

Neurofeedback Effect on Perceptual-Motor Skills of Children with ADHD



Mehdi Jahani¹, Ebrahim Pishyareh¹, Hojjat Allah Haghgoo¹, Sayed Ali Hosseini^{1*}, Seyedeh Neda Ghadamgahi Sani²

1. Department of Occupational Therapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.

2. Department of Occupational Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.

Citation: Jahani M, Pishyareh E, Haghgoo HA, Hosseini SA, Ghadamgahi Sani SN. Neurofeedback effect on perceptual-motor skills of children with ADHD. Iranian Rehabilitation Journal. 2016; 14(1):43-50. <http://dx.crossref.org/10.15412/J.IRJ.08140107>

doi: <http://dx.crossref.org/10.15412/J.IRJ.08140107>

Article info:

Received: 14 Jul. 2015

Accepted: 26 Dec. 2015

Keywords:

Attention deficit disorder with hyperactivity, Neurofeedback, Perceptual-motor skills

ABSTRACT

Objectives: This study investigates the impact of neurofeedback on perceptual-motor skills of 5 to 12 years old children with Attention Deficit Hyperactive Disorder (ADHD).

Methods: In this clinical study, 40 children between the ages of 5-12 years, who were patients of the Tavanesh Clinic and diagnosed with ADHD, were randomly chosen and divided into two groups of control and test. 20-neurofeedback intervention sessions were performed. The tools utilized in this study included Bruninks-Oseretsky Test of Motor Proficiency and Child behavior checklist (CBCL) survey questionnaire. For evaluation after the intervention, Bruninks-Oseretsky Test of Motor Proficiency scale for children, along with CBCL questionnaire surveys were asked to fill up by the participants' mothers.

Results: After the intervention, the analysis of the scores in all perceptual-motor skills showed significant differences in both groups, but no significant difference was observed in the subtest of strength. The CBCL survey questionnaire revealed that the average scores on attention disorder, aggression, lack of attention and hyperactivity, externalizing and general problems in the test group is significantly less than that of the control group. However, in the confrontational behavior (internalization), there was no statistically significant difference between the test and control groups. There was a correlation between the change of motor skills and change of behavioral patterns in ADHD children.

Discussion: Neurofeedback intervention can have positive effects on improving the perceptual-motor skills of children with ADHD.

1. Introduction

Attention-Deficit with Hyperactivity (ADHD) is a neural-psychiatry disorder. The symptoms of ADHD must appear before the age of 7 years, persist for at least 6 months, ex-

pressed both at home and school, and disrupt social and educational functions. In addition, ADHD can be distinguished by behavioral symptoms such as inattention, motor impatience, and impulsivity behaviors [1-3]. Children diagnosed with ADHD are characterized by weak coordination and disorder in the functioning of fine and gross

* Corresponding Author:

Sayed Ali Hosseini, PhD

Address: Department of Occupational Therapy, University of Social Welfare and Rehabilitation Sciences, Kodakyar Ave., Daneshjoo Blvd., Evin, Tehran, Iran.

Tel: +98 (21) 22180037

E-mail: alihosse@gmail.com

motor skills [4]. These children have trouble in the motor process, such as in motor preparation and motor regulation [5-7], and gross motor skills, such as hopping, jumping, romping, walking by side leg, and equilibrium [8, 9].

Improving these skills through various approaches such as sensory and perceptual-motor integration and motor control via occupational therapy interventions and the neural empowerment of related cerebral plexus can have positive effects on both cognitive skills and dimensions of daily living of such children [10-12]. Many studies have focused on the existence of defects in perceptual-motor skills in children diagnosed with ADHD and the relation of behavioral disorders with motor skills [10-13]. The defect in motor abilities in children can result in poor quality of participation in certain areas such as play, homework, and daily activities. It seems that children with motor difficulties are at a higher risk of behavioral and educational difficulties [12-14].

In 2000, the American Psychiatric Association reported that 5% of children of school age have ADHD [2] and about 47–69% of those involve coordination-motor difficulties [15]. The prevalence of this disorder in US is about 7%, and it ranges 2–29% worldwide [16]. A study on students between the ages of 7 to 9 in Tehran, reports the spread of this deficit is about 3% to 6% [17].

