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Original Article

Effectiveness of Hesabyar Cognitive Rehabilitation on Neuropsychological Functions of Children with Special Learning Disabilities

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Abstract

Background: Children with learning disabilities have cognitive impairments not attributable to their intelligence. The present study aimed to evaluate the effectiveness of Hesabyar Cognitive Rehabilitation on neuropsychological functions of children with special learning disabilities.

Methods: This was a quasi-experimental study which had pre-test and post-test design and conducted with a control group. The statistical population included all the male elementary students with special learning disabilities in Semnan, Iran, in the academic year 2019-2020. The sample consisted of 40 students (20 participants in each group) with special learning disabilities that were treated. The Conners Psychological Scale was used for data collection. The experimental group underwent cognitive load rehabilitation every other day for 10 sessions while the control group did not receive any treatment. The data were analyzed using the statistical method of multivariate analysis of covariance and SPSS version 24.

Results: The mean±SD of age in the experimental group and the control group were respectively 11.2±0.9 and 11.5±0.8. The results of ANCOVA analysis showed that Hesabyar Cognitive Rehabilitation program made significant changes in components of variables, including selective attention (P=0.002), sustain attention (P=0.001), attention shifting (P=0.001), attention divided (P=0.004), attention span (P=0.002) l-term memory (P=0.011) [components of difficulty in memory function and learning], executive functions (P=0.001), problem with speed and cognitive processing ability (P=0.016), as well as components of academic performance problems, namely attention functions (P=0.004), computational science (P=0.002), argument/calculations (P=0.014), and attitudinal discussions (P=0.001) [components of academic performance problems: mathematics].

Conclusion: Based on the findings of this study, Hesabyar Cognitive Rehabilitation program is one of the treatments that can be used to minimize the problems of students with math learning disorders.

Keywords: Hesabyar cognitive rehabilitation, Psychopsychological functions, Specific learning disorders

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1. Introduction

Specific Learning Disorders (SLD) include a heterogeneous group of learning problems that manifest in a variety of ways, such as basic problems in reading, writing, reasoning, and math comprehension (1). Children with special learning disabilities have problems in continuing their education despite their natural intelligence. Learning disabilities have their roots in prenatal and early childhood and continue into adolescence and adulthood (2). One of the specific types of learning disability is math learning disability. Children with math learning disabilities have cognitive problems that cannot be attributed to their intelligence. A number of these defects are delays in number processing, difficulty in learning mathematical strategies, difficulty in memorizing numbers, and defects in working memory (3). The prevalence of this disorder in Chinese students was estimated to be between 5% and 8% (4). In Tehran as well, the prevalence of this disorder was estimated at 3.6% (5). According to the DSM-5, math learning disabilities are classified as transformational nerve-specific learning disabilities. Students with learning disabilities have problems in processing numerical information, learning mathematical principles and rules, and performing calculations easily and correctly (1). These students face problems in learning the concepts and meanings of numbers or calculations, as well as in mathematical reasoning, applying concepts, principles or methods of solving numerical problems, and their progress in mathematics is significantly lower than expected for their age. The learning problems mentioned are not treated due to low intelligence, or vision

or hearing issues. It is also not justified by other mental or neurological disorders, acute socio-psychological conditions, lack of knowledge of the language in which education is provided, or low level of education. The disorder begins early in school and may not manifest until later in school; that is, until the educational requirements become more severe and exceed the individual's limited ability (1).

The most important characteristics of children with mathematical disorders are difficulties in learning and remembering mathematical concepts. Secondly, they have difficulties in performing calculations, applying inefficient and unsuccessful strategies in problems solving, spending a long time for finding solutions, and have a high rate of error in performing mathematical calculations (6). Learning math concepts includes learning basic skills and basic math skills. These skills include classifying and grouping, sorting, one-to-one matching (pairing), counting, and recognizing numbers. Many children lack basic math skills when they enter school and have difficulty understanding basic math concepts (7).

