive results; in a similar study [32], positive results were reported regarding the effectiveness of NFB therapy in enhancing executive functions of autistic children.

A part of the used protocol was theta waves suppression. Studies have shown that theta is related to poor performance. In other words, the suppressed theta group had a better performance while the increased theta group had a weak performance. Therefore, it can be concluded that NFB has positive effects on mental performance and cognitive processing. This finding was in line with results of other studies such as studies conducted by Hanslmayr and colleagues [33], Watson [34]; quoted by [35], Serman and colleagues [36] and Rasey and colleagues [37]. In a study, Yaghoubi, Jazayeri, Khushabi, Dolatshahi and Niknam (2008) concluded that although Ritalin is more effective than NFB, NFB is a more appropriate method of treatment because patients need to use Ritalin for many years and deal with its complications while NFB has long-term effects and no side-effect.

Madigan and colleagues (2003) conducted a study and showed that exercise therapy is an effective method of treating ADD in children. In other studies, it was specified that targeted exercise programs can improve attention in children with ADD [38,39].

At the initial stage of the treatment, beta waves (15 to 20 HZ) were used as incremental bandwidths and theta and high beta waves were used as compressed bandwidths. At the second stage of the treatment, instead of beta waves, low beta waves (12 to 15 HZ) were recorded as incremental band widths due to the existence of frontal lobe problems in ADD children.

### **Medication**

To help families make important decisions about treatment, the National Institute of Mental Health (NIMH) conducted the most in-depth study ever carried out for evaluating ADHD treatments. This study is called the Multimodal Treatment Study of Children with ADHD (or the MTA). Data from this study showed that methylphenidate (a commonly used stimulant medication for ADHD) is effective in treating the symptoms of ADHD, either alone or in combination with behavioral therapy. It is also found that the treatment that includes medication is more effective for the symptoms of ADHD (such as hyperactivity) than behavioral therapy alone. This is especially true when the medication's dosage is closely monitored and personalized for each child. Medication is a highly effective way to treat the symptoms of ADHD, but it only works when it is taken as prescribed. Unlike antibiotics and similar medications that are taken for short periods of time to treat infections and other ailments, the information contained in this guide is not intended as, and is not a substitute for, professional medical advice. All decisions about clinical care should be made in consultation with a child's treatment team. No pharmaceutical funding was used in the development or maintenance of this guide. There is no ADHD medication that will cure the mentioned condition. Fortunately, the majority of children with ADHD can improve significantly with a combination of medication and behavioral treatment.

Research is ongoing to find out more about the way ADHD affects brain function and how to best treat the condition. Other studies are looking at the long-term outcomes for people with ADHD. Most children treated with ADHD medication have some side effects. Some of the most common and predictable side effects from stimulant medication are reduced appetite, weight loss, problems sleeping, headaches, stomach pain, and irritability. These side effects usually get better within the first couple of months of treatment. Medication has been considered as the most important treatment of ADD; however, related side effects and complications have created concerns for both families and specialists. Accordingly, finding non-pharmacological treatments for ADD has become a priority.

### **Methodology**

This study was conducted as a screening test for attention problems in children starting elementary school and to compare the effectiveness of Pilates, NFB and Medication in reducing attention problems in school-age children with ADD. Thus, along with the national preschool children assessment done by the Department of Education in Iran, a set of tests were conducted to detect different types of attention problems in school-age children.

## **Participants**

The population consisted of all 6 to 7-year old children (boys and girls) who were living in Tehran in the 2014-15 school year ( $n=18602$ ); the average age of the children was 6.7 years ( $SD=0.9$ ). Students in this study refer to the education counseling centers in Tehran and request a list of students who were diagnosed with attention deficit disorder and through a random selection of sample size selection and consent from the parents to attend their children in the study were,

## **Process**

To assess children's attention problems, 25 examiners, who had been trained sufficiently, went to different preschool assessment centers in the city of Tehran, Iran. Then, a meeting was held and different available treatments for attention problems were explained for their parents. Accordingly, after collecting parents' consent forms, 67 children were placed in the Pilates group, 39 children in the Medication group and 51 children in the NFB Group. The present quasi-experimental study had a pretest-posttest design with a control group. To analyze the collected data, independent-samples t-test and Analysis of Covariance (ANCOVA) were used.

## **Research Tools**

A set of attention tracking software, the Wisconsin Card Sorting Test [1], the Stroop color and word test [2], the Continuous Performance Test [3] and the Digit Span Test [4] were used. Out of the whole population, 4197 children with attention problems were detected;

The Wisconsin Card Sorting Test (WCST)

The WCST [1] is a test of set-shifting [40] and executive functions. Strategic planning, abstract thinking, goal-oriented behaviors, organized searching and controlling impulsive responses are required to be successful in the WCST. This test is widely used to measure the frontal lobe function, abstract thinking and the ability to shift cognitive strategies or responses to changing environmental feedbacks.

