Research Paper: Effect of Computer-assisted Neurocognitive Rehabilitation on Inhibitory Control of the Students With Dyscalculia

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ABSTRACT

Objectives: Cognitive functions are the most important factors that influence the performances of students with dyscalculia. This study investigates the effect of computer-assisted neurocognitive rehabilitation on the inhibitory control of students with dyscalculia.

Methods: A quasi-experimental pretest-posttest design was applied in this research. Thirty elementary students with dyscalculia were selected through convenience sampling. Then, a control and an experimental group (each containing 15 individuals) were formed and matched based on age, intelligence, gender, and school grades. The experimental group received neurocognitive rehabilitation in 20 sessions, each one taking 45 minutes. To gather data, the Wechsler Test (WISC-R), Key Math Test, and Go – No Go Test were used.

Results: The results of covariance analysis showed that cognitive rehabilitation interventions did not lead to a significant difference between the experimental and control groups in inhibitory, omission, commission and reaction time scores (P>0.05).

Discussion: The study findings suggest examining the effectiveness of long-term rehab during different ages and training strategies with follow-ups.

1. Introduction

Mathematics learning disability, also known as dyscalculia, is considered as a learning disability characterized by the defects in arithmetic skills [1, 2, 3]. In Developmental Dyscalculia (DD), there is not necessarily any co-occurrence with other developmental disorders like reading disability or Attention-Deficit Hyperactivity Disorder (ADHD), where the intelligence quotient seems to be normal but with some weaknesses in math [4]. The common neuroscience theory on the DD suggests that this disorder is related to the disability in Magnitude Representation (MR), mostly called Approximate Number System (ANS) [5] or number module [6], in Inter Parietal Sulcus (IPS). This theory suggests that defects in MR lead to numerical skill disorders related to

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the solving of mathematic problems [5, 6], and this has been confirmed by using MRI. Studies have found that children with dyscalculia have lower gray matter density in the parietal cortex [7-9]. Regarding these results, it can be said that abnormal development of parietal cortex, especially right IPS in the brain, may attenuate the natural development of mathematical ability. Although MR theory on the mathematical disability is known as a common approach in the field of neurosciences, behavioral studies have introduced some important cognitive functions that are involved in the development of mathematical skills. First, there are various studies which support the verbal and visuospatial deficiency of working memory in DD [10-13]. Second, some studies have reported the problems of spatial processing in DD [14, 15] that may be related to visuospatial working memory. Third, other findings have referred to the inhibitory deficiency in DD and the relationship between inhibitory function and mathematical progression [16-20].

Inhibition is a key component of executive function that precedes other executive functions, providing developmental possibility to other cognitive functions [21, 22]. Generally, inhibition is an important process in daily life and learning at school. Based on Carlson and Moses (1988) cognitive inhibition has an important role in academic learning [23]. Thus, many studies have focused on the cognitive inhibition of students with learning disability [24-30]. Fourth, some studies have also focused on attention as well [31, 32].

All suggested cognitive functions are related to IPS. Thus, deficiency in each of these cognitive functions can explain the abnormal functioning of IPS in DD children [33]. Accordingly, based on the role and importance of cognitive functions in the children with mathematical disabilities, certain levels of cognitive interference and rehabilitation may help these children improve their cognitive abilities. The theoretical basis of cognitive rehabilitation is based on plasticity and cognition preservation [34]. The central nervous system adapts itself to the environment and environmental experiences [35]. Based on the neurological studies, brain will act stronger if it is stimulated. The more activity the brain is stimulated for, the more cognitive power it will have. By more stimulation, the brain cells get more dendrite and axon, creating more complex communication networks and cognitive power. Regarding research findings based on the flexibility of cognitive functions and capability of improving their functions [36], different programs for improving cognitive skills, such as working memory and inhibitory control have been designed in different modules, including computer-assisted cognitive program.

Although the above-mentioned studies showed poor performance of inhibitory control in children with dyscalculia despite the increasing interest in computer-based rehabilitation of cognitive skills, future researches have been suggested. The previous researches mostly focused on ADHD children, but this present study has focused on rehabilitation of inhibitory control of children with DD.

2. Methods

This study had a quasi-experimental, pretest-posttest design. The statistical population included all elementary school students with dyscalculia visiting the learning disability centers of Tabriz. The sample included 30 school students with dyscalculia who were selected from a pool of 48 students with dyscalculia based on the convenience sampling method. They were also randomly assigned to one experimental (n=15) and one control group (n=15) (an experimental methodology requires a sample size, not fewer than fifteen subjects [37]) and matched according to their ages, genders, intelligence, and school grades. The intervention program was conducted in 20 sessions for the subjects of the experimental group, each session taking 45 minutes while the control group followed its normal schedule. The intervention program was conducted in a silent class, where the subjects sat in front of their laptops while the researcher was present beside them monitoring the treatment session. After 20 sessions, a post-test was conducted for both control and experimental groups at the same time. After finishing evaluations, the control group received a free treatment like the treatment of experimental group after obtaining their parents' consents.

Subjects were selected based on: 1) Full awareness of the participation conditions of the study, 2) Receiving diagnosis of dyscalculia by the experts, 3) Having average intelligence, 4) Being in the age group of 7-11 years, 5) Not taking any medication, and 6) Lack of having audio, visual, motor, or communicative problems. Also, the subjects with dyscalculia having other disorders like hyperactivity and those who did not follow treatment sessions for two consecutive times were removed from the study.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the research committee. Informed consent: Informed consent was obtained from the parents of all individual participants included in the study.

