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The effectiveness of movement-based cognitive rehabilitation on self-regulation and self-control of students with learning disabilities

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Abstract:
This study aims to determine the effectiveness of movement-based cognitive rehabilitation in enhancing self-regulation and self-control in students with learning disabilities. The research design is a semi-experimental consisting of two groups: an experimental group and a control group, with pre-test and post-test stages. The statistical population comprises 8 to 10-year-old children with learning disabilities . A sample of 30 children, aged 8-10 years, was selected. The participants were paired based on age, social class, intelligence quotient (IQ), and level of previous education. They were then randomly assigned to either the experimental group (15 individuals) or the control group (15 individuals). The independent variable, movement-based cognitive rehabilitation training, was implemented on the experimental group. The ASEBA behavioral problems questionnaire and Tangney's self-control questionnaire were employed in the present study. The effectiveness of the treatment was examined using multiple regression analysis, while the status of variables was determined using one-sample t-test. Furthermore, independent samples t-test was employed to compare the variables between the two groups. The results of the statistical analyses indicate that movement-based cognitive rehabilitation significantly improves self-regulation in children with learning disabilities. However, it did not show a significant effect on self-control.

Keywords: Learning disabilities, movement-based cognitive rehabilitation, self-regulation, self-control.

Introduction

Learning disabilities have received significant attention and research from medical professionals, psychologists, and education specialists for over a century. Traditionally, the focus of study has centered around challenges related to reading, writing, math, spelling, comprehension, and speech disorders. In the mid-1970s, the field expanded to include a distinct category known as nonverbal learning disabilities.

Nonverbal learning disabilities are a specific type of neurocognitive disorder characterized by a unique combination of strengths and weaknesses in children's psychological traits. These difficulties can significantly impact social competence, academic performance, comprehension of instructions, reasoning abilities, visual-spatial perception, and motor coordination (Darvishi, 2019).

Learning disabilities encompass a range of cognitive impairments wherein students face challenges in one or more cognitive domains, such as speech perception, writing, listening, reading, or mathematics (Dehghani & Azizian Kohan, 2020). Children with learning disabilities may encounter significant difficulties that extend to behavioral issues (Karabel et al., 2018). Some researchers consider that behavioral problems are a direct consequence of learning disabilities, constituting the primary aspect affecting these children. However, it is also possible that disability represents a failure that impacts their emotional status, potentially leading to aggression (Shahedi, 2020).

Behavioral problems are pervasive issues during childhood and adolescence, with approximately 21% of children experiencing them at least once until adolescence. These 2 problems can have both short-term and

long-term effects on individuals and their surroundings, imposing significant economic, social, and personal costs on both individuals and society. Unfortunately, a considerable percentage of these problems persist without adequate intervention and extend into adolescence and adulthood. The continuation and escalation of such issues can result in expulsion from the education system, substance abuse disorders, occupational difficulties and unemployment, medically unexplained chronic illnesses, domestic violence, and even suicide (Nataghian, 2020).

A crucial aspect of psychological development in childhood is self-regulation, which entails the ability to control and manage behavior (Winsler, Diaz & Chapi, 1999; Calkins & Dedmon, 2000; Alarcon-Ropero, Medina & Grisales, 2014). Meeting children's needs for behavioral organization and social interaction is vital, and it should occur voluntarily and spontaneously while adhering to social norms, without excessive reliance on adults. Therefore, in early childhood, the primary goal is to foster self-regulation, establish rules, and genuinely "become social" (Dee & Smith, 2013; Amrayi, Amirsoleymani & Ajalloueyan, 2017). Considering these factors, it can be affirmed that children in the preschool age range (3-6 years old) can develop emotional and physiological self-regulation abilities (Collins & Dedmon, 2000).

Self-control encompasses the ability to align thoughts, emotions, and actions with long-term valuable goals, even in the face of more tempting short-term options. In other words, self-control significantly influences everyday behaviors and provides clear insights into one's personal tendencies. Individuals with strong self-control exhibit stronger adaptive behaviors and fewer maladaptive behaviors, displaying notable resistance against temptations (De Ridder, Kroese & Giaubart, 2018).

