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Original research

Comparing the effectiveness of working memory training and cognitive rehabilitation on executive functions and selective attention of students with specific learning disabilities

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Abstract

Introduction: The prevalence of specific learning disorder and the challenges it poses for affected students, especially in areas such as executive functions and selective attention, doubles the need for research to improve these variables. The present study aims to compare the effectiveness of working memory training and cognitive rehabilitation on executive functions and selective attention of students with specific learning disorders.

Research Method: This study was applied in terms of purpose and quasi-experimental in terms of method, with a pretest-posttest design with a control and follow-up group. The statistical population consisted of all students with specific learning disorders in Ardabil during the second semester of 1402-1403. Using convenience sampling, 45 individuals referred to centers for special learning disabilities were selected and randomly assigned to two experimental groups (cognitive rehabilitation and working memory training) and a control group (15 individuals each). The instruments included the Behavioral Rating of Executive Functions (BRIEF) questionnaire and the D2 test. The data were analyzed using mixed analysis of variance in SPSS 26 software.

Findings: The results showed that working memory training and cognitive rehabilitation had a significant effect on increasing students' executive functions and selective attention. This effect was 0.37 for executive functions, 0.22 for behavior regulation, and 0.23 for metacognition, and 0.26, 0.23, and 0.22 for selective attention, concentration efficiency, omission error, and commission error, respectively. Also, the effectiveness of these interventions was stable in post-test and follow-up, and cognitive rehabilitation was more effective than working memory training.

Conclusion: Working memory training and cognitive rehabilitation were effective on executive functions and selective attention of students with specific learning disorders, and there was a difference between the effectiveness of the two treatments, such that cognitive rehabilitation was more effective than working memory training.

Keywords: cognitive rehabilitation, executive functions, Selective attention, specific learning disorder, students, working memory training

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Introduction:

According to DSM-5, the diagnosis of a learning disorder depends on the presence of problems in learning reading, writing, arithmetic, and mathematics that are observed during one official academic year. The prevalence of this disorder has been estimated to be between 10 and 15% among primary school-aged children (1). In Iran, the study by Piroozi et al. (2) also showed that the highest and lowest prevalence rates of learning disorders were related to mathematical disorder (9.83%) and reading disorder (4.48%), both among girls. Reading, writing, and mathematics disorders were respectively reported with prevalence rates of 6.28%, 5.26%, and 8.73%, with the overall prevalence of these disorders estimated at about 6.75%. Researchers believe that deficiencies in executive functions are among the factors that play a role in the emergence of learning disorders (3). Executive functions include a wide range of processes involved in goal-directed behavior, including inhibitory control, mental flexibility, planning, and some of the brain's fundamental processes (4). From a neuropsychological perspective, executive functions are often used as diagnostic tools, and many studies show that impairments in executive functions are related to damage to the prefrontal cortex and encompass cognitive processes, behavioral self-regulation, and are responsible for the development of cognitive, social, and educational abilities (5). These cognitive abilities include maintaining information in working memory, response inhibition, sustained attention, and goal pursuit (6). Therefore, studies have emphasized that training and developing executive functions play a key role in enhancing the social, academic, and learning capabilities of this group of students (7).

Since attention plays a vital role in the learning process, it is expected that the student pays attention to the task before learning. The ability to maintain long-term attention to a task is essential for students to access necessary information and complete academic activities (8). Accordingly, it is believed that other variables associated with executive functions, such as selective attention, are also of interest in students with specific learning disorders. Studies have indicated the role of these constructs in specific learning disorder (9; 10). In fact, attention refers to the ability to regulate goals, adhere to plans, and pursue them in the presence of distractions (11). Selective attention refers to the ability to avoid interference from irrelevant information and focus on goal-related information (12).

It is considered noteworthy to implement educational interventions that can influence the improvement of these variables in such children. In this regard, one of the interventions based on cognitive functions is cognitive rehabilitation (13). Cognitive rehabilitation is a complex set of methods designed to enhance perception, understanding, attention, learning, recall, and problem-solving in individuals with impairments in these areas (14). There is considerable evidence supporting the use of cognitive rehabilitation in improving executive functions (15). Furthermore, the study by Akbarifard et al. (16) indicated the effectiveness of cognitive rehabilitation on attention levels in children with specific learning disorders.

On the other hand, many studies have shown that children with learning disorders have lower working memory capacity and ability compared to typical students, and experience more difficulties in processing and storing information simultaneously (17). Therefore, enhancing functions related to memory—especially working memory—in students with specific learning disorders has been considered one of the strategies for improving their cognitive performance (18), since working memory skills and reinforcement can independently predict success in reading and math performance (19). In fact, training based on active memory includes a set of complex cognitive skills, namely inhibition, active memory, and attentional control, which are involved in cognitive-emotional and behavioral regulation and planning (20; 21).

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Research has yielded promising results regarding working memory training and its effects on learning. For example, the results of studies by Bizwazou et al. (22), Marian et al. (23), and Gathercole et al. (24) indicated the effect of active memory training on improving executive functions and attentional shifting in students with specific learning disorders. After the training, a significant improvement was observed in these variables. Moreover, Kakojouybari et al. (25) found that working memory training was effective on attentional functions in students with dyslexia.

In general, given the aforementioned theoretical and research foundations and the prevalence of specific learning disorders and their associated problems, especially regarding executive and attentional deficits, conducting a study to improve these variables in the target group is of great importance. In addition, considering the research gap and the need to understand the impact of psychological treatments such as those examined in this study, the present research was conducted to answer this fundamental question: Is there a difference between the effectiveness of working memory training and cognitive rehabilitation on executive functions and selective attention in students with specific learning disorders?