Gray and colleagues found that children with math learning disabilities had problems with classroom attention, working memory, and retrieving information from memory, which impedes learning math, especially solving math problems effectively (3). The fields of learning disability and neuropsychology are intertwined. Over the recent years, research in the field of cognitive psychology and neuroscience has begun to further delve into the main possible causes of a particular learning disability. Psychological neuropathy is the study of the relationship between behavior and the brain, and neuropsychological evaluation is the application of this knowledge to assess and intervene in human behavior related to the normal functioning of the central nervous system (8). Research showed that students with special learning disabilities have severe weakness in neuropsychological abilities (9-11). Fletcher and Grigorenko were certainly assured that there is a strong association between brain dysfunction and specific learning disabilities (8). Moreover, literature indicated that students with math learning disabilities have impaired neuropsychological functions, such as attention, memory, organization, and planning (12, 13). Additionally, based on recent studies, students with math learning disorders experience problems in functions called neurological executive functions (14, 15). These students have also been shown to face problems with math learning disorders in various aspects of neuropsychology (executive functions and attention, language, visual-spatial processing, memory and learning). This deficiency in neuropsychological skills can be a predictor of nonverbal learning disability in students with math learning disabilities (16).

One of the treatments that have so far been less effective in promoting neuropsychological functions and math efficiency in students with math learning disorders is the Hesabyar Cognitive Rehabilitation program. This program includes three main topics such as counting, addition and subtraction; since one-to-one correspondence and the concept of collection were among the prerequisites for teaching the main topics, they were also used in the design. The software includes a main page through which the user can move between different sections (11). Due to the fact that the software is designed in a non-linear way, it is possible for the user to move between each section. Cognitive science, as one of the recent sciences developed significantly, is expected to create a profound change in human life with the help of other new sciences, such as biotechnology and nanotechnology. Students must be proficient in a set of skills to master homework. Among these skills are neuropsychological functions, the most important of which are executive functions and attention (11). Neurological executive functions are important structures responsible for controlling consciousness, thinking, and acting through psychological processes (10). These functions cover a wide range of cognitive processes and behavioral abilities, including reasoning, problem solving, planning, organizing, working memory, sequencing, ability to pay attention, dealing with interference, benefiting from feedback, and multitasking (17). Neuropsychological functions are very important structures that are related to psychological processes responsible for controlling consciousness, thinking and action, and are one of the most important factors involved in learning. Unfortunately, children with learning disabilities have impaired use of neuropsychological functions (18). Gray and co-workers showed that a cognitive rehabilitation program has an effect on working memory and attention and academic achievement of students with learning disabilities

(3). Isanejadbushehri and colleagues reported that computer cognitive training improves executive functions in people with attention deficit and hyperactivity (19).

Unfortunately, there is scarce research on math learning disabilities compared to that on reading and writing disorders while studies have shown that math knowledge is of particular importance in everyday life (20, 21). Mathematics is one of the basic subjects in elementary school and has always been one of the most difficult topics in the curriculum for students. In current educational classes, there are learning difficulties and lack of motivation to learn mathematical concepts. This necessitates the use of neuropsychological ability to improve learning problems of students with math learning disabilities. This exigence is due to the destructive and sometimes irreversible effects of learning disabilities, such as students' low self-esteem and academic self-concept, dropout, work tolerance, and lack of motivation compared to their peers. Furthermore, it is owing to the increasing progress of neuropsychological functions and the efficiency of these sciences in the treatment of various disorders, especially learning disorders (3, 18, 19). Accordingly, the present study aimed to investigate the effectiveness of Hesabyar Cognitive Rehabilitation on improving the neuropsychological functions of students with mathematical learning disorders.