Weak self-control stands out as a key predictor of deviant behaviors. Moreover, research findings indicate a negative correlation between mental problems and self-control, implying that individuals with mental difficulties often struggle with self-control. Consequently, those with limited impulse control encounter greater challenges (McDermott et al., 2019). Numerous research studies demonstrate that cognitive rehabilitation contributes to enhanced self-control/inhibition and intrinsic motivation (Faraji et al., 2020).

Cognitive rehabilitation serves as a recovery process with diverse applications for individuals with cognitive disorders. It encompasses two primary approaches: the compensatory or adaptive approach and the cognitive therapy approach. The compensatory approach aims to overcome individual limitations by modifying the environment, habits, task execution methods, and implementing executive strategies. Cognitive rehabilitation, on the other hand, seeks to restore lost cognitive capacities through targeted interventions and exercises, with the ultimate goal of enhancing an individual's performance in various activities (Davari et al., 2020).

Drawing from the mentioned information and taking into account the extensive body of cognitive and psychiatric research, which has investigated the efficacy of diverse treatments in alleviating symptoms of learning disorders, the key objective is to identify suitable therapeutic approaches for individuals with learning disabilities. This identification will aid therapists, parents, and researchers in effectively applying these approaches during treatment to achieve optimal outcomes. One particular form of treatment, cognitive-movement-based therapy, holds significant promise, and we aim to explore its effectiveness in this study. 3 Given the lack of existing research on cognitive rehabilitation treatment that focuses on self-regulation and self-control in children with learning disabilities, the primary objective of this study is to determine the effectiveness of cognitive rehabilitation therapy based on self-regulation and self-control for this population.

Research Hypotheses

Based on the aforementioned research findings, it has been consistently demonstrated that cognitive-movement-based rehabilitation therapy has a positive impact on self-regulation and subsequently improves self-control, as indicated in numerous studies. Furthermore, previous sections of this study have provided evidence supporting the effectiveness of cognitive rehabilitation therapy centered around self-regulation and self-control for children with learning disabilities. However, none of the previous studies have concurrently examined the efficacy of this therapy in relation to these specific variables. Therefore, our research aims to address this gap. Consequently, the research hypotheses and questions will encompass the following aspects:
Cognitive rehabilitation therapy based on movement is effective for children with learning disabilities.
Cognitive rehabilitation therapy based on self-control is effective for children with learning disabilities.
Cognitive rehabilitation therapy based on self-regulation is effective for children with learning disabilities.

Methodology

This study aims to investigate the effectiveness of cognitive rehabilitation therapy based on movement in addressing behavioral and self-control issues among children with learning disabilities in Ardabil city. The research design employed is a semi-experimental study with two groups (experimental and control) and includes pre-test and post-test phases. The target population for this study consists of all 8-10-year-old children with learning disabilities in Ardabil city. A sample of 30 children within the age range of 8-10 years, who have learning disabilities, was selected from Ardabil city. These participants were paired based on age, social class, intelligence quotient (IQ), and prior educational attainment, and then randomly assigned to two groups: an experimental group and a control group, each comprising 15 individuals. Following the selection of the experimental group, the independent variable, which involves the implementation of a cognitive-movement-based rehabilitative training program, was administered to this group.

For this study, two questionnaires were employed: The Achenbach System of Empirically Based Assessment (ASEBA) questionnaire for assessing behavioral problems and Tangney's Self-Control Scale (2004) questionnaire for measuring self-control abilities.

Tangney's Self-Control Questionnaire (2004)
Developed by Tangney and colleagues in 2004, this questionnaire comprises two subscales: 1) Preventive or inhibitory self-control, and 2) Initial self-control. Its purpose is to gauge individuals' level of self-control. The Tangney Self-Control Questionnaire (2004) has both a short form with 13 questions and a long form with 36 questions, the long form was employed in this study. Participants provide responses using a five-point Likert scale (ranging from 1, 4 "does not apply to me at all," to 5, "always applies to me"). Tangney and colleagues conducted research on the relationship and impact of high self-control on interpersonal success and reported the psychometric properties of this questionnaire. They found high internal consistency and reliability estimates for the test. Specifically, in their sample, Cronbach's alpha for the long-form self-control scale with 36 items was calculated as .89. The test-retest reliability for the 36-item form was found to be .89, while for the 13-item form, it was found to be .87 using the split-half method (Tangney et al., 2004). Additionally, in Mosavimoghaddam et al.'s study (2017), the obtained Cronbach's alpha was also .89, suggesting satisfactory validity for the questionnaire in our intended context.