Theories based on cognitive neuroscience mention the role of the frontal lobe, basal ganglia, and dopaminergic pathways and indicate that their defective functions can lead to attention difficulties and deficit in behavioral control [18, 19]. Multiple evidences show the functional insufficiency of dopamine in the brain of children with ADHD has an important contribution to the symptoms of ADHD [20, 21]. The findings of new researches reveal that in most children with ADHD, differences in Electroencephalography (EEG) and coordination of electric activities of the brain can be seen when compared with that

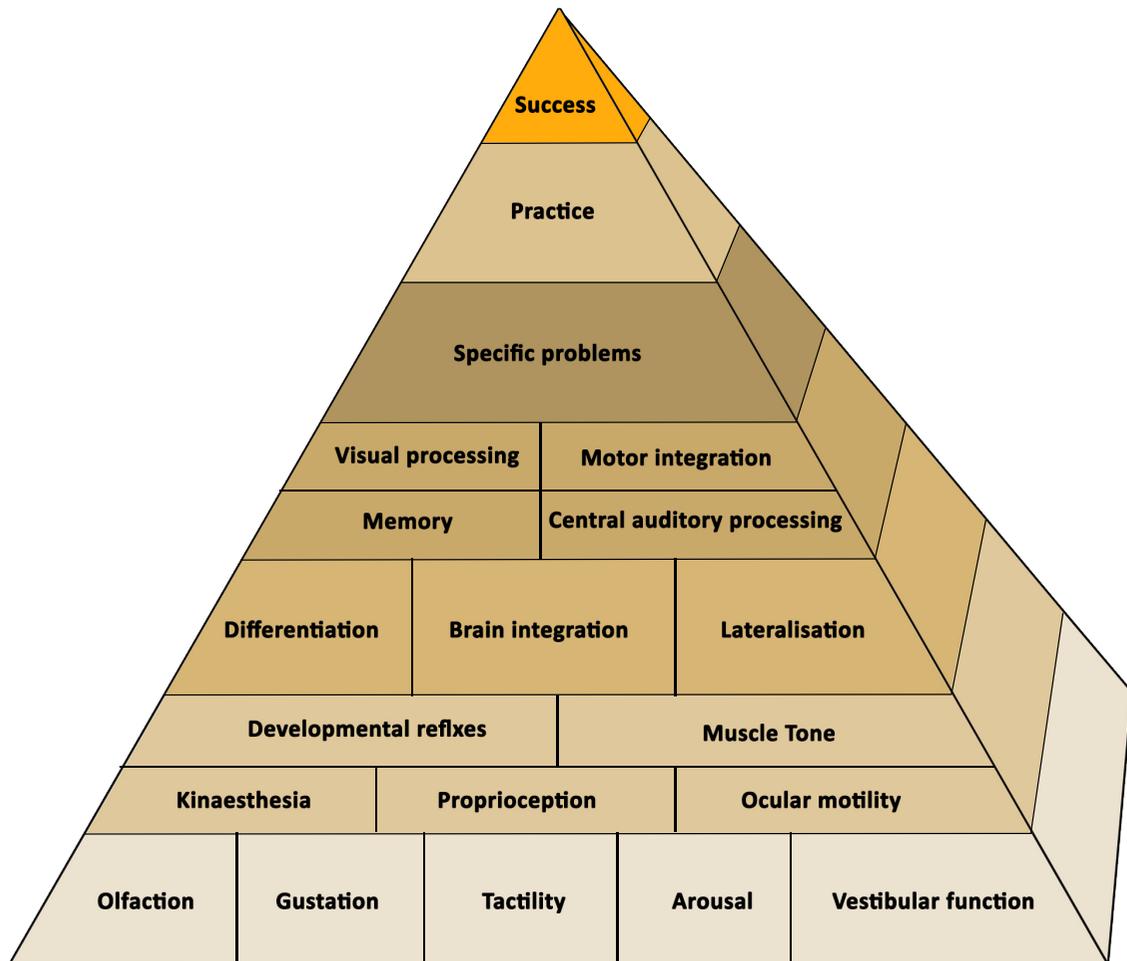


Figure 1. A leader's guide to the alert program for self-regulation [35].

of normal children. The activity of Theta waves in the frontal and central area that are related to hypoarousal is an index of the decrease in cortical activity. The increase in Theta potency is the most consonant finding in the EEG research documents about ADHD, and it clearly indicates that hypoarousal is a common neuropathological mechanism in children with ADHD [22].

