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Effectiveness of Compensatory Rehabilitation on Neuropsychological Functions of Preschool Children with Attention Deficit Hyperactivity Disorder Symptoms

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ABSTRACT

Background: Executive functions are impaired in children with attention deficit-hyperactivity disorder. One method to improve these functions is Compensatory rehabilitation. This study aims to assess the effectiveness of compensatory rehabilitation training on neuropsychological functions in preschool children with attention deficit- hyperactivity disorder (ADHD) symptoms.

Methods: This is an experimental study by pretest, posttest and follow-up design with control group. Thirty two (32) children with attention deficit-hyperactivity disorder symptoms were selected using convenience sampling and randomly divided into control and intervention groups. The neurological tests included missing scan, day and night stroop, continuous performance test and trial making test. In the intervention program, parents were taught how to use effective strategies and skills to manage cognitive deficits in children, based on Tameshk package. Data was analyzed by repeated measure analysis of variance (ANOVA).

Results: From the results of data analysis, compensatory rehabilitation had a significant effect on working memory (P<0.00), inhibition (P<0.00, errors; P<0.00, time) and shifting attention (P<0.01 errors in section A; P<0.00, time section A) in children.

Conclusion: Compensatory rehabilitation utilizes skills and instructions to improve cognitive functions in children. The current research showed that training by compensation approach could improve neuropsychological functions in children with ADHD.

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most prevalent psychiatric disorders. The prevalence rate is estimated to be more than 5% [1]. Symptoms are required to be present prior 12 years [2]. It is imperative that treatment begins in preschool age because ADHD children compared to normal peers experience more social, educational and family problems [3, 4].

Cognitive impairments are prevalent in ADHD children. Among the wide range of cognitive abilities, executive functions receive more focus. Executive functions (EF) deficits are not considered as sufficient causes of ADHD, but they play a role in its behavioral manifestations [5-7]. Executive functions are mental abilities that enable an individual to exhibit goal directed behaviors. Cognitive rehabilitation is a specialized treatment to reduce and improve cognitive deficits [8]. To achieve this purpose, two methods are utilized: remediation and compensation. Remediation focuses on repeated practice of computerized or paper

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pencil tasks which could improve or restore impaired abilities. On the other hand, in compensation approach, people learn how to adapt in the environment and use strategies and skills to improve their functions. It is also called "strategy training". Past research considered it as a change in behavior but neuroimaging studies have shown that it also causes changes in the brain [8]. Compensatory strategies like note taking and setting alarms are mainly designed for and applied by school aged children to manage their homework or for adults to accommodate their jobs duties [9].

Behavioral parent training (BPT) is recommended as the first line treatment for preschool ADHD children. In BPT, parents learn how to manage children behavioral problems [7]. It showed moderate effects on reduction of behavioral problems, but BPT had no effect on underlying neurocognitive deficits [10]. Moreover, cognitive deficits could have negative effects on behavioral training because attention problems can have a mediator role between parent and child interactions [11]. So, recently, studies are prone to use cognitive training for children to address basic cognitive deficits underlying ADHD. The study by Shuai et al. (2017) showed that EF training had significant effects both on neuropsychological assessments and daily functions of EF in ADHD children. Moreover, behavioral problems and ADHD symptoms were reduced after training [12]. Several studies confirmed these results [13, 14]. Limited research has been done to assess the effects of compensation training. The researches mainly focused on mild cognitive impairment (MCI) patients [15], compensation strategies used by adults ADHD [16, 17], organization training in adolescents [18], time management strategies in children [19], study skills and time management in learning disorder and ADHD students [20, 21]. All these studies showed that through compensatory strategies and skills, one could have a better function in daily life situations and better performance in cognitive functions. In spite of the fact that the brain has more flexibility for change in preschool period, less attention has been paid to preschool period [22]. Therefore it is essential to design training by compensatory rehabilitation for preschool ADHD children.

To examine the effects of compensatory rehabilitation on EF of preschool children with ADHD, a training program was designed according to compensatory principles. The sample age range was between 4-7 years; therefore parents were trained on how to make changes in the child's environment and learned which strategies and skills would help the child to have better cognitive function. The time frame of 4-7 years creates an opportunity for early identification and treatment of ADHD, which can prevent various difficulties they might encounter in future [23]. By considering the extraordinary potential of brain plasticity in this time frame, it seems necessary to start treatment in the early years [22]. The present research hypothesis was that compensatory rehabilitation will have positive effects on EF measured by neuropsychological tests.