Research Method:

This research is applied in nature and was conducted using a quasi-experimental design with a pre-test, post-test, control group, and follow-up. The statistical population included all students with specific learning disorders in Ardabil during the second semester of the 1403–1402 academic year. Forty-five children with specific learning disorders who had been referred to public and private learning disability treatment centers in Ardabil were selected as the sample using the convenience sampling method. To improve diagnostic accuracy, the Colorado Learning Disability Questionnaire was used to identify students with high scores who met the inclusion criteria. These participants were then randomly assigned to two experimental groups (15 participants each) and one control group (15 participants).

Inclusion criteria included completing a parental consent form, being enrolled in grades 4, 5, or 6, obtaining a high score on the learning disability questionnaire, and having no other psychological disorders. Exclusion criteria included lack of willingness to participate, being absent from two consecutive intervention sessions, and incomplete or invalid questionnaires.

The instruments included the Behavior Rating Inventory of Executive Function (BRIEF) and the D2 Attention Test. Data were analyzed using mixed ANOVA in SPSS-26.

The intervention method used in this study was working memory training and cognitive rehabilitation based on Dan's (2008) educational program, as adapted by Abedi (33). The training consisted of 12 sessions over 6 weeks, each lasting 60 minutes.

Cognitive rehabilitation was conducted in 21 one-hour group sessions based on the hierarchical model of Solberg and Matter (30), delivered intensively three times a week (to standardize pre-test and post-test timing and control confounding variables). This package has been used in several studies on children (31; 32). After an orientation session, rules were explained, relationships were established, the schedule and goals of the sessions were shared with participants, and the sessions were held as follows:

Findings:

Demographic data indicated that the total sample consisted of 45 students with specific learning disorders, including 23 boys (51.11%) and 22 girls (48.89%). The most frequent age group was 12 years (26.67%). Eleven students (24.24%) were 9 years old, 11 were 10 years old, and 11 were 11 years old. The mean age of the sample was 10.45 years with a standard deviation of 2.33.

Regarding grade levels, 15 students (33.33%) were in grade four, 15 (33.33%) in grade five, and 15 (33.33%) in grade six. The type of learning disorder revealed that 11 students (24.24%) had reading disorders, 11 (24.24%) had writing disorders, 12 (26.67%) had math disorders, and 11 (24.24%) had mixed disorders.

Descriptive statistics for the dependent variables (executive functions, selective attention) across the three research groups (working memory, cognitive rehabilitation, control) and three testing phases (pre-test, post-test, follow-up) are provided.

Given that the calculated F-value for executive functions (5.312) was smaller than the critical F-value at $p < 0.05$ with degrees of freedom 2.15 and 3.45 (3.20), the effectiveness of the intervention is confirmed with 95% confidence. It can be said that the intervention led to increased and improved executive function components. The mean scores for executive functions (behavioral regulation and metacognitive skills) in the pre-test, post-test, and follow-up phases were significant in both experimental groups, but not in the control group. Between-group comparisons showed that the differences in executive function scores between experimental and control groups were significant. Thus, the use of working memory training and cognitive rehabilitation led to improvement in executive functions in students with specific learning disorders. The effect size (eta squared) was 0.37, 0.22, and 0.23 for executive functions, behavioral regulation, and metacognition, respectively.

Additionally, findings showed that the calculated F-value for selective attention (6.91) was also smaller than the critical F-value at $p < 0.05$ with degrees of freedom 2.28 and 48.96 (3.20), confirming the effectiveness of the intervention. Based on the data, working memory training and cognitive rehabilitation improved selective attention and its components (concentration efficiency, omission error, commission error) in students with specific learning disorders. The effect sizes were 0.26, 0.23, 0.23, and 0.22, respectively.

Discussion and Conclusions:

The results indicated that working memory training and cognitive rehabilitation had significant effects on the executive functions of students with specific learning disorders. A difference was observed between the effectiveness of the two interventions on executive functions and their subcomponents—behavioral regulation and metacognition. Cognitive rehabilitation was more effective than working memory training in improving these functions. Moreover, the effects remained stable during the post-test and follow-up stages.

It can be inferred that cognitive rehabilitation, which involves repetition and effort to regulate personal performance, can gradually create structural and functional changes in neurons involved in executive functions through experience-dependent plasticity and guided or spontaneous improvements (the principle of neuroplasticity). These effects are due to the cognitive rehabilitation exercises' ability to adjust task difficulty from simple to complex, based on individual differences, and continuously challenge executive functions, thus engaging related brain areas in purposeful activity. This type of rehabilitation can repair impaired functions through practice and repetition. It activates executive functioning in the prefrontal cortex and

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strengthens working memory, cognitive flexibility, response inhibition, and processing—areas of core cognitive weakness in students with learning disorders.

Furthermore, the findings confirmed that both interventions had significant effects on selective attention (concentration efficiency, omission error, commission error), and working memory training was more effective than cognitive rehabilitation in improving selective attention and its components. The effectiveness of both interventions on selective attention remained stable during post-test and follow-up.

The current study had limitations, including its quasi-experimental nature, being limited to Ardabil city, not addressing behavioral-emotional problems, use of convenience sampling, reliance on self-report tools and questionnaires, and restriction to students in grades four to six. Therefore, it is recommended that the Ministry of Education include both cognitive rehabilitation and working memory training in teachers' in-service training programs so that teachers become familiar with these methods and can use them in classrooms and LD centers. Future research is recommended to use random sampling methods and include structured clinical interviews and behavioral observations along with questionnaires for more generalizable and valid results.

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