Comparison of the efficacy of cognitive rehabilitation and neurofeedback on specific learning disorder among primary school children of Tehran, Iran

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Abstract

Introduction: Specific learning disorder is an impairment in general academic skill that is identified in reading, mathematics and written expression fields; besides, it creates a major problem in academic achievement, job performance or daily life activities. The present study was aimed to compare the efficacy of cognitive rehabilitation with neurofeedback on specific learning disorder (math, reading and spelling) in primary school children in District 5 of Tehran.

Materials and Methods: The methodology of this research was quasi-experimental with pre-test-post-test design with control group. Using the Learning Disability Evaluation Scale, 45 patients in three groups were selected as experimental group (15 patients for cognitive rehabilitation and 15 patients for neurofeedback) and control group (15 patients). Then, the interventions were provided to the experimental group and the control group used the usual school training. Pre-test and post-test were taken from both experimental and control groups, after the intervention on the experimental group, the pre-test and post-test results of all three groups were compared with each other. The Learning Disability Evaluation Scale (LDES-R2), developed by McCarney, was used in the study. Multivariate analysis of covariance, with SPSS 22 software was used for data analysis.

Results: The results of the study showed that after the intervention, the treatment group was improved in the specific learning variables of reading, writing and math ($P < 0.001$). And the effect of cognitive rehabilitation approach was greater than the efficacy of neurofeedback ($P < 0.001$).

Conclusion: By improving specific learning disorders in children, their problems might be reduced and the effect of treatment might be improved. Though, in case of specific learning disorders in the children, we would need much more thorough treatments.

Keywords: Specific learning disorder, Reading disorder, Spelling disorder, Math disorder, Cognitive rehabilitation and Neurofeedback

Introduction

Specific learning disorder (SLD) is one of the most common neurodevelopmental disorders among school children (1). This involves continuous difficulties in learning key academic skills, including reading, spelling, and math. The prevalence of specific learning disabilities among primary school children is 5 to 15% (2). Compared to other students, students with special learning disorders are more likely to leave school (3), find no job or even have suicidal thoughts (4). Sustained Attention (SA) is denoted the ability to direct and focus on a particular stimulus without any distraction for a persistent period of time (5). Learning disabilities (LD) can be associated with attention function difficulties that complicate LD

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(6). Evidence suggests that children with specific reading disorders have difficulty in SA; besides, some studies have revealed that children with dyslexia have attention deficits (7,8). For example (9), showed that children with dyslexia have difficulty focusing on the text and simultaneously controlling distracting stimuli.

Specific learning disorders (SLDs) including dyslexia and arithmetic are investigated in the researches done for finding diagnoses and treatments. Reading and arithmetic are the main subjects of formal education, they predict academic achievement and income in our future life. The reason for examining the selected groups of children with specific disabilities is that understanding the cause and also its relationship to their defect can clarify the neurological mechanisms that generally develop impaired competencies (10). Children with SLD, compared to the general population, are more likely to be affected by an additional mental disorder. 58% of children with SLD had similar criteria for another mental disorder (11). The most common emotional disorder associated with SLD is anxiety disorder with comorbidity ranging from 9 to 24% (12). SLD and depression occur in 4 to 14% of cases (13). The prevalence of conduct disorder is ranging from 5 and 14% (14).

Over the past decade, due to the interest in the development of alternative non-pharmacological therapies for specific learning disorders, neurofeedback cognitive training has been welcomed as an intervention method. Several implicit assumptions have directed researchers' decisions about cognitive capabilities for teaching and the training tasks to use these abilities; For example, a special cognitive process might be used because it is assumed to be a higher-order function that predicts or affects another spectrum of other cognitive processes (15). The rational reason is that improving that particular process can lead to improving the skills affected (i.e., extensive transfer). Based on the aim of this study, we would refer to this as "higher order hypothesis". Although the performance of one measure of executive performance might significantly associate the performance of another performance measure, much information is not available about the specific nature of this relationship (16). For example, we have little knowledge about whether a change in one process causes a change in another or not. The second implicit assumption is that purposeful ability is a central defect in a particular disorder as to a specific learning disorder. We call this as the "central deficit hypothesis". Even if specific cognitive defects are frequently observed in a specific learning disability, the relationship between performance in cognitive tasks and symptom severity is moderate at best case and the nature of the relationship is not known (17).

