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Research Article

Cognitive and Perceptual Motor Rehabilitation Associated With Neurofeedback A Comprehensive Treatment For Adhd

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ABSTRACT:

Neurofeedback as a modern method is a popular therapy for hyperactive children, although it is considered as a complementary therapy for these patients. The goal of this study was to create an integrated therapy for ADHD children, so cognitive-motor rehabilitation therapy was used with neurofeedback to make more comprehensive therapy. For this experimental study, 45 subjects were selected through random selection from women who referred to 5 clinics of Tehran city, and they were placed into 2 experimental groups and 1 control group. Groups were matched in age, sexuality and economic situation. One group just received neurofeedback into 10 sessions, another group received neurofeedback plus cognitive-motor rehabilitation therapy, and control group received no therapy. Integrated visual and auditory test (IVA) was used as pretest and posttest, to measure two factors (attention and impulsivity) in ADHD children. In this regard, perceptual-motor task and NEurocognitive Joyful Attentive Training Intervention (NEJATI) were used at this study; this task is based on work of Nejati (1391). Data was analyzed by dependent T test and analysis of covariance. According to the results, there is a significant difference between all groups in attention and impulsivity factors. The group which received neurofeedback with cognitive perceptual motor intervention showed more improvement in attention and impulsivity factors. Also there was a meaningful difference between neurofeedback group and control group in attention factor. Neurofeedback is supposed as a complementary not a complete therapy to improve attention factor in ADHD children, especially about all executive and motor functions. Also, it is better to use a supplement therapy such as cognitive and motor skill training rehabilitation that improves performance factors. It leads to more positive effects on impulsivity or even hyperactivity.

KEYWORDS: neurofeedback, ADHD, cognitive-motor rehabilitation, NEurocognitive Joyful Attentive Training Intervention (NEJATI).

1.INTRODUCTION

Attention deficit and Hyperactivity disorder (ADHD) comprise three symptom domains: attention problem, poor impulse control and excessive motor restlessness (1) which often includes executive function disorder (2-3). Consequently, this disorder with such symptoms can lead to many difficulties in child development process including poor academic performance, high physical and verbal aggression (4). There are different neuropsychological models in order to explain deficits in self-regulation underlying these symptoms, for example deficits in the dealing out of neuropsychological resources (5), maladjustment of interacting neuronal networks (6), and reward deficiency syndrome (7). Since ADHD has serious and short and long term developmental implications that engender problems in different aspect of life including social, academic and quality of life, (8) treatment should begin early, in childhood (10). Given the high incidence of social, personality, or psychiatric disorders that many of these children develop throughout the years, the need for a more comprehensive evaluation and treatment of these children is obvious, particularly for their motor skills and cognitive attention deficits (11).

Accordingly, general treatment such as using drugs or behavior therapy is considered basic and beneficial treatments for ADHD children, but they still encounter fundamental limitations. Medication, as primary treatment of ADHD (9), often improves symptoms; however, it is far away from normal level and permanent, long-term medication therapy is effective about 13.2% to 64% (12,20). Once, medication therapy stopped the symptoms usually recur. In addition, stimulating drugs have no impact on 20-30% of children or sometimes have side effects including insomnia, decreased appetite (13, 14, and 1) and or preventing child development will occur followed by stopping medication therapy (15). Hence, parents prefer to do not use medication therapy.

The other treatments with experimental evidences in ADHD treatment include parents' training and behavioral interventions in school (16-17). Other interventions are promising in treatment such as academic interventions, summer treatment plan for these types of children (18) and programs that combined parents training and training social skills. However, mental treatments are not as much effective as medication therapy, since it is not possible to generalize them to all contexts (19).

Increasing ADHD symptoms especially in classrooms, with common limitation of current treatments, provide the importance of alternative treatment options such as computer based attention training (CompAt) to apply at schools. CompAt, based on brain flexibility and conditional agent theories, is designed to improve core and critical skills that commonly have defects in ADHD children. Two main types of it are Neurofeedback (NF) and Cognitive training (CT) (20).

Neurofeedback and such treatments had more promising results and also fewer side effects (24). Obtained findings of EEG in ADHD children showed increased Theta waves activity as well as increasing Theta ratio to Beta in the frontal cortex. So, neurofeedback is mostly applied in training how to increase Beta waves (a situation requiring attention) and decrease Theta (θ) waves to people. Neurofeedback, with these specific brain waves patterns, provides an immediate feedback of how people concentrate.

