Comparing the Effectiveness of a Physical–Motor Literacy Promotion Program and Computer-Based Cognitive Rehabilitation on Selective Attention in Children with Learning Disabilities

Somayeh Abedi[1*], Akbar Atadokht[2], Sajjad Basharpour[3], Mohammad Narimani[4]

1. Ph.D. Candidate, Department of Psychology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran.
2. Professor of Psychology, Department of Psychology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran.
3. Professor of Psychology, Department of Psychology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran.
4. Professor of Psychology, Department of Psychology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran.

Abstract

Introduction and Objective: Learning disabilities are often associated with difficulties in information processing, concentration, and attentional control, which can adversely affect children's academic performance and daily life. The present study aimed to compare the effectiveness of a physical–motor literacy enhancement program and computer-based cognitive rehabilitation on selective attention in children with learning disabilities.

Method: This experimental study employed a pretest–posttest design with a control group. The statistical population consisted of boys and girls aged 7–15 years with learning disabilities in Shahroud during the academic year 2022–2023. From among children attending a therapeutic clinic, 45 participants were selected through convenience sampling and randomly assigned to three groups: physical–motor literacy enhancement program, computer-based cognitive rehabilitation, and control (15 children per group). The instruments included a researcher-developed physical–motor literacy enhancement program, Captain's Log cognitive rehabilitation software (2018), the Stroop Test software (developed by Sina Psychological Equipment Center), and the Marathon pedometer. Data were analyzed using analysis of covariance (ANCOVA) and Bonferroni post hoc tests.

Results: The results revealed no significant difference between the effectiveness of the physical–motor literacy enhancement intervention and the computer-based cognitive rehabilitation program in improving attention scores. These results indicate that the physical–motor literacy enhancement program, by providing an integrated understanding of human nature, was able to fill the gap of previous motor-based programs and demonstrated comparable therapeutic effectiveness to computer-based cognitive rehabilitation.

Conclusion: Both the physical–motor literacy enhancement program and computer-based cognitive rehabilitation can be beneficial in improving attention in children with learning disabilities. However, limitations such as the absence of follow-up on treatment persistence and the influence of moderating variables (e.g., weight, age, gender) highlight the need to address these constraints in future research.

Keywords: Physical–Motor Literacy Enhancement Program; Computer-Based Cognitive Rehabilitation; Selective Attention; Learning Disabilities

***Corresponding author:** Somayeh Abedi
Address: Department of Psychology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran
Tell: 09125730249
Email: s.abedi@uma.ac.ir

Introduction

Learning disability is a common developmental disorder in childhood (Chiarenza, 2021). It is identified in approximately 5% of school-aged children, while some researchers argue that the actual prevalence may reach 15–20% (Setiawati et al., 2023). In Iran, the overall prevalence is estimated at 6.75% (Siavoshifar et al., 2020). In this condition, one or more fundamental psychological processes, such as understanding or using language, are impaired, leading to difficulties in listening, thinking, speaking, reading, writing, spelling, or performing mathematical calculations (Filippello et al., 2020). Such impairments can affect learning ability, academic achievement, and socio-emotional development. Poor academic performance, low self-esteem, emotional disturbances, social dysfunctions, and barriers to occupational advancement are among the adverse consequences associated with learning disabilities in children (Setiawati et al., 2023). Therefore, early intervention is essential to optimize learning potential and provide necessary support.

Selective attention refers to the ability to avoid interference from irrelevant stimuli while focusing on task-relevant information (Isbell et al., 2016). Deficits in this process influence other cognitive functions, particularly learning (van der Fels et al., 2019). Hence, selective attention must be considered a critical variable for intervention.

A variety of therapeutic approaches, including behavior therapy, occupational therapy, sensory–motor integration therapy, and movement-based interventions, have been proposed for children with learning disabilities (Sadati Firoozabadi & Abbasi, 2018). For the treatment of attention deficits, various approaches such as cognitive therapy, behavioral therapy, and pharmacotherapy have been suggested (Shahmohammadi et al., 2019). However, research regarding motor-based interventions remains limited, despite evidence indicating that play and movement can improve attention and concentration (Higgs et al., 2019). The physical–motor literacy enhancement program was developed by the researchers to address the need for a comprehensive approach that integrates physical, cognitive, and motivational factors related to physical activity. It emphasizes lifestyle modification through daily motor behaviors, knowledge and understanding of movement, achievement of motor competence, and motivation for sustained engagement in motor behaviors (Abedi et al., 2025).