2. Methods

This was a quasi-experimental study which had a pre-test and post-test design and conducted with a control group. Our statistical population included all the primary school students with special learning disabilities in Semnan, Iran, in the academic year 2019-2020. The sample consisted of 40 students (20 in the experimental group and 20 in the control group) with special learning disabilities. The sample consisted of first 70 students with specific learning disorder. Then, based on the screening and inclusion and exclusion criteria, 40 people were selected and replaced in 2 tests and control groups (20 people in each group) by a simple random method. The sample size was determined via G*Power statistical software with an effect size of 0.75, a significance level of 0.05, and power test of 0.75 which was conducted with two groups (22). In order to analyze the data, the presuppositions related to parametric statistics and ANCOVA were initially examined. Primarily, Shapiro-Wilk Test showed the normal distribution of the data; in fact, a significant level of over 0.05 for all the components indicated the univariate normality. Subsequently, the significance level of Levin test implied that the variances between the two groups were homogeneous (P<0.05). Finally, the data obtained from the questioners were analyzed using analysis of covariance (ANCOVA) via SPSS version 24.

2.1. Data Collection Tools

Conners Neuropsychological Scale: This test was evaluated by Conners and co-workers in 2004 to assess neuropsychological problems, including attention, memory, language, sensory-motor function, executive functions, and visual-spatial processing in four spectrums (23). This questionnaire is made for children aged 5 to 12 years old. The scoring of the Conners Psychological Nerve Scale is based on four items: severe (3), moderate (2), mild (1), and unobserved (0). The components of the Neuropsychological Scale used in this research were: attention problems (selective attention, sustained attention, attention shifting, divided attention, attention span), difficulty in memory function and learning (short-term memory, working memory, and long-term memory), executive function problems (problem solving, planning, organization), problems with speed and cognitive processing ability (cognitive ability), as well as academic performance problems: mathematics (attention functions, computational science, argument, calculations, and attitudinal discussions). In Iran, Jadidi and Abedi translated and standardized this questionnaire. Internal reliability coefficients ranged from 0.75 to 0.90 and test-retest reliability coefficients with an 8-week interval were reported to be from 0.60 to 0.90 (24). In order to evaluate the prevalence of neuropsychological learning disorder among children, according to the instructions of Conners questionnaire, a score of 1.5 was mentioned as the cut-off point. Jadidi and Abedi evaluated the construct validity of this scale and reported the reliability of this scale with Cronbach's method to be 0.72 (24).

2.2. Treatment Protocol

So far, practical educational software for the treatment of mathematical learning disorders has

not been designed in Iran; therefore, designing and building an interactive educational software for this group of students by considering the theories and research done in this field, as well as asking for opinions and consulting with teachers and experts in learning disorder after choosing topics with the help of multimedia program (multimedia flash version) seems essential. The designed software of Hesar Yar includes 15 games, and since one-to-one correspondence and the concept of the collection were among the prerequisites for teaching the main topics, they were also used in the design. After completing the development of Hesabyar educational software by the researchers, which took three months, and establishing the necessary coordination with the two introduced centers, as well as random determination and assignment of experimental and control groups, both groups

Table 1: Mean and standard deviation of pre-test and post-test components of neuropsychological functions of students with special learning disabilities