Similarly, the ratio of Theta to Beta, which is related to cortical stimulation, distinguishes between children with ADHD and normal children in a consonant way [23]. The results of Beta activity -that show cortical hyperarousal- are in less consonant. Several studies have reported the decrease in Beta activity in the frontal and central areas, but a few studies have also reported that about 15% of children with ADHD show an increase in Beta activity [22, 24]. In neurofeedback interventions, the alteration of wave's amplitudes originated from the cerebral cortex causes changes in the function of cortex structures that are involved in movements and have influences on the motor efficiency of individuals, considering the changes in the motor cortex.

Neurofeedback is a training process that helps the brain learn self-regulation. Self-regulation means the expansion of personal knowledge and skills in all areas, through individual endeavor and experience of situations and various things [26]. Neurofeedback helps the brain to learn how to regulate itself and obviate its functional defects [27, 30]. The effects of neurofeedback on motor coordination and equilibrium have been mentioned in previous articles [31, 32]. Neurofeedback can increase the efficiency of rehabilitation interventions based on Sensory Integration (SI) and Perceptual Motor (PM) approaches, raise interestedness of children because of the use of visual effects, deepen and stabilize the findings of other interventions, and can fill the vacuum left by the absence of coherent and appropriate protocol for children with ADHD [10, 13].

According to the findings of several researches that have elucidated that children with ADHD have an abnormal pattern of EEG, neurofeedback can provide a mechanism to children that normalize themselves by decreasing the slow wave activity and increasing the fast wave activity [33]. According to perceptual-motor standpoints, all human actions originate from movement and motor learning has an important role in the expression of cognitive functions [13, 34]. Thus, it seems that behavioral-motor deficits are a result of inappropriate and uncoordinated information processing from input to the output stage (motor behavior).

Hence, it seems that a change in perceptual processing patterns on brain inputs plays a role in changing the behav-

ioral outputs. As it shown in Figure 1, the pyramid of sensory integration draws the evolution and growth of sensory systems in a systematic and scientific way and explains the processing matrix of sensory input from an unrefined sensory stimulation to becoming a complex behavioral pattern [35]. Interestingly, the deficits and defects in each stage of sensory functions, in cycle and procedure of giving, processing, perceptual, incorporation and recognition, can cause a problem in higher classes of sensory integration pyramid, hampering the growth of sensory stimulations to becoming complex combinational behaviors.

Figure 1 shows that Rehabilitation interventions and perceptual-motor exercises can be effective in decreasing the symptoms of children with ADHD [10, 36]. The American Psychiatric Association has accepted biofeedback or neurofeedback EEG as a supplement therapy [28]. This therapy can also increase the effectiveness and efficiency of other therapeutic interventions. Since cortical waves rise from cortex functions of the nervous system, the children with ADHD have a higher level of Delta and Theta waves, domain increase of cortical Beta in the frontal lobe, and disturbance in Alpha waves balance. The increase in cortical Beta has a strong relation with their disability in stable attention and impulses control [37].

Due to Theta high and Beta low in the frontal lobe of children with ADHD, we have used decreasing Theta and increasing Beta protocol in sensory-motor areas. Several articles have mentioned the effectiveness of neurofeedback therapy on decreasing impulsivity, construction of control, and improving attention [39]. It seems that the major symptoms of inattention are related with motor coordinating [41]. Thus, the motor deficit of children with ADHD is one of the reasons for increasing inattention and defects in occupational memory [42, 43]. In the past, the relation of hyperactivity/impulsivity symptoms with motor coordination has been reported [44, 45].

In this research, one of the input factors is earned at least one year lower than calendar age in the Bruininks-Oseretsky test of motor proficiency. Based on the results of the previous studies on effectiveness of improving perceptual-motor skills, reduction of writing skills, impulsivity, improving working memory and attention span in ADHD children, Studying the improvement of perceptual motor skills in these children is deemed necessary [46].

2. Methods

Children (aged 5 to 12 years) diagnosed with ADHD by a child psychiatrist and referred to the Rehabilitation Center of Tavanesh, located in Tehran, were initially se-

lected for the study. Of them, 40 children who earned at least one year lower than the calendar age [47] in the Bruininks-Oseretsky test of motor proficiency (BOMT) were finally selected for inclusion in the study. The BOMT is a descriptive index for the evaluation of fine and gross motor skills, and it has four subtests for gross motor skills, three subtests for fine motor skills, and one subtest for both fine and gross motor skills. The parents of the selected children were asked to fill the demographic and Child Behavior Checklist (CBCL) survey questionnaires and complete the consent form of conscious participation in research.