Self-Regulation Questionnaire by Bouffard et al. (1995)
The questionnaire developed by Bouffard et al. (1995) consists of 14 items and serves as a tool for assessing self-regulation based on Bandura's social cognitive theory. The questions are presented on a Likert scale and measure two factors: cognitive and metacognitive strategies (adapted from Khodadadyour, 2001). The questionnaire comprises two cognitive dimensions (questions 3, 5, 8, 9, 10, 12, 13) and non-cognitive dimensions (1, 2, 4, 6, 7, 11, 14). The score for each dimension is obtained by summing the scores of the corresponding items. The Likert-type scale for scoring ranges from completely agree (score 5) to completely disagree (score 1), with questions 5, 13, and 14 being reverse scored. Khodadadyour (2001) conducted a study on the validity and reliability of this tool. The questionnaire demonstrated satisfactory structural validity through correlation coefficients and factor analysis, and the internal consistency was assessed using Cronbach's alpha coefficient, yielding a value of 0.80. Consequently, it can be concluded that this questionnaire possesses the capability to predict individuals' actual scores.

Cognitive-Movement Rehabilitation Program
The study employed a 10-session cognitive-movement rehabilitation program, with the therapeutic steps outlined in Table 1. Cognitive-movement rehabilitation is a non-pharmacological and psychological therapy program aimed at improving motor skills and enhancing cognitive functions in individuals. In this study, the program was implemented with a focus on two main objectives: conducting motor and cognitive exercises over the course of 10 sessions, each lasting 60 minutes for the participants in the experimental group. The details of the cognitive-movement rehabilitation program are provided in the table below.

Table 1. ***Cognitive-Movement Rehabilitation Program***

Session	Cognitive Objectives	Motor Objectives
1	Improving attention: Games focused on enhancing age-appropriate attention, such as letter-based games, improving attention to specific stimuli (e.g., thread, bead, puzzle pieces)	Balance maintenance, finger Skills (dexterity)
2	Improving working memory: Exercises targeting cognitive and academic memory improvement, improving	Finger skills, coordination of feet and fingers, balance maintenance,

	attention to specific relational stimuli, and memorizing and repeating appropriate communicative phrases	eye-foot coordination, attention enhancement, eye-hand coordination
3	Problem-solving skills: Performing academic problem-solving exercises, solving interpersonal problem-solving exercises	Balance maintenance, eye-foot coordination, coordination of lower limbs and trunk, attention enhancement, two-handed coordination, response speed, eye-hand and foot coordination, upper limb agility
4	Improving problem-solving skills:	Two-handed balance coordination, finger skills, response speed, eye-hand coordination, two-handed coordination
5	Improving cognitive and metacognitive strategies: Performing mindfulness exercises related to academic and interpersonal matters.	Balance, coordination of large muscle activities, agility, coordination of upper limbs
6	Improving cognitive and metacognitive strategies: Performing mindfulness exercises related to academic and interpersonal matters.	Agility, coordination of eye, hand, and upper limbs, finger skills
7	Improving cognitive and metacognitive strategies: Performing mindfulness exercises related to academic and interpersonal matters.	Finger skills, coordination of hand and eye, response speed, balance, coordination of lower limbs
8	Improving prediction and behavioral exercises in social skills.	Creating stories and arranging images, pantomime with stickers, fire-fighting game teaching essential numbers
9	Summarizing cognitive skills to the child and performing more exercises in this area (academic and interpersonal).	Balance, coordination of upper and lower limbs, agility and quickness
10	Performing post-tests with parents and informing them about the child's acquired skills.	Performing post-tests, session with parents, and informing them about the child's acquired skills.

Data analysis in this study involved both descriptive and inferential methods. Descriptive statistical methods, such as calculating measures like mean and standard deviation, were employed to summarize and describe the data. To examine the effectiveness of the treatment, multiple regression analysis was run. The status of variables was determined using one-sample t-tests. Furthermore, independent samples t-tests were employed to compare the status of variables between two independent groups.