Any change in brain waves patterns on computer screen is illustrated through characters and figures moving with auditory feedback. Subjects learn to change their brain waves in achieving a target and enhancing attention by practicing (22). Indeed, they learn how to control underlying processes of these brain waves and to improve cognitive, emotional and behavioral self-regulatory (23).

In the literature, some studies have demonstrated the effect of neurofeedback treatment on children with ADHD (24). Other studies have investigated the effect of neurofeedback and medication therapy were studied on ADHD children. They investigated the results based on parents and teachers reports. Both groups presented satisfactory results, in 6 months follow-up, in improving ADHD symptoms. However, the group which received neurofeedback treatment showed more fundamental improvement in academic performance. This research was the first controlled study with the next six month follow-up on ADHD with non- pharmacologic treatment and again proving the impact of neurofeedback (23).

Nevertheless, there is some aspects of this disorder which medication and neurofeedback cannot improve, for example, reduced ability to regulate motor behavior seems to be an essential aspect of Attention-Deficit Hyperactivity Disorder (ADHD) which is not addressed in literature of neurofeedback training. This motor impairment may reflect deficits in behavioral response inhibition. In this respect, practical clinical experience over the last two decades, in daily practice, training of motor control has played an important role within multimodal treatment approaches, although an adequate proof of its efficacy is still lacking. Several intervention methods have been used since the 1950s, including perceptual motor training (PMT), sensory integration therapy (SIT), and kinesthetic training (25). Shoemaker et al. (2004) used a treatment based on sensory-motor training and the Bobath and Bobath technique. It was a controlled study where physical therapists were blinded to the patient's performance on the Test of Motor Impairment and the Movement Assessment Battery for Children (MABC). The results showed that the clumsy group's motor performance improved significantly over 3 months compared to the control group (26).

Moreover, there are other approaches to improve ADHD symptoms: cognitive training applies frequent computer feedbacks to enhance correct responses beside training attention, working memory and reducing impulsiveness. Studies showed that cognitive interventions and effective training will improve working memory; further, it reduces the amount of disorder symptoms reported by parents and teachers (27). Practicing working memory also contains improvement in various areas including improving mathematic problem solving and or reading comprehension (28).

In one study, Steiner et al (2014) compared neurofeedback method with cognitive training. In this study, children in neurofeedback group offered better results as compared to cognitive training and control group. The results of this study were also investigated in terms of teachers and parents reports. To date, there is not any documented study investigating the integrated impact of neurofeedback and cognitive rehabilitation (3). Gevensleben et al (2009) used neurofeedback along with cognitive training and found out that teachers and parents reported more improvements. But, due to the sample's heterogeneity, it was not generalizable to larger population (29).

Studies show that executive parts of working memory are one of the damaged functions in these people (30). There are two points of views. Barkley (2006) believed that failure in response inhibition is the main cause of this disorder which may lead to damaging working memory and other executive functions (31). In contrast, Rapport et al believed that this disorder is caused by early failure in working memory leading to executive functions' defects (30). Therefore, both approaches, in spite of different insights, represent working memory defects in this disorder. Working memory is a set of cognitive processes to maintain and manipulate different information of daily routines. Some of these daily routines are rehearsal, retrieval, manipulation and controlled attention (32).

Hence, applying an approach that improves working memory and motor functions along with neurofeedback, may lead to improving the symptoms of attention deficit and hyperactivity. According to these, two groups of task were used at this study: perceptional-motor training and NEurocognitive Joyful Attentive Training Intervention (NEJATI).

The term perceptual motor implies the interpretation and the changes in the individual response to a stimulus (33). Perception is the recognition and justification of stimulus which brain perceives as nerve stimulations by sensory organs; the perceptual motor reactions are the motor responses resulting from the analysis of perceptual motor actions in brain (21).A hyphen is used between the two words of perceptual and motor because of two special reasons. First, it explains that intentional voluntary activity depends on some types of perceptual information. Second, hyphen indicates that the growth of perceptual skills of a person is partly dependent on his / her motor activity (34).

Perceptual motor training not only provides an appropriate tool to train basic motor skills, but also can affect cognitive processes, attention, perception, concentration, neuromuscular coordination, and the growth of personal and social skills (39), so it can influence delicate movements of patients. Khalaji and Emad (2002) investigated the effects of selected activities on perceptual motor performance in children aged four to six years using Lincoln oseretsky tests and they concluded that the selected exercises improved perceptual motor performance in both females and males (35).