Another group of researchers (18), in their study has shown that neurofeedback has a significant impact on improving visual memory. Also, the efficacy of Neurofeedback therapy has been reported in depression, learning disorder with attention deficit / hyperactivity disorder (ADHD) (19). In general, various researches have shown that neurofeedback method has been effective in improving the condition of different groups including children with attention deficit, and patients with mental disorders or other learning disorders (20). The main focus of this research is on the role of cognitive skills; executive functions and working memory improve learning disability by using one of the intervention methods (cognitive rehabilitation or neurofeedback) (21). among children and adolescents with LD (22). CR is a set of methods designed to increase executive performance such as perception, attention, comprehension, learning, memory, problem solving, and reasoning in individuals with difficulties in these areas (23). Evidence indicates that CR can cause SA in LD (24), cerebral

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palsy (25), Alzheimer's disease (26), and multiple Sclerosis (27, 28).

Neurofeedback (NFB) is another method used to reduce the LD symptoms (29). By adjusting electroencephalogram (EEG), functional magnetic resonance imaging (fMRI), HEG abnormalities, and NFB might be considered as useful interventions in the treatment of some disorders (30). This therapeutic approach, as a non-pharmacological intervention, attempts to change brain activity by providing feedback on EEG activity (31). NFB increases beta activity, suppresses theta activity and improves SA in some disorders such as reading disorder and ADHD (32).

As mentioned earlier, SLD is often associated with neurological dysfunctionality such as SA defects. Recent studies have reported the positive impact of CR and NFB on specific learning disorder and other disorders. Though, no study has compared the impact of CR and NFB training in children with specific learning disorder. the current study aimed to determine and compare the efficacy of CR and NFB on specific learning disorder among primary school students with specific learning disorder (33).

Materials and Methods

This study is a quasi-experimental, it uses a pre-test-post-test design with a control group. The statistical population of consists of male elementary school students, having referred to the psychiatric clinic in Karaj and being diagnosed with attention deficit hyperactivity disorder in the academic year 2017-2018. Convenience sampling method was used to select the subjects. In order to determine the sample size in experimental and quasi-experimental research, due to time and financial constraints, researchers can use 15 individuals in each experimental and control group (34). Therefore, considering the possibility of elimination in the experimental and control groups, a total of 50 students referring from schools in District 5, agreed to receive interventions. Also, the inclusion criteria are IQ 90-110, lack of disability or other disorders, as well as not using medication or other treatments until the end of this study. Using the Learning Disability Evaluation Scale, 45 patients in three groups were selected as experimental group (15 patients for cognitive rehabilitation and 15 patients for neurofeedback) and control group (15 patients). The following instruments were used for data collection.

Cognitive Rehabilitation Program of Purposeful Matrices

In this research rehabilitation intervention method is purposeful matrices method (35). This instrument consists of the following sections:

1- Rehabilitation manual that explains the underlying theories and procedures.

2- Wooden parts related to making designs and guide rulers

Rehabilitation instrument in this study is a researcher-made tool that includes 28 wood pieces that are divided into 7 groups (4) from each piece. 4 wooden rulers, two of which, completely white and without any mark on them, and the other two, which are guide rulers, with special design on them. There is also a handbook that that exactly explains the procedure and illustrations of each step. The child is taught in 14 (1 hour) sessions.

In order to confirm the internal validity of this instrument, and to make relevant corrections, a checklist of efficacy indicators of other instruments that have similar use was prepared. Then, the instruments were presented to five experts. The experts' agreement coefficient actually confirmed the validity of this instrument. It is worth mentioning that the researcher made all corrections and changes to improve and to increase the efficiency agreed upon by the experts in making the final package. The agreement coefficient of experts was equal to 0.7; Thus, if any of the sections and components of package