Findings

Descriptive statistics regarding the pre/post-test self-regulation and self-control of the participants in the experimental and control groups is presented in Table 2. As shown in Table 2, the mean score of correct responses in the control group remained relatively stable in the 6 post-test and follow-up assessments compared to the pre-test. However, in the experimental group, there was a noticeable increase in the mean score of correct responses. Additionally, the mean response time exhibited a decreasing trend in the experimental group, while remaining relatively constant in the control group. These observed differences prompted the need for a statistical analysis to determine their significance. Therefore, a repeated measures mixed-design analysis of variance was conducted to assess the statistical significance of these differences.

To ensure the reliability of the results obtained from the repeated measures mixed-design analysis of variance, Mauchly's test of sphericity was initially conducted. The chi-square statistic for this test yielded a significant result ($p = 0.016$) with 2 degrees of freedom, suggesting a violation of the assumption of sphericity. Given the specific characteristics of the current study, such as small group sizes, an epsilon correction using Huynh-Feldt Epsilon was applied. This correction helps address the violation of sphericity. The results of the within-subjects effects test are presented in Table 3.

Table 2 . ***Descriptive Statistics of the Experimental and Control Groups in Pre/Post-Tests for Self-Regulation and Self-Control***

Variable	Group	Assessment	Maximum	Minimum	Mean	Standard Error	Standard Deviation
Self-Regulation	Experimental	pre- test	6	25	17/84	1/84	6/63
		post-test	11	27	22/61	1/19	4/29
	Control	pre- test	3	26	19/46	2/09	7/54
		post-test	2	26	19	2/33	8/39
Self-Control	Experimental	pre- test	102	411	187/92	24/01	86/58
		post-test	85	336	160/77	19/99	72/08
	Control	pre- test	86	235	152/84	12/34	44/50
		post-test	79	267	140/46	14/61	52/71

Table 3. ***Within-Subjects Effects Test***

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F	Significance	Statistical Power
Self-Regulation	89/95	2	44/97		0/006	0/19
Self-Regulation*	115/18	2	57/59		0/002	0/23
Error	384/20	40	8/00	-	-	-