Methods

This is an experimental study by pretest, posttest and follow up design with control group. The statistical population consists of preschool children with ages between 4-7 years, with ADHD symptoms who were referred to three counseling clinics in Tehran, in 2017. Thirty two (32) children were selected by convenience sampling and randomly divided into experimental (n=15) and control groups (n=17), respectively. A psychiatrist diagnosed and confirmed the exhibition of more than 50% of ADHD symptoms in all the children. Compensatory training was performed for parents of ADHD children via Tameshk package in the intervention group. The control group received no treatment but considering ethical issues, all sessions were implemented for this group after follow up assessment. Training was conducted at Agah counseling clinic in 10 sessions (2 sessions in a week), for 5 weeks. All children were evaluated by neuropsychological tests. Assessments were done prior to training, immediately after training, and two month after training. First, all parents filled a consent form to partake in the research. This form contained the following details: title, method, and supervisors of the research. Inclusion criteria were: 1- more than 50% of ADHD symptoms in children according to DSM-5 and psychiatric diagnosis, 2- age ranges 4-7 years old, 3- completion of consent form, and 4- no other psychiatric disorders and medical diseases. EF was assessed by neuropsychological tests.

Day and night stroop is an inhibitory control test designed by Gerstadt (1999). A set of 21 pictures which display day or night, were used as test stimuli. Then the child was instructed to say night upon presentation of the sun card and vice versa. Number of errors and time to completion was recorded. Validity of this test is within a range of r=0.76 to 0.93 [24, 25]. In an Iranian study, validity was estimated as r=0.78 [26].

Working memory was measured by missing scan test. It was designed by Buschke (1963) for preschool children [27]. A total of thirty four (34) animals were used as test stimuli. The child was required to identify and label all animals. If the child could not recognize the animal, it was removed from the test. After that, in each level, the child viewed a set of animals (3-10), then they hide behind a house and all animals were brought back except one. The child must guess the missing animal. At first, the examiner conducted a practice set with the child using 2 animals. If the child understood the instructions and displayed correct response, the test would proceed. The test started with 3 animals and after each correct response; the length of each set was increased by one animal. The "memory span score" is the longest size the child can correctly recall. The scores of this test have a good correlation with other memory tasks (r=0.71) [28].

Kiddie continuous performance test (KCPT) was used to assess sustained attention. It is designed according to Conners CPT test instructions. The children were asked to respond to all target picture (all pictures except ball) but not non-target (ball) that appeared on the

computer screen. This test lasted between 7-8 minutes. Scores included omission errors, time and number of true answers and time and number of false answers. Test retest reliability of KCPT was 0.57 and split half reliability was between 0.86 and 0.89 [29]. Hadianfar et al. (1998) reported a reliability of between 0.59 and 0.93. There was a significant difference between ADHD and normal groups in their test performance; so criterion validity was also confirmed in their study [30].

To assess shifting attention ability, TRAILS –P was used, which is a preschool version of trial making test. This test has two conditions. In condition A, 5 dogs are depicted on a page and the child is instructed to draw a line between the dogs in order of size. In condition B, dogs and bones with different sizes are depicted and the child is expected to match each dog to the bone with a similar size. The child must alternate between dog and bones. Epsy and Quick (2004) showed a good test retest reliability for this procedure (r=0.45 to 0.65) [31].

Compensatory cognitive rehabilitation was carried out by Tameshk training program. The program was made by researchers according to compensatory principles [32]. It was designed to help parents reduce children cognitive deficits through applying a wide range of skills, strategies and environmental changes. After designing Tameshk training package, 10 experts evaluated the training program to validate its contents. The range of agreement on content validity ration (CVR) was about 80%. According to evaluations, inappropriate contents were removed or modified. This program included 10 sessions of training and could be performed individually or in groups. It covered the following topics: psycho-cognitive education, behavior management, types of executive functions, neurocognitive basis of each behavior in ADHD children, strategies to manage these types of behaviors, acknowledging strengths and weaknesses in both child and parent EF and ways to manage them. Trainings were provided by a certified psychologist who is also an expert in this field. Each session began by providing an opportunity for parents to discuss about the challenges which they faced in the procedure of implementing strategies. Then, in the central part of each session, the trainer introduced the main topic. After that, parents did a brain storm and role play about what they have learned. At the end of each session, parents were encouraged to practice new skills and strategies with their children and were asked to complete the worksheets for the next session. To assess compliance, parents were required to fill diaries for each day, separately. They must record the number