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and the method itself were agreed upon by the judges with the mentioned coefficient of agreement, the remained programs and any of the sections or articles that did not obtain the above coefficient, were examined for correction or elimination. In this method, during the sessions 60 shapes were made by the therapist and clients in 6 steps, which makes a total of 360 designs. The child and the therapist sit in front of each other on either side of a table so that the child is completely in control of the table. The therapist first divides parts 1 to 4 evenly between himself and the child before him. That is, he himself has 2 of each piece, and 2 belong to the child (each person has a set of 8 pieces). The therapist puts one of the rulers in the middle so that he divides the table into two parts. He begins to recognize pattern number 1 and asks the child to make a pattern like him at the same time. Each piece that the therapist puts, then waits for the child to put the same piece in its place. In the primary designs, sometimes there is a need for guidance, which is done by pointing the finger and guiding the child to make the pattern. In the first session, the first 8 designs of the handbook were shown to the child. 2- After the child could make the design simultaneously, was asked to destroy that and make it again. The therapist approves the task of the child with head movement, or smile, etc. Preferably, it is attempted that the child makes the design independently, but in case of having any problem he is guided. 3-The child was asked to memorize the design. When the child sees the shape carefully again, we ask him to destroy the design and the therapist covers his design with white cardboard and asks the child to make the design by heart. If the child needs guidance, he is allowed to pick up the cardboard himself and see the design, but the moment he makes the design, he must put the cardboard in its place and make it by heart. The manual is continuously with the therapist. From stage 4 onwards, it is for children 8.5 years old and above (Indeed, if the younger child is able to continue, in this stage, the examiner puts another ruler in front of the child and asks him make the design exactly the same as the built design because there was a ruler in the middle and the design was made symmetrically). This step was exercised with the use of guide rulers, spatial and mental rotations. In the fifth step of the design, the symmetry is designed by heart. In step 6, 90-degree rotation to the left or right was done. During the sessions, the number of wooden pieces is up to 7 pairs which are given to the clients and 7 pairs was given to the therapist. Finally, the progress speed, depending on the abilities of the individual, might be slower than the program, and it is necessary to increase the number of sessions for slower individuals by one or two sessions relative to one's speed.

Neurofeedback

Neurofeedback training was performed using Atlantis II 2× 2 equipment, Brainmaster equipment was applied. This equipment uses impedance (less than 5 km) and automatically controls the tools (> 120 volts). EEG was analyzed in two frequency bands (theta: 4-7 Hz, beta: 15-20 Hz). This training was given to the child as a computer game (puzzles, races, calm people, etc.). You should focus to win games. Specifically, the children were taught by their teacher to use this strategy that best helps them to obtain score in the game. In their success in controlling dust, the children received the condition of visual and auditory enhancement from theta and / or beta.

Learning Disability Evaluation Scale (LDES-R2)

Learning disability evaluation scale - Modified second edition (LDES-R2) is used to enable education staffs to recall functional behaviors that are more than the features of learning disabilities in children

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and adolescents. This instrument is designed to provide an index based on the definition of the most accepted learning disabilities. The subscales consisted of listening, thinking, speaking, reading, spelling, and math. LDES-R2 was standardized on a total of 4473 students aged 6 to 18 years and grades 12-12.

Learning Disorder Diagnosis Test (LDES): (36), is used for diagnose learning disabilities and includes the scales of listening, thinking, speaking, reading, writing, spelling and calculating mathematics. In the present study, reading, spelling and math scales of this test were used. The test consists of 88 items that are responded by the child's parents (or a person familiar with the child's educational status and tasks) and is based on the Likert scale. The scoring is based on 0 to 3 as: 0 is inappropriate for age in terms of development, 1: rarely, 2: occasionally and 3: always or mostly, and then the rater interprets it. The internal consistency for each section is 0.41 and the reliability of the test is ranging from 0.60 to 0.70 (36). Content validity of the questionnaire was evaluated and verified by experts after the translation and translation approval by the language experts, and experts of clinical psychology. Cronbach's alpha test was used to evaluate the reliability of the questionnaire. The Cronbach's alpha coefficient for the total score was 0.832 and for the used components in the present study (math, reading and spelling) was 0.742, 0.689 and 0.811, respectively.

Statistical Analysis

Descriptive statistics methods including mean indices, standard deviation, etc. were used for data analysis; besides, inferential statistics was used to compare the mean scores of the dependent variables of the experimental group and the control group of the analysis test. Also, Multivariate covariance was used with SPSS 22 software.

Results

Based on findings, in the pre-test stage, the average scores of the sample in the experimental group and the control group was approximately close to each other. However, in the post-test and follow up stage of the subjects' scores in the experimental groups, significant changes have been made. The applied instrument was analyzed using multivariate analysis of covariance test. The findings show the difference between the two groups regarding the dependent variables totally is significant.