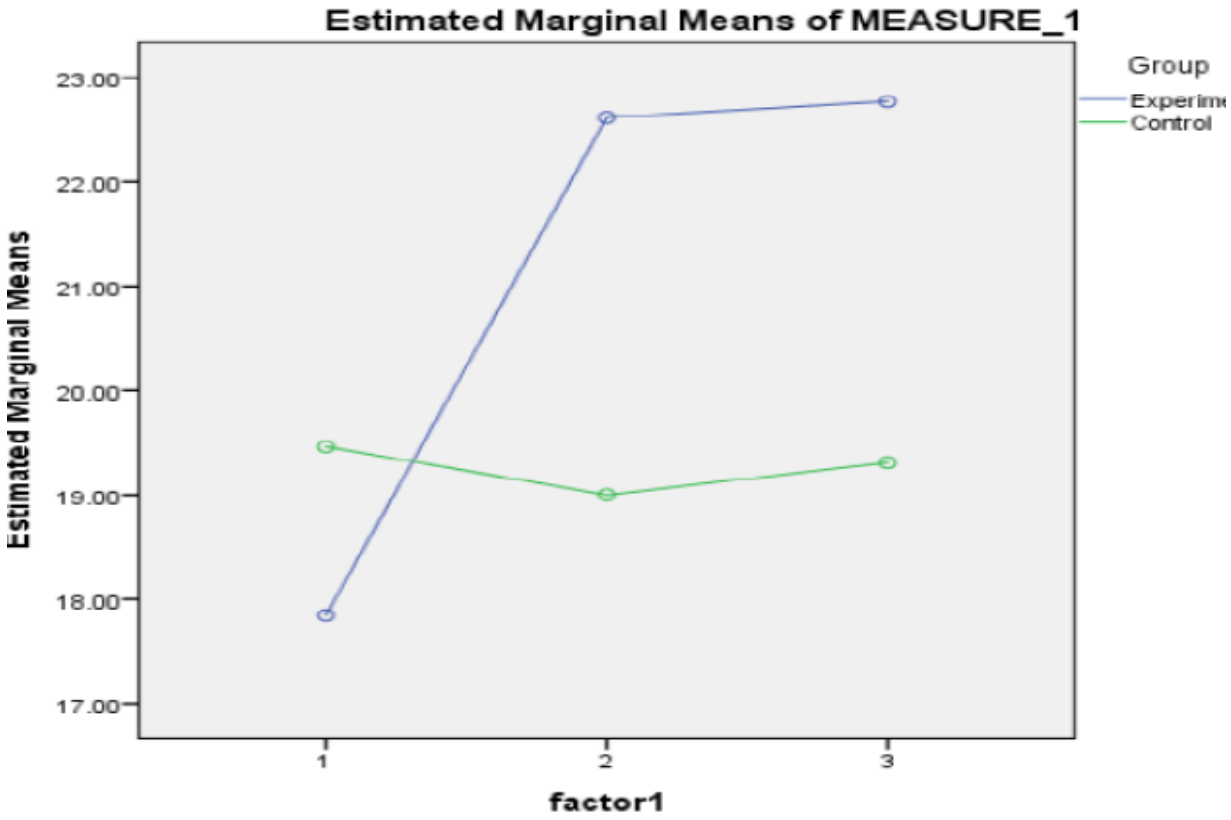

Figure 1. ***Interaction Difference Plot of Two Groups in Pre-test and Post-test Stages***

Table 4. ***Within-Subjects Effects Test***

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F	Significance	Statistical Power
Self-Regulation	27496/72	2	13748/36	10/93	0/0001	0/31
Self-	1503/18	2	751/59	0/60	0/55	0/02