Table 1: Outline of Tameshk Compensatory cognitive rehabilitation training

Program component	Objective
Session 1: psycho-cog education	▪ Group leader educates parents about ADHD symptoms in preschool period, its prevalence and gender differences. ▪ Leader also explains the effects of treatment versus no treatment and its adverse effects on family members.
Session 2: Brief review of behavior management principles	▪ Parents learn how to use positive parenting strategies (praise and rewards) with their children to increase positive interactions as well as negative parenting strategies (timeout and consequences) to reduce inappropriate behaviors.
Session 3: Definition of executive function	▪ Group leader gives an explanation about EF definition and its differences with IQ. ▪ EF subcomponents also presented briefly.
Session 4: Inhibition	▪ Group leader defines inhibition and discusses behaviors rooted in inhibition deficits like child inability to wait for his/her turn. Then provide strategies to manage these behaviors like using reinforcements. ▪ Parents make a list of child problematic behavior and determine its severity on a rating scale from 1-10.
Session 5: Working memory	▪ Group leader defines working memory and discusses behaviors rooted in working memory deficits like forgetting future tasks. Then provide strategies to manage these behaviors like taking pictures of tasks and attaching them on the wall ▪ Group leader gives instructions to manage one of child problematic behavior according to the last session's list (specifically for each child)
Session 6: Sustained attention	▪ Group leader defines sustained attention and discusses behaviors rooted in sustained attention deficits like inability to complete a task. Then provides strategies to manage these behaviors like using headphones to reduce stimulus ▪ Group leader gives instructions to manage another child problematic behavior according to the last session's list (specifically for each child)
Session 7: Shifting attention	▪ Group leader defines shifting attention and discusses behaviors rooted in shifting attention deficits like inability to accept changes in plans ▪ Group leader gives instructions to manage these behaviors like starting with positive changes
Session 8: Planning	▪ Group leader defines planning and discusses behaviors rooted in planning deficits like pick up toys before sleeping ▪ Group leader gives instructions to manage these behaviors like make a TO DO List ▪ Group leader gives instructions to manage another child problematic behavior according to the last session's list (specifically for each child)
Session 9: Prioritizing and organization	▪ Group leader defines prioritizing and organization and discusses behaviors rooted in prioritizing and organization deficits like inability to organize bedroom ▪ Group leader gives instructions to manage these behaviors, like colored shelves
Session 10: Strength and weakness in EF	▪ Group leader discusses about cognitive functions that have strength and weakness in child and parents and teaches strategies to manage differences and similarities in weakness and strength between parents and child.

of times and period in which each strategy was used for the child in a given paper. The completed worksheets for each training session were also collected. Parents could also discuss about their probable problems in group. Moreover, in each session, the involvement of parents in the learned strategies and feasibility and applicability of the technique for their children were required from parents, what worked well and what was difficult for them. Table 1 presents a list of important topics.

Results

Mean age of children was around 5 years old. In each of the intervention and control group, 2 children were administered drugs for ADHD. Mean age of mothers in experimental group and control group was, respectively 32 and 33. Table 2 presents the demographic information of samples.

To assure that there were no differences between groups before training, T test was conducted. The results showed no differences between groups in all variables. Table 3 presents the descriptive statistics.

To examine the differences between intervention and control group, repeated measure variance analysis was performed. The results of Kolmogorov–Smirnov test showed normalization of data (P<0.94). Test of sphericity was significant for all variables at the level of P=0.001, except for stroop time, the forming of section A and B trial, and false answers of CPT. Greenhouse-Geisser is reported for these variables (Table 4).

From the above table, training had significant effects on working memory ($F_{1,14}$=10.35, P<0.001), inhibition ($F_{1,14}$=15.21, P<0.001(error); $F_{1,14}$=7.68, P<0.001(time)) and shifting attention ($F_{1,14}$=4.50, P<0.01 (error A); $F_{1,14}$=12.87, P<0.001(time A); F1,14=2.71, P<0.02 (error B)). To assess these effects in each measurement level, Bonferroni test was performed (Table 5).

Post hoc analysis revealed significant difference between baseline and post treatment in working memory, inhibition, and shifting attention. The differences for inhibition and shifting attention remained stable from post-test to follow up.