The CBCL survey measures a child's competence and behavior through parents or those who know the child well. It includes two wide dimensions (external and internal problems) and eight limited syndromes (Anxiety/Depression, Withdrawal, Physical Complaints, Social Problems, Thought Problems, Attention Problems, Delinquent Behavior and Aggressive Behavior) [14]. The children were then randomly allocated (using simple random method) into two groups (intervention and control groups) of twenty children each. The intervention group received neurofeedback therapy according to decreasing Theta and increasing Beta protocol in the central zone (CZ) area.

All the evaluations were performed by an experienced occupational therapist with three years of experience in occupational therapeutic tests for pediatrics. All inter-

ventions and tests, at all levels, were free for the participants. After 8 weeks of the intervention, the BOMT test and CBCL survey questionnaire were retaken. After Kolmogorov-Smirnov, analysis of covariance for checking the effect of the independent variable with the witness of pretest effect, and the Pearson Correlation Coefficient were done.

3. Results

In terms of demographics variables, no significant difference was observed between the intervention and control groups (Table 1). The scale of the average difference of scores in pretest-posttest shows a significant difference between the two groups in subtests of agility and run's speed, equilibrium, lateral coordination, gross motor skills, coordination of upper limb, speed response, motor-visual speed, upper limb speed, fine motor and perceptual-motor skills ($P < 0.001$). However, no significant difference was observed in the strength subtest ($P = 0.104$) (Table 2).

The scale of average difference of scores in pretest-posttest shows a significant difference between two groups in subtests of attention problems, aggressive behavior, attention deficit/hyperactivity, externalizing and general problems (P while there is no significant difference in confrontational behavior subscale (P in order to modify the scores effect of the pretest, subtests, and subscales, with posttest scores in both the groups of exami-

Table 1. Comparison evaluation of sex and grade of children with ADHD in the two groups.

Variable	Variable level	Number	Percent	Number	Percent	Statistics	Probability
		Control examination				Chi 2 test/fisher's exact test	
Sex	Boy	13	65	16	80	1.29	0.288
	Girl	7	35	4	20		
	Total	20	100	20	100		
School	Preschool	6	30	6	30	-	-
	Primary	14	70	14	70		
	Total	20	100	20	100		
Grade	Preschool	6	30	6	30	0.95	0.999
	Primary	4	20	4	20		
	Third	7	35	7	35		
	Fourth	1	5	2	10		
	Fifth	2	10	1	5		
	Total	20	100	20	100		

Table 2. Comparison of the average scores of perceptual-motor skills posttest in the two groups.

Variable	Variable source	Total squares	Mean squares	F	The probability	Size effect
Agility and run's speed	Pretest	266.01	266.01	62.55	<0.001	0.628
	Group	259.85	259.85	61.11	<0.001	0.623
Equilibrium	Pretest	145.69	145.69	64.87	<0.001	0.637
	Group	106.14	106.14	47.25	<0.001	0.561
Lateral coordination	Pretest	180.23	180.23	63.05	<0.001	0.630
	Group	211.31	211.31	73.92	<0.001	0.666
Strength	Pretest	841.83	841.83	179.51	<0.001	0.829
	Group	13.04	13.04	2.78	<0.001	0.070
Gross motor	Pretest	2037.68	2037.68	101.19	<0.001	0.732
	Group	2137.93	2137.93	106.17	<0.001	0.742
Coordination of upper limb	Pretest	104.58	104.58	27.67	<0.001	0.428
	Group	381.72	381.72	101.10	<0.001	0.732
Speed response	Pretest	170.29	170.29	31.56	<0.001	0.460
	group	359.65	359.65	66.66	<0.001	0.643
Motor-visual speed	Pretest	303.16	303.16	81.50	<0.001	0.688
	Group	268.79	268.79	72.26	<0.001	0.661
Upper limb speed	Pretest	236.99	236.99	47.87	<0.001	0.864
	Group	236.37	236.37	47.75	<0.001	0.563
Fine motor	Pretest	1552.26	155.26	52.72	<0.001	0.588
	Group	3087.01	3087.01	104.55	<0.001	0.739
Perceptual-motor skills	Pretest	4493.48	4493.48	61.85	<0.001	0.626
	Group	14614.40	14614.40	201.08	<0.001	0.845