In the WCST, 64 cards are used that are different in terms of color, number and shape. The participants are asked to match the cards based on the experimenter's verbal feedback provided after each trial. If the participant matches the cards correctly, the experimenter will change the rule for the next trial. Thus, the WCST can assess both cognitive flexibility and conceptualization ability. Results of this test can be affected by frontal lobe damages. Examined on a group of Iranians, a test-retest reliability of 0.85 and a validity coefficient of 0.86 have been reported for the WCST.

The Stroop Color and Word Test (SCWT)

The SCWT [2] was developed to assess selective attention. The SCWT is used to measure attention and set-shifting. The respondent receives three cards: a color card, a word card and a color-word card. The color card is a series of dots/asterisks in the same color (green, red, blue or yellow) (the respondent is asked to name the colors); the word card is a list of words of colors (i.e. green, red, blue, yellow) (the respondent is asked to read aloud the color words); the color-word card is a list of those same color words printed in conflicting colors (e.g. the color 'red' is printed in 'blue') (the respondent is asked to name the colors, ignoring the printed color words). The respondent's reaction time to each card is recorded. The difference between time used to answer the color card and time used to answer the word card is used as an index of differentiation. This test has been normalized in Iran by the Institute of Cognitive Sciences [41].

The Continuous Performance Test (CPT)

The CPT was developed [3] to assess sustained attention [42]. There are a variety of CPTs. In CPTs, the respondent is presented with a repetitive task and must maintain his/her focus over a period of time in order to respond to targets. There are four main scores in each CPT administration: correct detection (the number of correct responses); reaction time (the amount of time between the presentation of the stimulus and the respondent's response); commission errors (the number of times the respondent responded but not correctly; high commission errors indicate high levels of impulsivity); and omission errors (the number of times the stimuli was presented, but the respondent did not respond; high omission errors indicate distraction or sluggish response).

The Digit Span Test (DST)

The DST was developed by Wechsler [4] to assess attention capacity [43]. The DST includes two tasks: 1) forward recall of digit sequences and 2) reverse-order recall of digit sequences. The number of correct answers is used to estimate the participant's attention capacity. Validity of the DST, as an oral test assessing attention capacity, has been verified [43].

## **Results**

To evaluate attention problems in children starting elementary school, independent samples t-test was used. To compare the effectiveness of Pilates, NFB and Medication in reducing symptoms of ADD, repeated measurement and ANCOVA were conducted. The Bonferroni post hoc test was also used for a deeper analysis of the results.

**Table 1.** Means and SDs of participants' demographic characteristics

	Mean	SD	Mean	SD	Mean	SD
IQ	110.2	11.19	109.12	9.17	107.01	8.19
Age	6.5	0.9	6.11	0.7	6.4	1.01

Note. ADD = attention deficit disorder

Estimated IQ based on performance on the Wechsler Intelligence Scale–Third Edition Standard score based on performance on the Wide Range Achievement Test–Third Edition.

In Table 1, Means and SDs of demographic characteristics of the participants are presented. Participants' diagnosis as ADD has been approved by Psychiatrist Subjects were recruited by available sampling. The sample was matched by age and sex, then, randomly divided into equal control and experimental groups. Statistical results in Table 2 show that there are no significant age differences between groups.

**Table 2.** Comparison of different types of attention between the groups of participants

		Selective attention		Sustained attention		Attention capacity		F	ES	PS
		M	SD	M	SD	M	SD			
The Stroop Color and Word test		1.01	0.27	1.39	0.31	1.41	0.21	2.97	0.07	<b>0.5</b>
Stroop		49.37	9.63	43.21	8.72	45.11	14.5	3.17	0.06	<b>0.5</b>
Continuous performance task	Correct Detection	40.17	9.10	43.21	11.78	47.42	17.23	1.27	0.01	<b>0</b>
	Error Reaction	0.31	0.66	0.69	0.31	1.11	1.29	1.39	0.01	<b>0</b>
	Omission errors	0/43	0/76	0/43	0/91	0/82	0/72	0/65	0/01	<b>0</b>
	Commission errors	48.01	14.21	51.3	13.09	59.12	1.17	1.41	0.01	<b>0</b>
	Commission errors	0.79	0.39	1.34	1.02	1.91	1.13	2.39	0.04	<b>0</b>
Code score		2.31	0.31	3.2	0.67	3.41	0.73	9.17	0.17	<b>0.01</b>
Digit span	forward	7.21	1.93	8.61	2.01	7.89	2.31	7.12	0.19	<b>0.01</b>
Digit span	backward	5.78	1.09	5.01	1.97	4.13	1.31	4.11	0.7	<b>0.01</b>

Accordingly, 4197 children (%22.51) had attention problems and the first and the second most common attention problems were Selective Attention Deficits and Sustained Attention Deficit respectively (see Table 2).