Discussion

This research aimed to assess the effects of compensatory cognitive rehabilitation on executive functions according to neuropsychological assessments. According to the results, working memory, inhibition, and shifting attention abilities were significantly improved. These findings are in line with previous studies [12, 13, 33, 34]. Traverso et al. (2015) found substantial effects of EF training on inhibition, working memory, and cognitive flexibility of 5 years old children [13]. In a study of EF

Table 2: demographic information

	Child age	Gender		Medication (M)		Mother age	Employment (E)	
	Mean±SD	Boy	Girl	Non-M	M	Mean±SD	Un-E	E
Experimental group	5.40±1.05	10	5	13	2	32.47±5.24	3	12
Control group	5.56±1.35	12	5	15	2	33.06±4.96	4	13

Table 3: Summary of descriptive statistics for both groups

Variables	Group	N	Pretest Mean±SD	Post test Mean±SD	Follow up Mean±SD
Working memory	intervention	15	4.67±0.81	6.20±1.20	6.07±1.16
	control	17	4.47±1	4.59±1.32	4.88±1.26
Inhibition errors	intervention	15	7.53±3.09	3.73±2.46	3.93±3.40
	control	17	8.82±3.35	7.06±3.81	7.88±3.27
Inhibition time	intervention	15	58.67±12.94	44.60±13.80	45.40±16.63
	control	17	69.24±27	60.76±24.26	58.53±22.41
Shifting attention errors section A	intervention	15	1.40±1.54	0.60±0.82	0.87±1.12
	control	17	1.88±1.45	1.65±1.69	1.41±1.46
Shifting attention time section A	intervention	15	37.33±27.01	17±10.05	22.47±16.39
	control	17	36.94±26.96	30.59±17.81	26.41±17.18
Shifting attention errors section B	intervention	15	3.73±2.65	3±1.30	2.60±1.84
	control	17	5.18±1.31	4.94±3.15	4.59±1.87
Shifting attention time section B	intervention	15	90.93±49.87	57.60±18.56	56.07±33.49
	control	17	106.18±40.76	79.65±33.73	75.24±30.43
Omission errors CPT	intervention	15	35.53±23.46	46.26±23.83	34.47±11.02
	control	17	40.11±24.14	44.11±29.72	39.24±29.60
True answers CPT	intervention	15	156.46±22.23	145.46±23.85	156.80±12.11
	control	17	147.52±23.21	144.29±27.28	147±26.12
Time true answers CPT	intervention	15	0.57±0.20	0.54±0.13	0.57±0.14
	control	17	0.42±0.15	0.44±0.22	0.41±0.23
False answers CPT	intervention	15	11±5.1	9.26±3.91	9.46±4.59
	control	17	13.23±4.56	12.47±5.20	14.76±5.80
Time false answers CPT	intervention	15	0.46±0.17	0.40±0.14	0.33±0.23
	control	17	0.31±0.19	0.40±4.59	0.33±0.25

Table 4: Repeated measure test for differences between groups

Variables		Sum of squares	Sig	Partial Eta Squared
Working memory	Sphericity assumption	14.60	0.00	0.42
Inhibition errors	Sphericity assumption	120.82	0.00	0.52
Inhibition time	Greenhouse-Geisser	2753.68	0.00	0.35
Shifting attention errors section A	Sphericity assumption	8.60	0.01	0.24
Shifting attention time section A	Greenhouse-Geisser	4441.86	0.00	0.47
Shifting attention errors section B	Sphericity assumption	15.35	0.02	0.16
Shifting attention time section B	Greenhouse-Geisser	26525.86	0.08	0.53
Omission errors CPT	Sphericity assumption	1344.46	0.08	0.16
True answers CPT	Sphericity assumption	921.66	0.13	0.13
Time true answers CPT	Sphericity assumption	39.26	0.38	0.06
False answers CPT	Greenhouse-Geisser	4.47	0.34	0.06
Time false answers CPT	Sphericity assumption	0.02	0.61	0.03