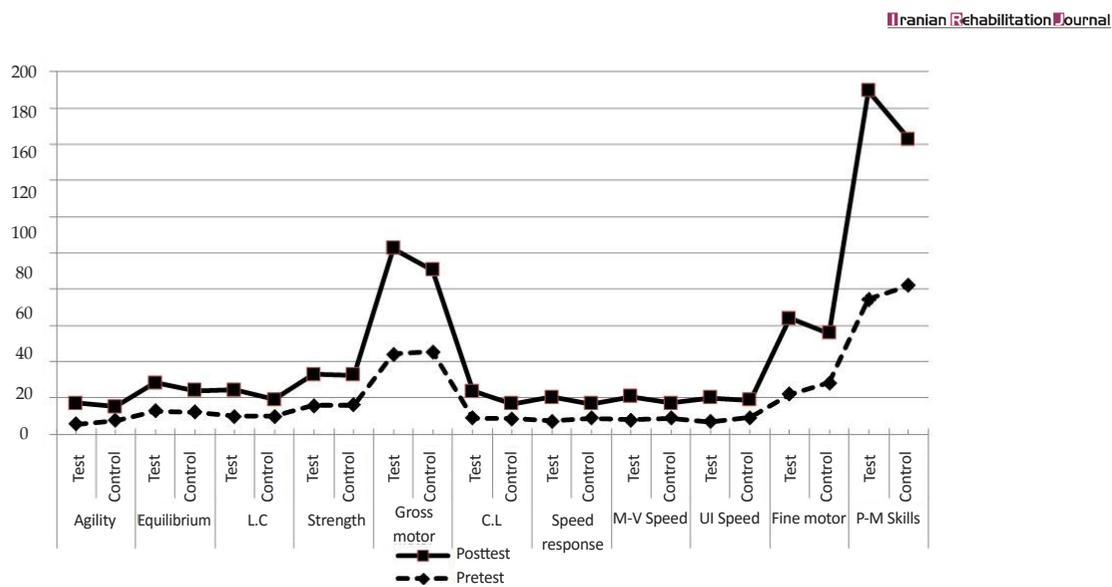


Figure 2. Average of perceptual-motor skills in posttest and pretest measurement of the two groups.

Table 3. Comparison of posttest average scores of behavioral problems of test and control group with statistic control of post-test effect, through covariance analysis test.

Variable	Variable source	Total squares	Mean squares	F	The probability	Size effect
Attention problems	Pretest	2684.77	2684.77	149.55	<0.001	0.802
	Group	386.93	386.93	21.55	<0.001	0.368
Aggressive behavior	Pretest	1183.47	1183.47	84.09	<0.001	0.694
	Group	2124.35	2124.35	150.95	<0.001	0.803
Attention deficit/hyperactivity	Pretest	66.297	66.297	54.27	<0.001	0.595
	Group	2374.18	2374.18	194.35	<0.001	0.840
Confrontational behavior	Pretest	1514.38	1514.38	218.20	<0.001	0.855
	Group	2.97	2.97	0.430	<0.056	0.011
Externalizing	Pretest	1387.37	1387.37	321.17	<0.001	0.897
	Group	397.51	397.51	92.02	<0.001	0.713
General problems	Pretest	914.65	914.65	95.68	<0.001	0.721
	Group	2363.74	2363.74	247.27	<0.001	0.870

Iranian Rehabilitation Journal

nation and control, data analyzed in terms of compare average and all results show that there is no significant effect of the pretest, subtests, and subscales, on posttest scores (Table 3).

4. Discussion

Both intervention and control groups reported significant improvement in all subtests and subscales, considering eight weeks break between pretest and posttest. However, the results that earned by using neurofeedback intervention according to decreasing Theta and increasing Beta protocol showed a significant rate of improvement in the intervention group compared with the control group. This is about subtests of Bruininks-Oseretsky motor test: agility and run's speed, equilibrium, lateral coordination, gross motor skills, coordination of upper limb, speed response, motor-visual speed, upper limb speed, fine motor and perceptual-motor skills, and subscales of CBCL behavioral questionnaire: attention problems, aggressive behavior, attention deficit/hyperactivity, externalizing and general problems. There was no significant improvement in two groups in the strength subtest of Bruininks-Oseretsky motor, test and confrontational behavior subscale of CBCL behavioral questionnaire. The findings of this study are consonant to the findings of another research done by Dehghan et al. (2010), in which they investigated the effects of using perceptual-motor practices on ADHD children aged 5 to 8 years. They showed that the improvement in motor

skills results in the improvement in behavioral problems in ADHD children [10].