NEurocognitive Joyful Attentive Training Intervention (NEJATI) is one program which can be regarded as one of the ways of rehabilitating working memory. This program which is designed by Nejati (2010), based on the studies, is effective on working memory. This program is a software program in order to rehabilitate maintain, transfer, update and inhibit information abilities. This program includes a group of organized hierarchical tasks enhancing several aspects of working memory (maintenance, transferring, and updating as well as inhibiting information). Basic principle of this program is as follows:

1. Tasks are hierarchically organized according to the difficulty and based on user response during sessions.
2. Rewards are given immediately after performing tasks; and rewards are gradually offered in longer delays.
3. Tasks are designed based on various functions of working memory including updating, transferring and inhibition.

4. Tasks are fun and presented with motivational stimulators so that enhance patient's motivation.
5. Tasks may be retrieved until the patient gets the desired level.
6. Developing the program depends on patient efficacy; and, the therapist is required to improve task level (36).

Therefore, considering the effect of this program on cognitive memory, it is assumed that it can also be effective as an alternative, supplementary treatment in improving attention deficiency disorder.

According to above, this study intended to investigate a more complete treatment in improving attention deficiency and hyperactivity that concentrated on working memory executive functions and motor functions and aimed to achieve more positive results besides neurofeedback which its effect has been proved in previous studies. Thus, neurofeedback effect with and without cognitive rehabilitation was compared. It is assumed that neurofeedback will be effective alone, but integrating it with cognitive rehabilitation and training would lead to better results.

2.METHODS

This study was an experimental research design with pre- and post- test with control group. So, three experimental groups were randomly selected from those referred to the clinic. First, the participants were 67 children with symptoms of attention deficit and hyperactivity selected based on DSM-V criteria. Of these, 45 individuals were randomly assigned in to three (15 individuals) groups. Subjects of one group just received neurofeedback, the other group received a combination of neurofeedback and cognitive-motor skill rehabilitation and the last group, as control group, did not receive any treatments. The age range was within 5 to 7 years old from the same economic level. All children were homogenized in all aspects. Moreover, they all had no history of ADHD treatment, medication and non-medication treatment, in order to avoid effecting on the present study results.

Initially, the subjects were tested by IVA+plus to measure their impulsion and attentions' basic rate. Then, two experimental groups received ten treatment sessions according to protocol and the determined timing. Finally, a post test IVA+plus was done in order to measure changes during treatments. Cognitive training program or cognitive rehabilitation in the combined group was done one day later followed by neurofeedback.

3.TREATMENT PHASE:

Neurofeedback Treatment was carried out by a master's level psychologist specialized in neurofeedback. Sessions took place 2–3 times a week, for 20–30 min provided in 5 min blocks separated by a 2 min pause. The wireless Brainquiry PET 4.0 (Brainquiry B.V.) and BioExplorer software (CyberEvolution, Inc.) were used to provide visual feedback (bargraphs or neuropuzzles) and auditory feedback. Tresholds were set to achieve a 75–80 % reward per training contingency.

Perceptual motor training was performed during every session (fifteen sessions; one hour per day for 2 week) for intervention group. Perceptual-motor training included the training movements of static and

dynamic balances, balance orientation skills, body awareness, understanding shape, determination and sequences of auditory and visual, auditory and visual perception, eye-hand coordination and spatial relationships.

Joyful computer based tasks was presented to participants. These tasks were graded and their level of difficulty increased in based on the response of user. Grading of tasks was based on the amount of flanker stimuli, velocity of stimuli presenting, number of goal stimuli and changing task rule. For example in one of these tasks, the user should arrange faces in different categorizes based on three properties; emotional status (sad, angry and neutral), hair color (green, white and black) and skin color (yellow, white and black). Each face has one property of each categories and participant should act only based on presented rule. In each set of tasks user should inhibit two properties of face and act based on one of them. Cognitive demand of this task is inhibition of unrelated properties of stimuli and selective attention to related one (37).

4.TOOLS

IVA+PLUS CPT test: The Integrated Visual and Auditory (I.V.A.) which lasts approximately thirteen minutes, presents 500 trials of "1"s and "2"s in a pseudo-random pattern requiring the shifting of sets between the visual and auditory modalities. The subject is required to click the mouse only when he sees or hears a "1" and to inhibit clicking when he sees or hears a "2." During some segments of the IVA+Plus test, the "1"s are more common than the "2"s, creating a response set which "pulls" for errors of commission, or impulsivity. During alternate segments of the IVA+Plus test, the "1"s occur rarely; this invites more errors of omission, or inattention, since the subject must remain vigilant while he waits for a "1" to occur. IVA+PLUS test consists of 6 total scales and 22 subscales classified in to 5 groups: response inhibition, attention, attribution, indicator as well as delicate movements. However, this study just considers the scores of three subscale: response inhibition, and attention and delicate movements.