As shown in the Table 1, the P value in the post-test stage in the math disorder with a value, reading disorder factor, spelling disorder factor, and the total score of specific learning disorder with value ($P = 0.001$) is significant at the level of $\alpha = 0.05$. Therefore, it can be said that the effect of the combination of cognitive rehabilitation and neurofeedback on a specific learning disorder is significant.

Table 1. Summary of the multivariate analysis of covariance test results regarding comparison between the effectiveness of cognitive rehabilitation with neurofeedback for specific learning disabilities.

Variables	Pretest	Posttest	P value
Math disorder	3.17 ± 0.17	2.14 ± 0.53	0.002
Reading disorder	3.64 ± 0.07	2.66 ± 0.56	0.001
Spelling disorder	2.62 ± 0.40	3.82 ± 0.44	0.001
Specific learning disorder	74.00 ± 8.60	44.61 ± 8.89	0.0001
Total score	3.54 ± 0.34	3.28 ± 0.89	0.001

Data are shown as mean ± SD.

Discussion

Generally, the results of the present study showed that cognitive rehabilitation and neurofeedback are effective in increasing the quality of specific learning disabilities (math, reading and spelling) in primary

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school children in District 5 of Tehran province. There was no significant difference between the two groups in terms of affecting the quality of learning and reducing learning disabilities. However, the effect of cognitive rehabilitation based on the means is more than the effect of neurofeedback. The results of the present study are consistent with the results of Kesler et al. (37) with the aim of evaluating the efficacy of rehabilitation programs on memory and work attention, and improving academic and behavioral performance of 60 students aged 12 to 17. The results of the study show that the effectiveness of the rehabilitation program and treatment focuses on working memory and students' attention; besides, in neuroimaging studies performed by Cicerone et al. (38), he showed that working memory rehabilitation has a significant effect on neural activity in brain-related areas of the brain, and improves their functionality. It can be said that the results are consistent with the results of the present study.

There are some studies that evaluate the effects of CR on cognitive function, such as attention in individuals with learning disabilities. In a randomized controlled trial, Gary et al. (24) examined the effects of Computer –based working memory training (WMT) program on adolescents with LD / ADHD. They compared their attention to pre- and post-math training and computer-based working memory training. Finally, they showed that computer-based working memory training is more effective in improving attention than Motor Training (MT). Their findings compared to the previous studies, showed a smaller effect size for elimination errors, commission errors, and in particular, response time (24). Cognitive rehabilitation can have significant impact on academic performance either (21). For example, Kasper et al. (26) reported that there was improvement in SA in CR cases in Alzheimer's disease cases. Some other studies support these findings for other diseases such as CP (25) and MS (27), (28).

Cognitive rehabilitation is often part of a comprehensive multi-principal program, and if used correctly, is based on theoretical and strategic structures arising from neuroscience, neurophysiology, neurobiology, neuropsychology, neurolinguistic, language development, cognitive development, and cognitive neuroscience (38). On the other hand, increasing the importance of cognitive skills, the development of computer technologies, the prevalence of educational programs and their accuracy and also ease of use, has resulted into the design of various cognitive computer programs in various educational fields.

Conclusion

Both experimental groups (cognitive rehabilitation and neurofeedback) showed improved learning disabilities. The group that received cognitive feedback reported better results (36). This study showed that the effect of light reflection in children with specific learning disorder might be increased (37). Based on the results of the present study, and using additional therapy such as cognitive rehabilitation, the use of alternative and more complete therapies, the risks of drug therapy can be decreased (38). Some of the limitations of this study are that the intervention goals are complex on children with specific learning disorder, and getting to know what change is necessary for performance improvement is a big challenge. For example, although an intervention may improve one of the symptoms, achieving certain results might not be exact because of the instruments. Therefore, the method used in this study can be effective in only a few areas of attention and response movement. So, it would be appropriate to use other measuring instruments. Also, based on the research results and the effect of cognitive rehabilitation, and the combination of this program with Neurofeedback in treatment of math learning disorder, it is suggested

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that some issues on working memory and its importance in learning and memory enhancement ways be trained in at service courses of primary school teachers. Based on the findings of the present study, teachers and instructors of educational centers for students with math disorder can use memory rehabilitation in the educational programs of these centers and improve students' working memory and executive functions, and also enhance the mathematical performance of this group and avoid the academic failure of these students.

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