Similarly, our findings with respect to neurofeedback with decreasing Theta and increasing Beta protocol on ADHD children are in agreement with the findings of another clinical research done by Beauregard and Colleagues in 2006. In this research, they showed that FMRI enhanced the activities of some brains areas: right anterior cingulate, left caudate and lateral prefrontal cortex. It also exposed that the neurofeedback intervention with decreasing Theta protocol [4-7] and increasing Beta domain [13-16] and Beta 1 [16-19] improved attention in children with ADHD [49]. It can be expressed that children with ADHD have motor coordination problems because of weakness in attention [44]. Motor weakness because of attention deficit must not be ignored [49]. High level of attention deficit along with motor coordination indicates a common neurological mechanism [40]. Attentional and sensory-motor functions are dependent on each other. Therefore, low attention is required for doing automatic motor actions, and high attention is required for doing complex motor assignments [40]. It seems that the major symptoms of inattention have relation with motor coordinating [41].

Thus, the motor deficit of children with ADHD is not only a motor problem; rather it is one of the reasons for increasing inattention and defects in occupational memory [42, 43]. Future studies should focus on daily liv-

ing perceptual-motor activities and stable attention. This inquiry consists of some limitations such as differences in age, symptoms, and cultural context of children, and lack of control over their diets that increased the deficit symptoms.

5. Conclusion

The present study shows that neurofeedback intervention can have a positive effect on improving the perceptual-motor skills of children with ADHD. This intervention can also decrease attention problems, aggressive behavior, attention deficit/hyperactivity, externalizing, and other general problems.

Acknowledgments

We thank all the participants of this research proposal. We are also grateful to the director of Tavanesh Rehabilitation Center for his contribution in running the study. This article is a part of Mr. Mehdi Jahani's Master's thesis in the Department of Rehabilitation, University of Social Welfare and Rehabilitation Sciences.

Conflict of Interests

The authors declared no conflict of interests.