5.RESULTS

One-way between groups covariance analysis was conducted to compare the effectiveness of two different interventions of participants' response inhibition, attention and delicate movement scales. Intervention type (neurofeedback and cognitive-motor rehabilitation with neurofeedback) was independent variable and dependent variable was consisted of three subscales of IVA+PLUS test. Participants' scores of response inhibition, attention and delicate movement subscales before intervention were used as covariance in this analysis.

Table 1: summary of covariance for therapy effects on 2 subscales of IVA+PLUS test (compulsivity, attention and delicate movement) before therapy.

Variable source	ss	df	Ms	f-ratio
Main effect of therapy	55.738	2	28.895	** 7.955
Covariance (impulsive scores before therapy)	153.495	1	153.395	0.585**
Main effect of therapy	47.988	2	25.012	7.015**
Covariance (attention scores before therapy)	137.988	1	137.877	40.018**
Residual error	136.989	-	2.878	

Firstly analyses were done to ensure that normality, linearity; variance homogeneity, regression slope homogeneity and the reliability of covariance hypotheses were not violated.

Table 2: Weighted Mean of 3 situation of experiments on attention subscale

groups	mean	Standard deviation	confidence level 95%	
			Low limit	Up limit
1. neurofeedback & rehabilitation	92.014	1.681	87.450	89.012
2. neurofeedback	83.011	1.234	77.965	84.321
3. control	70.775	0.632	69.765	72.432

Table 3: Weighted Mean of 3 situation of experiments on impulsivity subscale

groups	mean	Standard deviation	confidence level 95%	
			Low limit	Up limit
1. neurofeedback & rehabilitation	92.018	1.814	89.016	93.897
2. neurofeedback	82.017	1.562	77.998	84.987
3. control	70.765	0.875	69.025	71.221

Table 4: Weighted Mean of 3 situation of experiments on delicate movement subscale

groups	mean	Standard deviation	confidence level 95%	
			Low limit	Up limit
1. neurofeedback & rehabilitation	93.123	1.654	88.654	95.654
2. neurofeedback	82.123	1.452	77.654	86.876
3. control	69.654	0.543	69.223	72.774

Followed by correcting pre-intervention scores, significant difference was seen among three groups (two under intervention groups and one control group) response inhibition subscale, f (2, 39) = 8.167, p= .001, Partial Eta Squared 0.29.

Moreover, a significant difference was also seen among three groups (two under intervention groups and one control group) in attention subscale followed by correcting pre-intervention scores, f(2,39)= 6.904, p= .003, Partial Eta Squared 0.26. Eta squared statistics in both subscales (0.29 and 0.26) showed a big effect and determined that there is a strong relation between pre- and post-intervention scores in two IVA+PLUS test subscales (response inhibition, attention and delicate movements). In addition, as data shown in Tables 6 and 7, the group which received neurofeedback with cognitive rehabilitation represented more improvement as compared to the other group in two attention and impulsion factors.

Table 5: multiple Comparison of interacting between variables (3 groups) on attention subscale

I group	J group	Compare means (I-J) groups	Standard deviation	Significant level	confidence level 95%	
					Low limit	up limit
1	2	10.453*	2.443	.000	5.032	13.654
	3	22.765*	1.654	.000	19.654	24.543
2	1	-10.654*	2.321	.000	-15.543	-6.065
	3	13.123*	1.654	.000	7.324	16.654
3	1	-22.213*	1.654	.000	-24.123	-19.543
	2	-12.178*	1.432	.000	-16.987	-9.432

Groups: 1. Neurofeedback & rehabilitation 2. Neurofeedback 3. Control

Table 6: multiple Comparison of interacting between variables (3 groups) on impulsivity subscale

I group	J group	Compare means (I-J) groups	Standard deviation	Significant level	confidence level 95%	
					Low limit	up limit
1	2	12.543*	1.987	.000	5.087	13.654
	3	23.543*	1.654	.000	16.654	24.132
2	1	-9.554*	2.554	.000	-12.432	-4.043
	3	10.987*	1.654	.000	8.012	13.123
3	1	-23.876*	1.654	.000	-24.123	-18.543
	2	-12.123*	1.876	.000	-16.987	-6.765