Regulation*						
Error	60384/77	48	1258/02	-	-	-

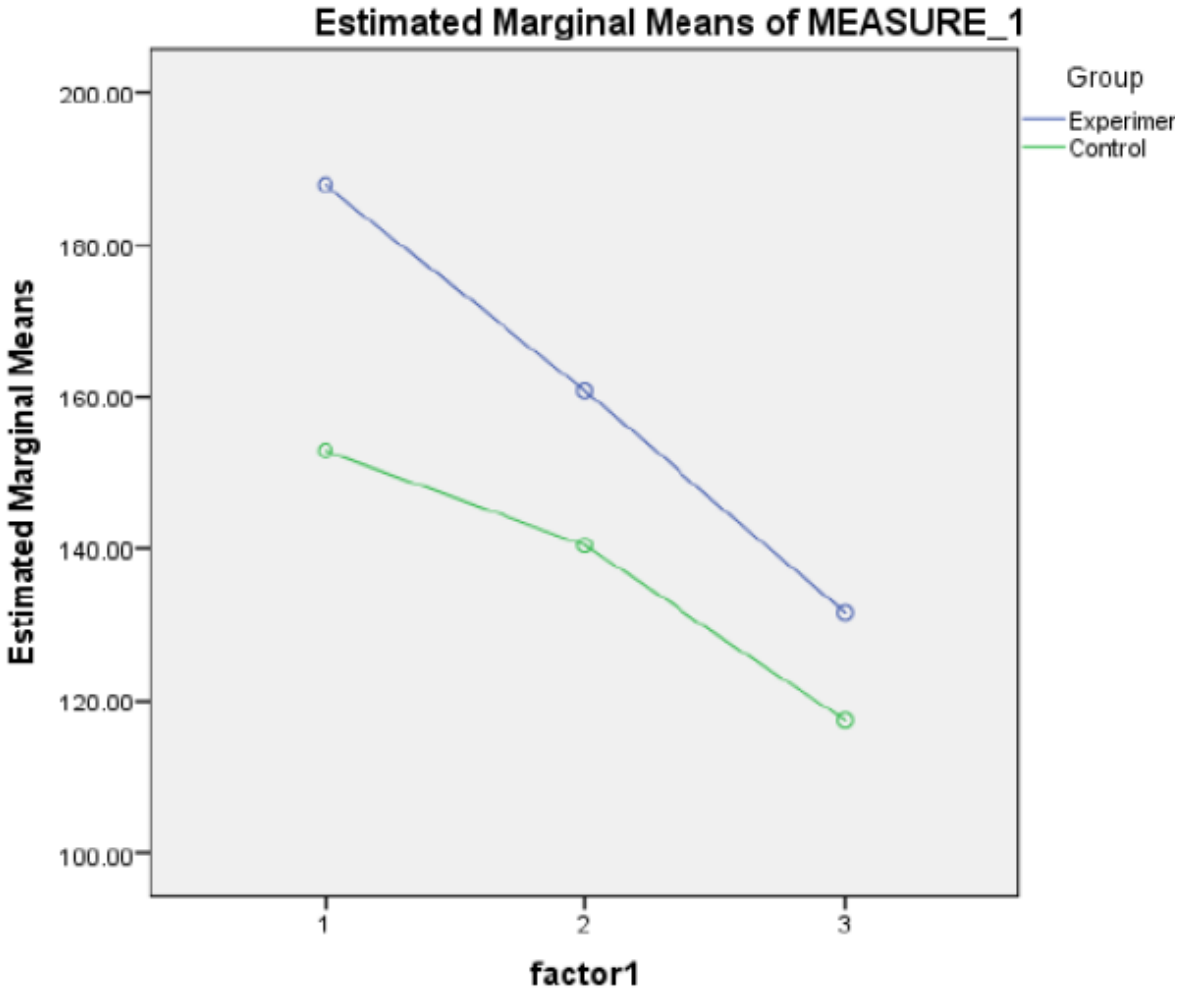

Figure 2 . ***Interactions Difference Graph of Two Groups in Pretest and Posttest Stages***

In Figure 2, the interaction difference plot between the two groups during the pretest and posttest phases of self-regulation is depicted. Mauchly's test of sphericity for this plot yielded a chi-square statistic of 53.1 with 2 degrees of freedom, which was not significant ($p = 0.46$). Thus, the assumption of sphericity is not violated. The results of the within-subjects effects test can be found in Table 3.

The results of the test indicate a significant difference between the two conditions in self-regulation. A pairwise comparison revealed that the difference between Level 1 and Level 2 (pretest and posttest) is statistically significant, with an F-value of 7.10 and a p-value of 0.01. Furthermore, the interactive differences between the two groups at Level 1 and Level 2 (pretest and posttest) are also significant, with an F-value of 47.10 and a p-value of 0.007. Figure 1 illustrates the interaction differences between the two groups, demonstrating a consistent trend in the control group and an increasing trend in the experimental group.

Self-Regulation

Regarding self-regulation, the Kruskal-Wallis test yielded a non-significant result, with a test statistic value for Chi-square of 1.53 at 2 degrees of freedom ($p = 0.46$). Therefore, the hypothesis regarding self-regulation is valid. The results of the within-subjects effects test can be found in Table 3.

The results of the test indicated a significant difference in self-regulation between the two conditions. A comparison of the paired stages using paired t-tests suggested that the difference 9 between Level 1 and Level 2 (pretest and posttest) is statistically significant, with an f-value of 10.7 and a p-value of 0.01. Additionally, the

interactive differences between the two groups at Levels 1 and 2 (pretest and posttest) are also significant, with an f-value of 10.47 and a p-value of 0.007. Figure 1 illustrates the interaction differences between the two groups, showing a consistent trend in the control group and an ascending trend in the experimental group.

Self-Control

Regarding self-control, the examination of Mauchly's test assumption revealed that the chi-square statistic for this test was found to be 83.7 with 2 degrees of freedom, which was not statistically significant ($p = 0.06$). Therefore, the assumption is met. The results of the within-subjects effects test can be found in Table 4.

The results of this test did not show any significant differences among the three conditions in the self-control variable. Further analysis through pairwise comparisons indicated that the difference between the two groups at both the pretest and posttest levels was not statistically significant, as evidenced by an F-value of 2.63 and a p-value of 0.118. Additionally, the interactive differences between the two groups at these levels were also found to be non-significant, with an F-value of 0.37 and a p-value of 0.55. Figure 2 demonstrates that the interaction differences between the two groups at the pretest and posttest levels in terms of the self-control variable are not statistically significant.

Discussion and Conclusion

The purpose of this study was to assess the effectiveness of movement-based cognitive rehabilitation in enhancing self-regulation and self-control among students with learning disabilities. The findings of our research indicate that the cognitive rehabilitation program centered around movement successfully improved self-regulation in students with learning disabilities. However, there was no significant improvement observed in self-control as a result of the intervention. This aligns with previous studies conducted by Faraji et al. (2019) and Makado and Gabriel (2018), which similarly found no significant effects of movement-based cognitive rehabilitation on motor control and cognitive-emotional regulation.