References

- [1] Sadock BJ, Sadock VA. Kaplan and Sadock's Synopsis of Psychiatry: Behavioral Sciences/Clinical Psychiatry. 10th ed. Philadelphia: Lippincott Williams & Wilkins; 2007.
- [2] American Psychiatric Association. DSM-IV-TR: Diagnostic and statistical manual of mental disorders, text revision. Washington, D.C.: American Psychiatric Association; 2000.
- [3] American Psychiatric Association. DSM-IV: Diagnostic and statistical manual of mental disorders: DSM-IV. Washington, D.C.: American Psychiatric Association; 1994.
- [4] Bart O, Podoly T, Bar-Haim Y. A preliminary study on the effect of methylphenidate on motor performance in children with comorbid DCD and ADHD. *Research in Developmental Disabilities*. 2010; 31(6):1443-447.
- [5] Cohen DM, Dalal SR, Parelus J, Patton GC. The combinatorial design approach to automatic test generation. *IEEE Software*. 1996; 13(5):83-87.
- [6] Reader MJ, Harris EL, Schuerholz LJ, Denckla MB. Attention deficit hyperactivity disorder and executive dysfunction. *Developmental Neuropsychology*. 1994; 10(4):493-512.
- [7] Van der Meere J, Vreeling HJ, Sergeant J. A motor pre-setting experiment in hyperactive, learning disabled and control children. *Journal of Child Psychology and Psychiatry*. 1992; 33(8):1347-351.
- [8] Licari M, Larkin D. Increased associated movements: influence of attention deficits and movement difficulties. *Human Movement Science*. 2008; 27(2):310-24.
- [9] Harvey WJ, Reid G. Motor performance of children with attention-deficit hyperactivity disorder: a preliminary investigation. *Adapted Physical Activity Quarterly*. 1997; 14:189-202.
- [10] Dehghan F, Behnia F, Amiri N, Pishyareh E, Safarkhani M. [The effectiveness of using perceptual-motor practices on behavioral disorder among five to eight year old children with attention deficit hyper activity disorder (Persian)]. *Advances in Cognitive Science*. 2010; 12(3):82-96.
- [11] Pishyareh E, Tehrani-Doost M, Mahmoodi-Gharaie J, Khorrami A, Rahmdar SR. A comparative study of sustained attentional bias on emotional processing in ADHD children to pictures with eye-tracking. *Iranian Journal of Child Neurology*. 2015; 9(1):64-70.
- [12] Pishyareh E, Tehrani-Doost M, Mahmoodi-Gharaie J, Khorrami A, Joudi M, Ahmadi M. Attentional bias towards emotional scenes in boys with attention deficit hyperactivity disorder. *Iranian Journal of Psychiatry*. 2012; 7(2):93-96.
- [13] Soluki S, Behnia F, Khushabi K, Pishyareh E, Hosseinzadeh S. [Motor performance in relation with sustained attention in children with attention deficit hyperactivity disorder (Persian)]. *Journal of Rehabilitation*. 2012; 13(1):47-57.
- [14] Ahadi B. Comparison Of behavior problems and school achievement between children with and without motor problems (Persian)]. *Journal of Rehabilitation*. 2009; 10(1):32-36.
- [15] Kadesjo B, Gillberg C. Developmental coordination disorder in Swedish 7-year-old children. *Journal of the American Academy of Child & Adolescent Psychiatry*. 1999; 38(7):820-28.
- [16] Barkley RA. Attention-deficit hyperactivity disorder: a handbook for diagnosis and treatment. New York: Guilford Press; 2005.
- [17] Khooshabi K, Puretemad H. [Investigation of rate of ADHD and comorbid disorders on elementary students of Tehran (Persian)] [Research Report]. Tehran: University of Social Welfare and Rehabilitation Sciences; 2002.
- [18] Chu S, Reynolds F. Occupational therapy for children with attention deficit hyperactivity disorder (ADHD), part 1: a delineation model of practice. *British Journal of Occupational Therapy*. 2007; 70(9):372-83.
- [19] Arns M, de Ridder S, Strehl U, Breteler M, Coenen A. Efficacy of neurofeedback treatment in ADHD: the effects on inattention, impulsivity and hyperactivity: a meta-analysis. *Clinical EEG and Neuroscience*. 2009; 40(3):180-89.
- [20] Hawi Z, Lowe N. Molecular genetic aspects of attention deficit hyperactivity disorder. In: Fitzgerald M, Bellgrove M, Gill M, editors. *Handbook of Attention Deficit Hyperactivity Disorder*. New York: John & Wiley Sons; 2007, p. 129-135.
- [21] Mayer K, Wyckoff SN, Fallgatter AJ, Ehlis AC, Strehl U. Neurofeedback as a nonpharmacological treatment for adults with attention-deficit/hyperactivity disorder (ADHD): study protocol for a randomized controlled trial. *Trials*. 2015; 16:174. doi: 10.1186/s13063-015-0683-4
- [22] Chabot RJ, Serfontein G. Quantitative electroencephalographic profiles of children with attention deficit disorder. *Biological Psychiatry*. 1996; 40(10):951-63.