Groups: 1. Neurofeedback & rehabilitation 2. Neurofeedback 3. Control

Table 7: multiple Comparison of interacting between variables (3 groups) on delicate movement subscale

I group	J group	Compare means (I-J) groups	Standard deviation	Significant level	confidence level 95%	
					Low limit	up limit
1	2	10.987*	2.432	.000	4.058	13.543
	3	22.876*	1.654	.000	16.654	24.123
2	1	-7.765*	2.432	.000	-12.543	-6.065
	3	12.665*	1.554	.000	8.543	13.654
3	1	-22.324*	1.546	.000	-25.184	-17.593
	2	-10.213*	1.543	.000	-16.564	-8.765

Groups: 1. Neurofeedback & rehabilitation 2. Neurofeedback 3. Control

6.DISCUSSION

The goal of this research was creating a more enriched and integrated protocol to successfully treat attention deficit and hyperactivity disorder. Based on the obtained results, only neurofeedback group and neurofeedback with cognitive and perceptual motor training showed better results in comparison to control group. This finding addressed the impact of neurofeedback on treating children with ADHD disorder. This finding is relevant with previous studies such as Sherlin, Arns, Lubar, et al. (2011), Gonzeleberge et al (2009), Ahmadlou, Rostami and Sadeghi (2012) and Marizzio et al (2013) (22, 29, 38, 40). The aim of neurofeedback using is to change brain waves with cortex self-regulatory where people learn how to focus on an issue; in addition, it is concentrated on generalizing this skill into other situations outside of therapy zone.

The combined group of neurofeedback with cognitive and perceptual motor rehabilitation provided better results compared to the two other groups. In preceding research studies, applying the cognitive training method was not so much practical; hence, only some executive areas of brain were enabled

(3,42). This research used cognitive rehabilitation program combining perceptual motor training. As it was stated, this method focuses on working memory and executive processes subsets and motor skills. Thus, improving this part of memory is the cause of this effect. As it is shown, this therapy also has influenced delicate movement.

While neurofeedback has influences brain waves and enhances concentration, perceptual motor training influences more functional features. Gligororic et al (2011) conducted a study involving 1165 male and female students aged 7.5 to 11 years who were selected from urban and rural areas. They found a positive correlation between perceptual skills and academic skills of children (41). Perceptual-motor training programs are a type of valid physical education programs which are designed based on the evolution level and they share a set of similar elements. The objective of these programs is to enhance children's academic success or progress in school. Increasing body awareness can help to direct children toward the development of motor skills. Perceptual motor activities play an important role in the development of attention, impulsivity and motor abilities of children (43).

As mentioned above, in theta/Beta treatment with neurofeedback, children learn to decrease theta activity (4-8 HZ), and increase Beta activity. Then, this theta/beta activity indicates a neurophysiological defect. Regardless of this supposed deficit, neurofeedback consider as a method to improve cognition and attention (27). Cognitive rehabilitation works on cognitive processes involving in maintaining attention on information and improves executive control. In fact, one of the difficulties of the children with this disorder is disability in concentrating on an issue, or, in other word, distraction. So, that is why response control and inhibition is too difficult in these children; then, impulsion symptoms are manifested. It may be said that rehabilitation influences on impulsion symptoms; therefore, children showed better results in response inhibition.

Goals of ADHD interventions are complicated, and this is a challenge to detection of their impact on symptoms. For example, one treatment can be useful for one symptom that leads to improve quality of daily life, but we do not have any questionnaire to measure it (3). In this study, there was short interval between treatment sessions, while for some children, it is better to consider more sessions with long interval between sessions. It will lead to stability and more self-regulation and they can transfer them to the daily life easily. It is like the methods that are common in conventional cognitive behavior therapy (17). It is suggested to consider this for future studies.

7.CONCLUSION

Experimental groups showed better performance in attention and response inhibition factors as compared to control group. The group that received only neurofeedback represented better results in IVA test by improving and increasing Beta waves. In contrast, the groups which received cognitive-motor rehabilitation beside neurofeedback, along with improving waves with working memory enhancement, attained better scores in IVA, particularly in response inhibition factor.

The result of this study, demonstrated that the effect of neurofeedback on children with ADHD can be increased by using a supplementary treatment like perceptual motor and cognitive rehabilitation also to

apply alternative and more complete mental treatments replacing medication. These findings approved the significant role of training-based computer treatments.

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