In order to explain this finding from the study, it is essential to consider the cognitive demands associated with emotional activities and motor exercises. According to a study conducted by Tomporowski and McCullick in 2009 (as cited in Dehghani & Azizian, 2020), it was observed that the use of appropriate strategies and adaptability to changes is a fundamental cognitive requirement in motor-mental activities. These strategies and adaptability align with the cognitive demands associated with executive functions, as described by Banich in 2009 (as cited in Dorooshi et al., 2020). Engaging in cognitive and motor tasks activates a neurotrophic factor derived from the brain. This activation leads to structural and chemical changes in the individuals' nervous system, including the formation of synapses and an increase in nerve cells, as indicated by Churchill in 2000 (as cited in Shahidi, 2022).

Research has also investigated the sustainability of the effects observed in cognitive and motor tasks. Notably, studies by Ziersch and Jensen (2015) and Verret et al. (2013) have provided evidence supporting the enduring efficacy of cognitive rehabilitation interventions incorporating movement in enhancing executive functions and information processing. The effectiveness of the cognitive rehabilitation approach based on movement can be explained by the activation of underlying brain structures, such as the prefrontal cortex (Castellanos et al., 102002), the cerebellum (Dorsten et al., 2004), and the limbic cortex (Sowell et al., 2003), leading to the growth of these structures and consequently improving performance and increasing the level of emotional-cognitive activities through inhibitory control, working memory, and attention (Dorsten et al., 2003; Valera, Faraone, Biederman, Poldrack, & Seidman, 2006; Sonuga-Barke et al., 2013).

This study reveals a significant and positive relationship between essential bioenergetic pathways, motor control, and cognitive regulation. This finding is in line with the results of previous studies conducted by Vafamand et al. (2012) and Bakro et al. (2010), both of which independently concluded that combining a variety of cognitive tasks with moderate-intensity physical activities enhances cognitive performance across different age groups.

Another relevant investigation conducted by Mehdiyeh Shahdi (1401) focused on the effectiveness of movement-based cognitive rehabilitation in improving behavioral problems and self-control in children with learning disabilities. The study concluded that combining cognitive tasks with physical exercises had a significant impact on these variables. This intervention proved particularly effective due to the involvement of the prefrontal cortex in improving behavioral problems and the stimulation of neuronal production through physical activities. Consequently, the combination of cognitive training and physical activities led to

improvements in behavioral problems and more effective self-control in individuals. Notably, this research also highlighted enhanced self-regulation and self-control in children with learning disabilities as a result of the cognitive training and physical activity combination.

To provide a more comprehensive explanation of this finding, it is important to highlight the principles of cognitive rehabilitation, which include comprehensive training, exercises, and feedback. By adhering to these principles, sustainable improvements in cognitive and emotional functioning can be achieved. Furthermore, it should be noted that these improvements have the potential to extend beyond cognitive domains to other functions and abilities of the nervous system (Klingberg, 2010).

In order to further enhance the understanding of self-regulation and self-control, future research should consider employing additional assessment methods, including physiological measures. This would provide a more comprehensive perspective on the effects of movement-based cognitive rehabilitation on these variables. Additionally, comparing the efficacy of movement-based cognitive rehabilitation with other therapeutic programs in improving self-regulation and self-control among children with learning disabilities is recommended. Such comparisons would contribute to a more comprehensive understanding of the relative benefits of different interventions.

Overall, the present study highlights the effectiveness of movement-based cognitive rehabilitation in improving self-regulation and self-control in children with learning disabilities. These positive effects can be attributed to the establishment of structural and physiological adaptations in the cognitive domain, particularly in the prefrontal cortex of the nervous system, as well as enhanced energy metabolism to support physical activities, leading to increased neurogenesis.

It is important to acknowledge the limitations of this study, as with any research endeavor. One limitation to consider is the small sample size, which may have been challenging to obtain due to the specific characteristics of the target population. Additionally, the study focused on 11 students aged 8 to 10, and caution should be exercised when generalizing the results to older students. Future research could address these limitations by expanding the sample size and including participants from a wider age range to provide more robust and generalizable findings.

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