**Table 3.** Changes in selective attention in the groups of participants

	Pretest			Posttest			Sig.
	Score	SD	Standard error	Score	SD	Standard error	
Pilates	17.43	3.56	2.43	15.81	4.32	3.92	0.01
Medication	1.03	0.64	0.50	0.73	0.41	0.39	0.01
NFB	39.45	2.56	1.79	31.28	8.29	2.33	0.01

According to the results presented in Table 3, the difference between pretest and posttest scores of selective attention was significant in all groups ( $p < 0.05$ ). In Table 4, changes in attention capacity in the groups of participants are shown:

**Table 4.** Assessment of changes in attention capacity in the groups of participants

	Pretest			Posttest			Sig.
	Score	SD	Standard error	Score	SD	Standard error	
Pilates	2.41	0.54	0.43	2.01	0.56	0.32	0.01
Medication	2.13	0.73	0.50	1.23	1.17	0.41	0.01
NFB	10.45	0.32	0.79	9.28	0.76	0.29	0.01

According to the results presented in Table 4, the difference between pretest and posttest scores of attention capacity was significant in all groups ( $p < 0.05$ ). In Table 5, changes in set-shifting in the groups of participants are presented.

**Table 5.** Assessment of changes in Sustained attention in the groups of participants

	Pretest			Posttest			Sig.
	Score	SD	Standard error	Score	SD	Standard error	
Pilates	13.15	3.06	1.73	12.21	2.82	2.12	0.05
Medication	2.02	1.04	1.20	0.93	0.86	0.19	0.01
NFB	26.57	1.56	1.99	21.02	5.19	1.32	0.05

In Table 5, changes in sustained attention in the groups of participants are shown. According to the results presented in Table 5, the difference between pretest and posttest scores of sustained attention was significant in all groups ( $p < 0.05$ ).

### Discussion and Conclusion

Most brain activities require a lot of attention, whether it is to memorize information, to understand a text, or to find a certain thing. All intellectual activities require attention, either to be generally vigilant, to focus on something in particular, or to divide your concentration among different activities. Attention, as one of the main brain functions, is an essential aspect of cognitive structure that plays an important role in the formation of intelligence, memory and perception. The first step in information processing is attention that is defined as the ability to select a portion of the environmental information for further processing based on concentration and awareness [5].

The results showed that NFB can improve attention. This result was consistent with results of a study conducted by Vernon and colleagues [11]. A part of the protocol used in this study was simultaneous increase of CZ. To explain this finding, it can be stated that NFB affects sensory cortex and motor context. In Vernon and colleagues' study, therapists could improve executive functions, concentration and attention by reducing theta waves (7 to 12 HZ) and SMR. After 8 sessions of NFB therapy, they could increase their SMR selectively (that increase was determined by raising the ratio of SMR to theta/beta waves). The results indicated that their retention, working memory and attention were significantly improved by the increase of SMR [11].

Increased SMR reduces the control of voluntary motor system over cognitive information processing; accordingly, Agner and Grazilier [50] assumed that NFB facilitates information processing. Thus, the effectiveness of NFB on improving executive functions was confirmed. In other words, NFB therapy could increase executive functions of students in the NGB group. Increased SMR improves sensitivity and reduces inattentiveness; nonetheless, the existence of direct relationships between cognitive activities have not been confirmed yet [11].

Sensory motor cortex helps the cerebral cortex in encoding physical and cognitive tasks (i.e. executive functions). It is understandable why the early pioneers in the field of neurological treatments started the analysis of learning process from the sensor motor cortex. Ratey [44] stated that "brain circuits used to regulate and sequence mental activities are similar to brain circuits used to regulate and sequence physical activities". In other words, sensory motor cortex regulates both physical and

mental processes. The sensory motor cortex is mostly active in sensory motor processes. Thus, patients who have difficulties in understanding logical sequences of cognitive tasks can benefit from NFB therapy.

NFB includes systems related to emotions, feelings, attention and working memory. These systems have close interactions with each other and involve the sources of energy for both external (movements) and internal (reasoning, thinking) actions [45].

To explain the results of this study, it can be said that increased SMR can also activate neural circuits involved in executive functions. Previous studies have shown that working memory functions through neural circuits resulting from the interactions between intentional control system (located in the prefrontal lobe) and sensory information storage (located in the parietal lobe) [46,47]. The results showed that, the medication alone cannot meet the therapeutic requirements of children with ADHD and shall be combined with other intervention methods.

Results of previous study have also shown that visual exercises can increase attention and improve learning. Studies conducted on mice with damages in the frontal lobe showed that sport and physical activities might enhance their attention [48]. Similar to medication, physical exercises might increase the number of neurotransmitters and the availability of dopamine receptors [49].

One of the limitations of the researcher The lack of detailed neurological evaluation methods That could all change Track and have a better explanation.

In future research it is better to principles of neuroscience at each of the three therapeutic models mentioned be paid to the neurological completely certain and using brain imaging to track changes to be effective.

### **Compliance with Ethical Standards**

#### **Funding**

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#### **Conflict of Interest**

Sakineh Soltani Kouhbanani declare that she has no conflict of interest. Mohammad Hossein Soltani Kouhbanani declare that he has no conflict of interest.

#### **Ethical Approval**

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

#### **Informed consent**

Informed consent was obtained from all individual participants included in the study.

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