Variable		Time	Experimental Group		Control group		P value (between groups)
			Mean	Standard deviation	Mean	Standard deviation	
Attention problems	Selective attention	Pre-test	7.111	1.778	6.055	2.235	0.091
		Post-test	3.000	1.236	6.715	1.451	0.002
	P value		0.001		0.211		
	Sustain attention	Pre-test	6.777	1.437	6.611	1.719	0.412
		Post-test	3.055	1.433	6.388	1.685	0.001
	P value		0.000		0.090		
	Attention shifting	Pre-test	6.611	1.786	7.000	1.680	0.310
		Post-test	2.944	0.998	6.500	1.248	0.001
	P value		0.001		0.116		
	Attention Divided	Pre-test	6.555	1.688	7.000	1.714	0.211
		Post-test	2.111	1.278	6.388	2.033	0.004
	P value		0.001		0.064		
	Attention span	Pre-test	6.500	1.465	5.555	1.765	0.061
		Post-test	2.333	1.680	6.055	1.797	0.002
	P value		0.001		0.122		
Difficulty in memory function and learning	Short term memory	Pre-test	9.000	2.057	9.056	2.484	0.321
		Post-test	6.166	1.504	9.055	2.484	0.024
	P value		0.001		0.324		
	Working Memory	Pre-test	8.055	1.661	7.944	1.513	0.123
		Post-test	4.555	2.430	7.388	1.685	0.001
	P value		0.001		0.081		
	Long-term memory	Pre-test	8.888	1.529	8.611	1.289	0.312
		Post-test	4.383	2.249	7.512	1.113	0.011
	P value		0.002		0.181		
Problems with executive functions	Problem solving/ planning/organizing	Pre-test	14.556	3.166	12.777	3.687	0.194
		Post-test	6.777	1.699	13.555	3.416	0.001
	P value		0.001		0.059		
Problems with speed and cognitive processing ability	Cognitive ability	Pre-test	13.444	2.661	15.222	2.981	0.140
		Post-test	8.722	3.044	14.166	2.812	0.016
	P value		0.001		0.211		
Academic performance problems: Mathematics	Attention functions	Pre-test	3.500	1.504	3.444	1.293	0.087
		Post-test	1.277	0.826	3.888	1.131	0.004
	P value		0.001	0.200			
	Computational science	Pre-test	2.833	1.504	2.555	1.580	0.071
		Post-test	1.000	0.840	2.944	1.304	0.002
	P value		0.006		0.093		
	Argument/ Calculations	Pre-test	3.166	1.465	3.000	1.495	0.303
		Post-test	1.055	0.725	3.000	1.188	0.014
	P value		0.001		0.103		
	Attitudinal discussions	Pre-test	3.111	1.490	3.555	1.381	0.221
		Post-test	1.166	0.857	3.166	1.200	0.001
	P value		0.001		0.071		

underwent a pre-test of KEY-MATH test (The KeyMath Diagnostic Assessment is a widely used assessment of children's mathematical abilities). The participants of the experimental group were trained individually in 10 sessions lasting one and a half hours every other day.

3. Results

The participants consisted of 40 students (20 in the experimental group and 20 in the control group) with special learning disabilities. The inclusion criteria were: a) refering to the student file and take the Colorado test (The Colorado Learning Difficulties Questionnaire was prepared by Willcutt and colleagues in 2011 (25) to diagnose learning disabilities); b) completion of the ethical consent form for participation in the research by the parents and willingness to participate in the research by the student; c) not suffering from other mental disorders. The exclusion criteria were: a) absence in more than one intervention session; b) simultaneously participating in other intervention programs; c) withdrawing from the study. The mean and standard deviation of students' age in the experimental and control groups were 11.2±0.9 and 11.05±0.8, respectively.

According to the results of Table 1, the results showed that Hesabyar Cognitive Rehabilitation program has reduced the neuropsychological problems of students with math learning disorders. It means that, in all the components of attention problems, difficulty in memory and learning function, executive functions, cognitive processing speed and ability, and academic performance of mathematics in children with pre-learning disabilities, pre-test and post-test are different in the experimental and control groups.

With the aim of inferential analysis of the research data, the presuppositions related to parametric statistics and variance analysis were tested first. The output of the Kolmogorov-Smirnov test showed a significance level of greater than 5%, indicating the normality of the distribution of the variables (P>0.05). Levene's test was also used to check the homogeneity of variance, showing that the significance levels of all dependent variables were greater than 5% (P>0.05). Examination of the assumption of homogeneity of the covariance matrix in the form of Mbox test output also revealed that the covariance matrices of the independent variable were the same in the groups; therefore, this hypothesis was confirmed (Box's M=182.095, P=0.632). The results of ANCOVA analysis showed that based on Hesabyar Cognitive Rehabilitation, there were significant differences between the groups in terms of the components of attention problems, namely selective attention (P=0.002), sustain attention (P=0.001), attention shifting (P=0.001), attention divided (P=0.004), attention span (P=0.002). Additionally, the components of difficulty in memory function and learning showed that short-term memory (P=0.004), working memory (P=0.004), and long-term memory (P=0.004) significantly changed in the experimental group. The changes in problems with executive functions (P= 0.001) and problems with speed and cognitive processing ability (P=0.016) also indicated that the intervention was significantly effective. Finally, attention functions (P=0.004), computational science (P=0.002), argument/ calculations (P=0.014), and attitudinal discussions (P=0.001), as subscale of academic performance problems, significantly decreased in the experimental group.