- [23] Monastra VJ, Lubar JF, Linden M. The development of a quantitative electroencephalographic scanning process for attention deficit-hyperactivity disorder: Reliability and validity studies. *Neuropsychology*. 2001; 15(1):136-44.
- [24] Lubar JF, Shouse MN. Use of biofeedback in the treatment of seizure disorders and hyperactivity. In: Lahey BB, Kazdin AE, editors. *Advances in Clinical Child Psychology*. New York: Plenum Press; 1977, p. 203-65.
- [25] Larsen S, Sherlin L. Neurofeedback: an emerging technology for treating central nervous system dysregulation. *Psychiatric Clinics of North America*. 2013; 36(1):163-68.
- [26] Schunk DH, Zimmerman BJ. *Self-regulation of learning and performance: issues and educational applications*. Denmark: Lawrence Erlbaum Associates Inc; 1994.
- [27] Demos JN. *Getting started with neurofeedback*. New York: W. W. Norton & Company; 2005.
- [28] American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*. Washington, D.C.: American Psychiatric Association; 1980.
- [29] Vollebregt MA, Dongen-Boomsma M, Buitelaar JK, Slaats-Willems D. Does EEG-neurofeedback improve neurocognitive functioning in children with attention-deficit/hyperactivity disorder? a systematic review and a double-blind placebo-controlled study. *Journal of Child Psychology and Psychiatry*. 2014; 55(5):460-72.
- [30] Gevensleben H, Holl B, Albrecht B, Vogel C, Schlamp D, Kratz O, et al. Is neurofeedback an efficacious treatment for ADHD? a randomised controlled clinical trial. *Journal of Child Psychology and Psychiatry*. 2009; 50(7):780-89.
- [31] Farshchi F, Akbarfahimi M, Nazari MA. [Effects of occupational therapy and neurofeedback on recovery of the motor function in stroke patients (A Single-System Design) (Persian)]. *Modern Rehabilitation*. 2012; 5(4):42-48.
- [32] Hammond DC. Neurofeedback for the enhancement of athletic performance and physical balance. *Journal of the American Board of Sport Psychology*. 2007; 1(1):1-9.
- [33] Vernon D, Frick A, Gruzelier J. Neurofeedback as a treatment for ADHD: a methodological review with implications for future research. *Journal of Neurotherapy*. 2004; 8(2):53-82.
- [34] Kephart NC. Perceptual-motor aspects of learning disabilities. *Exceptional Children*. 1964; 31(4):201-206. doi: 10.1177/001440296403100406
- [35] Williams MS, Shellenberger S. *How does your engine run?: A leader's guide to the alert program for self-regulation*. Santa Monica, C.A.: Physical TherapyWorks Inc.; 1996.
- [36] Bahrami A. [The Effectiveness of ball and non-ball games on improvement of Attention Deficit/Hyperactivity Disorder in the 9-11 year old male students in Arak (Persian)]. *Journal of Arak University of Medical Sciences*. 2012; 15(5):19-22.
- [37] Ogrim G, Kropotov J, Hestad K. The QEEG theta/beta ratio in ADHD and normal controls: sensitivity, specificity, and behavioral correlates. *Psychiatry Research*. 2012; 198(3):482-88.
- [38] Lubar JF. Neurofeedback for the management of attention-deficit/hyperactivity disorders. In: Schwartz MS, editor. *Biofeedback: A Practitioner's Guide*. 2nd ed. New York: Guilford Press; 1995, p. 493-522.
- [39] Friel PN. EEG Biofeedback in the Treatment of Attention Deficit/Hyperactivity Disorder. *Alternative Medicine Review*. 2007; 12(2):146-51.
- [40] Bart O, Daniel L, Dan O, Bar-Haim Y. Influence of methylphenidate on motor performance and attention in children with developmental coordination disorder and attention deficit hyperactive disorder. *Research in Developmental Disabilities*. 2013; 34(6):1922-927.
- [41] Piek JP, Pitcher TM, Hay DA. Motor coordination and kinaesthesia in boys with attention deficit hyperactivity disorder. *Developmental Medicine & Child Neurology*. 1999; 41(3):159-65.
- [42] Ferrin M, Vance A. Examination of neurological subtle signs in ADHD as a clinical tool for the diagnosis and their relationship to spatial working memory. *Journal of Child Psychology and Psychiatry*. 2012; 53(4):390-400.
- [43] Barnett R, Maruff P, Vance A. An investigation of visuospatial memory impairment in children with attention deficit hyperactivity disorder (ADHD), combined type. *Psychological Medicine*. 2005; 35(10):1433-444.
- [44] Fliers E, Rommelse N, Vermeulen S, Altink M, Buschgens C, Faraone S, et al. Motor coordination problems in children and adolescents with ADHD rated by parents and teachers: effects of age and gender. *Journal of Neural Transmission*. 2008; 115(2):211-20.
- [45] Piek JP, Dyck MJ. Sensory-motor deficits in children with developmental coordination disorder, attention deficit hyperactivity disorder and autistic disorder. *Human Movement Science*. 2004; 23(3):475-88.
- [46] Tseng MH, Henderson A, Chow SM, Yao G. Relationship between motor proficiency, attention, impulse, and activity in children with ADHD. *Developmental Medicine & Child Neurology*. 2004; 46(6):381-88.
- [47] Bruininks RH. *Bruininks-Oseretsky test of motor proficiency: Examiner's manual*: Crowley, T.X.: American Guidance Service Publication; 1978.
- [48] Beauregard M, Lévesque J. Functional magnetic resonance imaging investigation of the effects of neurofeedback training on the neural bases of selective attention and response inhibition in children with attention-deficit/hyperactivity disorder. *Applied Psychophysiology and Biofeedback*. 2006; 31(1):3-20.
- [49] Williams J, Omizzolo C, Galea MP, Vance A. Motor imagery skills of children with attention deficit hyperactivity disorder and developmental coordination disorder. *Human Movement Science*. 2013; 32(1):121-35.