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Table 1. Covariance analysis for the inhibition, commission, omission and reaction time

	Sources	Sum Squares	df	Mean Square	F	Significance Level	Eta Square
Inhibition	Pretest	37.75	1	37.75	0.13	0.72	0.00
	Group	794.57	1	794.57	2.74	0.10	0.09
	Error	7820.64	27	289.65			
Commission	Pretest	528.75	1	528.75	9.22	0.00	0.25
	Group	2.64	1	2.64	0.04	0.83	0.00
	Error	1547.37	27	57.31			
Omission	Pretest	5.74	1	5.74	0.01	0.89	0.00
	Group	606.41	1	606.41	2.03	0.16	0.07
	Error	8056.11	27	298.37			
Reaction time	Pretest	55404.6	1	55404.6	5.12	0.03	0.15
	Group	1117.07	1	1117.07	0.10	0.75	0.00
	Error	292011.13	27	10815.22			

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Materials

Researcher-made questionnaire: This questionnaire measured all demographic information of the subjects, such as age, grade, average score of previous term, taken medications, etc.

Key Math Test: This test was designed to identify the strengths and weaknesses of the students aged between 6-11 years in different mathematical fields [38]. This test included three components of concepts, operations, and applications. Concepts included three subsidiary tests of numeration, rational numbers, and geometry. Operation consisted of addition, subtraction, multiplication, division, and general mental calculations. Application included questions for measurement, time, money, estimations, data interpretation, and problem solving. This test was adapted to Iranian students at the age of 6.6 - 11.8 years [39]. Reliability of this test was estimated by Cronbach Alpha whose value was reported to be 80%-84% for five grades [39].

Go – No Go Task: This task includes 100 moving objects (airplanes). The subject should press arrow button at its movement direction on the screen. Hearing the beep tone after representing the airplane, the subject should stop pressing the key. Then, the number of right and wrong answers of the subject in go stage and its mean as well as the time and the number of right and wrong answers of the subject during the No go stage with its mean were measured [40].

WISC-IV: Intelligence measure of WISC-IV is an adoption of intelligence measure of Wechsler. Fourth version of this scale is WISC-IV, published in 2003. In WISC- IV, five types of intelligences including verbal comprehension, perceptual reasoning, working memory, process speed, and total intelligence quotient are estimated [41, 42]. This test was used to test the match between the experimental and control group regarding intelligence quotient of the students.

Intervention program

In this study, Cogniplus Program [43] and rehabilitation program of working memory [44] were implemented. Cogniplus Program was based on the recent findings of the neurologists and psychologists in six main areas and some subsets that focused on 16 cognitive functions with the goal of improving cognitive abilities. To train working memory, one tool called “Robomemo” was designed by Klinberg [44]. For the lack of the conformity of this software with Persian language, Persian version of working memory software in Iran was designed, adopted from Robomemo Software, by Khodadadi et al. (2009) [45].

3. Results

Data analysis was conducted in both descriptive and inferential forms. To analyze data, SPSS [35] software was used. Results of independent t-test showed that both experimental and control groups were similar in terms of age (P=0.46), IQ (P=0.27), math performance (P=0.81), gender (7 girls and 8 boys in each group), and educational grade (second grade (3 cases), third grade (4 cases), fourth grade (8 cases) in each group). To examine the efficiency of cognitive rehabilitation, two groups were compared in posttests using covariance analysis.

Table 1 shows that cognitive rehabilitation interventions did not lead to a significant difference between the experimental and control groups in inhibitory, omission, commission and reaction time scores (P>0.05). Thus, it has been observed that rehabilitation interventions did not improve inhibitory, omission, commission and reaction time scores in children with DD.

4. Discussion

The results showed that cognitive rehabilitation intervention did not lead to a significant difference between the experimental and control groups in inhibitory, omission, commission and reaction time scores (P>0.05). Inhibitory studies have reported the efficiency of cognitive rehabilitation in improving inhibitory performance among the subjects [46-49].

The program types and offered practices are effective factors in cognitive practices affecting cognitive skills that can be the reasons for such discrepancy in the results. Interactive nature of this program towards the subjects and offering of immediate feedback to them and balancing difficulty levels of the tasks based on the performance level of the person have a basic role in the success of the program. Representing the tasks from simple to difficult provides the possibility of dominating elementary skills for doing more difficult tasks and higher motivation for finishing the task.

In this study, especially in inhibitory rehabilitation, there was immediate feedback and the balance of difficulty level. However, the feedback given to the children in the beep form in case of wrong answer created tension and anxiety in the children. So, the children had no tendency to play that inhibitory game. Accordingly, one effective factor in the inefficiency of the intervention program could be the lack of the motivation and interest of the subjects, which was absent in inhibitory rehabilitation despite other parts of the program.

Also, it is likely that cognitive skills, especially inhibitory skills, are learned by the subjects; but they need some time to express themselves and show their effects. These likely factors can provide some rationales for the lack of the efficiency of rehabilitation program in the inhibitory control.

5. Conclusion

Our findings indicated that cognitive rehabilitation intervention did not lead to a significant difference between the experimental and control groups in inhibitory control. This finding suggested an examination of the effectiveness of long-term rehab in different ages and different training strategies with follow-up.

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Conflict of Interest

The authors declared no conflicts of interest.

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