4. Discussion

The aim of this study was to evaluate the effectiveness of Hesabyar Cognitive Rehabilitation on psychological and neurological functions of students with special learning disabilities. The results showed that Hesabyar Cognitive Rehabilitation program reduced the neuropsychological problems of students with learning disabilities. There was a significant difference among attention problems, difficulty in memory function and learning, problems with executive functions, problems with speed and cognitive processing ability, and mathematics academic performance between the two experimental and control groups. Furthermore, the cognitive rehabilitation program of Hesabyar reduced the neuropsychological problems of students with math learning disorders; this finding is consistent with those reported by Yavari and colleagues (26). They showed that Hesabyar educational software reduced the math problems of students with learning disabilities (26). Kesler and co-workers conducted a cognitive study indicating that the program of computer cognitive disability significantly increased processing speed, cognitive flexibility, verbal news memory scores and vision, and played a significant role in increasing the activity of the

frontal cortex (20). Bayrami and colleagues also concluded that neuropsychological rehabilitation improved continuous attention in students with learning disabilities (27). Veloso and co-workers stated that computer cognitive training improves executive functions in people with attention deficit hyperactivity disorder (28). Research showed that deficiency in neuro-psychological skills can be a predictor of mathematical learning disorder in students (29, 30).

Accordingly, it can be inferred that neurological functions are important structures responsible for controlling consciousness, thinking, and action through psychological processes (10). These functions cover a wide range of cognitive processes and behavioral abilities, including reasoning, problem solving, planning, organizing, working memory, sequencing, ability to pay attention, dealing with interference, benefiting from feedback, and multitasking (17). Neurocognitive functions are one of the most important factors involved in learning, but unfortunately, children with learning disorders have defects in using these functions (18). Today, one of the ways to improve the neuropsychological functions of computers is to design games. Computers and computer-based education are known to function as mental rehabilitation strategies for students with learning disabilities (31). Ota and DuPaul stated in a study that playing in teaching mathematics is one of the most effective ways to reduce the problems of children with learning disabilities (32). Therefore, designing and teaching through educational software can have a significant impact on solving the problems of students with learning disabilities. These kinds of software can minimize the problems faced by students with math learning disabilities and facilitate learning for this group, provided that they are designed in accordance with students' ability to understand. In general, the use of technology in special education has been emphasized due to its positive effect in increasing self-confidence, independence and self-concept of children with special needs as a result of improving cognitive skills (31).

4.1. Limitations

This research has some limitations, such as that the statistical population included a special group of the society; that is, the students with mathematical learning disorders in Semnan city. Thus, it is rather impossible to generalize the results to the whole society. Another limitation concerned the internal validity and design of the research. This was a semi-experimental study and did not have the advantages of real experimental designs. Data collection in this research was based on self-report scales. Therefore, another limitation of this research regards measurement; these reports are susceptible to distortion due to unconscious defenses, response bias, personal introduction methods, and social desirability in general. For further effectiveness of trainings of the Hesabyar Cognitive Rehabilitation program based on the achievements of modern cognitive sciences and technologies on neuropsychological functions, it could be suggested counselors and specialists be trained about this program.

5. Conclusions

It can be concluded that game-based cognitive training for children can bring about sustainable improvements in the field of performing actions in children who suffer from learning disabilities. In general, it seems that the use of cognitive rehabilitation technology in education improves the self-confidence, independence, self-concept and cognitive ability of children with special learning disabilities, which in turn improves the mathematical skills of students with learning disabilities.

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Ethical Approval

The Ethics Review Board of the university approved the present study with the code of IR.IAU.SDJ.REC.1399.058. Also, written informed consent was obtained from the participants.

Conflict of Interest: None declared.

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