Table 5: Summary of the main effects of time with pairwise comparison

Variable	Time		Mean±SD	Sig	95% Confidence Interval for Difference	
					Lower bound	Upper bound
Working memory	Pretest	Post test	-0.80±0.21	0.00	-1.39	-0.21
		Follow up	-0.10±0.22	0.00	-1.46	-0.33
	Post test	Follow up	-0.90±0.20	1.00	-0.71	0.51
Inhibition errors	Pretest	Post test	2.63±0.52	0.00	1.20	4.05
		Follow up	0.40±0.51	0.00	0.87	3.59
	Post test	Follow up	2.23±0.50	1.00	-1.01	1.81
Inhibition time	Pretest	Post test	11.80±4.23	0.04	0.29	23.31
		Follow up	-0.13±2.09	0.02	1.67	21.65
	Post test	Follow up	11.66±3.67	1.00	-5.81	5.54
Shifting attention errors section A	Pretest	Post test	0.60±0.27	1.35	-0.14	1.34
		Follow up	0.10±0.22	0.05	0.00	1.39
	Post test	Follow up	0.70±0.25	1.00	-0.51	0.71
Shifting attention time section A	Pretest	Post test	14.73±3.43	0.00	5.40	24.06
		Follow up	0.33±1.93	0.01	3.22	26.91
	Post test	Follow up	15.06±4.35	1.00	-4.91	5.57
Shifting attention errors section B	Pretest	Post test	0.63±0.51	0.72	-0.77	2.04
		Follow up	0.36±0.38	0.06	-0.61	2.06
	Post test	Follow up	0.00±0.39	1.00	-0.67	1.40
Shifting attention time section B	Pretest	Post test	35.73±8	0.00	13.97	57.49
		Follow up	1.33±4.76	0.00	12.92	61.20
	Post test	Follow up	37.06±8.88	1.00	-11.62	14.28
Omission errors CPT	Pretest	Post test	-7.63±4.70	0.38	-20.42	5.15
		Follow up	8.66±3.88	1.00	-8.11	10.17
	Post test	Follow up	1.03±3.36	0.12	-1.87	19.21
True answers CPT	Pretest	Post test	6.33±4.43	0.52	-5.71	18.38
		Follow up	-7.16±3.43	1.00	-10.08	8.41
	Post test	Follow up	-0.83±3.40	0.16	-16.51	2.17
Time true answers CPT	Pretest	Post test	1.36±1.29	0.92	-2.14	4.87
		Follow up	-1.43±1.18	1.00	-2.63	2.50
	Post test	Follow up	-0.06±0.94	0.73	-4.64	1.78
False answers CPT	Pretest	Post test	0.02±0.04	1.00	-0.10	0.14
		Follow up	-0.48±0.47	1.00	-1.78	0.86
	Post test	Follow up	-0.46±0.48	0.98	-1.77	0.81
Time false answers CPT	Pretest	Post test	0.03±0.03	0.94	-0.05	0.12
		Follow up	-0.00±0.03	1.00	-0.08	0.13
	Post test	Follow up	0.02±0.04	1.00	-0.10	0.09

training for preschool children, it was indicated that their functions in the areas of attention, inhibition, and working memory were significantly improved [33]. Halperin et al (2012) mentioned that gains of EF training on preschool children were maintained until 3 month follow up [34]. This was mainly because parents were involved in the study and were actively engaged in training, so benefits of treatment were observable even after treatment. Even college students with ADHD used a wide array of compensatory strategies to achieve school success such as studying in a quiet environment or working on their assignments in short time intervals [35]. It could be explained that by use of strategy and skill training for managing EF deficits in ADHD children, they could compensate their developmental gaps of cognitive functions in comparison to normal peers.

The current compensatory training was specifically designed for preschool children. Strategies designed in this training to compensate cognitive deficits were generalized to some real life situation. One of the critics of other types of cognitive rehabilitation like remediation training is the limited generalization of improvement in computerized tasks to daily tasks and parents do not report a significant change on real life situations [36]. A good reason for choosing compensation approach in this research was this limitation. Compensatory strategies are implemented in behavioral level but the effects are transferred to neuropsychological functioning. New behavior could organize or reorganize damaged neural cycles; so compensation is not a change in behavior but changes that occur in neurocognitive functions of brain [9]. These transfer effects have also been reported in other studies [14, 34-37].

One of the important prerequisite of compensatory training is a mismatch between environment and skill [38]. In developing a compensatory system, both must consider why previous studies focused mainly on skills. Tameshk compensatory training paid attention to skills training and changes in environment, simultaneously. The other important point of this training is the wide range of cognitive abilities. Although cognitive functions could not be distinct from each other, but each of the cognitive functions must be trained separately.

Limitation

Assessments were conducted by raters who were not blind to the training allocation. Although they had no bias, but blind raters performing the assessments could provide more reliability for the training. It is suggested for future studies that children should also be involved in the training, in separated sessions, concurrently with parents. This will require a new and developed version of Tameshk.

Conclusion

Compensatory training could improve cognitive performance in some areas in preschool children by ADHD symptoms. Removal or elimination of cognitive deficits in childhood might to some extent eliminate some problems associated with ADHD.

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