Motor competence and physical fitness are associated with executive functions in children, including mathematical tasks, executive control, brain performance, and working memory (Spanou et al., 2022). Physical activity stimulates the production of new brain cells, but does not automatically increase neural connections. Therefore, brain health can be enhanced through the combination of physical activity and learning, facilitated by the development and maintenance of physical literacy (Higgs et al., 2019).

Meanwhile, the rapid advancement of digital technologies has transformed various aspects of healthcare, including rehabilitation (Herren et al., 2025). Cognitive rehabilitation has emerged as a promising approach to strengthening executive functions by employing targeted exercises and stimuli to enhance cognitive capacity. Numerous studies have demonstrated its positive effects on information processing speed, attention, cognitive improvement, language skills, and diverse aspects of executive functioning (Gharashi & Abdi, 2025).

The challenges of pharmacological treatment for attention deficits underscore the importance of non-invasive interventions such as psychological therapies and cognitive rehabilitation (i.e., restoring cognitive functions). Computer-based interventions, such as Captain’s Log software, were initially introduced to treat children with neurodevelopmental disorders (Wiest et al., 2020). Through computer interaction and mouse-based tasks, this software provides training in working memory, problem-solving abilities, and attention skills (Wiest et al., 2022). Neuroplasticity has been recognized as the underlying mechanism contributing to its effectiveness (Rossignoli -Palomeque et al., 2018).

However, limited research has compared the effectiveness of physical–motor literacy enhancement programs and computer-based cognitive rehabilitation. Therefore, the present study aimed to compare the effectiveness of these two interventions on selective attention in children with learning disabilities.

Method

The research method in this study was quantitative, of an experimental type, using a pretest–posttest control group design.

The statistical population of this study included all students aged 7 to 15 years with learning disabilities in Shahroud who had been referred to rehabilitation clinics during the 2022–2023 academic year. After reviewing the clinical records and contacting the parents, a total of 45 children with learning disabilities were identified through convenience sampling and were randomly assigned to three groups: the Physical–Motor Literacy Promotion Program intervention group, the computer-based cognitive rehabilitation group, and a control group (15 children in each group). The inclusion criteria for the children were being between 7 and 15 years old, voluntary participation and parental consent, absence of neurological–muscular or cardiac problems, no comorbidity with other developmental disorders (including ADHD and autism spectrum disorder) assessed through a clinical interview based on the Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria, and not using medications that might interfere with executive functioning. The exclusion criteria included lack of cooperation and irregular attendance in the training sessions (more than two absences). To confirm the diagnosis, results of diagnostic tests, intelligence tests, teachers' reports, and other relevant documents for each participant were reviewed, and all participants underwent a clinical interview based on DSM criteria for learning disabilities. The final sample was selected according to the inclusion and exclusion criteria. At the beginning of the study, the Selective Attention Test using the Stroop Test Software (developed by the Sina Psychological Equipment Institute) was administered as a pretest among all three groups. Then, for the Physical–Motor Literacy Promotion Program group, the intervention was implemented in 24 sessions of 80 minutes each, including 5 minutes of daily behavior, 5 minutes of self-confidence and motivation, 10 minutes of knowledge and perception, and 60 minutes of motor competence training. The sessions were conducted three times per week for eight weeks under the supervision of the researcher and with the assistance of a graduate student in motor behavior. For the computer-based cognitive rehabilitation group, the intervention included 24 sessions of 60 minutes each, conducted three times a week for eight weeks, using the Captain's Log cognitive rehabilitation software, while the control group did not receive any specific training.

After completing the training sessions, the Selective Attention Test using the Stroop Test Software was re-administered to all three groups. The following ethical considerations were observed in this study: obtaining written informed consent from participants (the children's parents), maintaining confidentiality, informing participants about the study objectives, ensuring voluntary participation, and granting the right to withdraw from the study at any time. The data obtained from the research were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (analysis of covariance) with SPSS software version 27. The following instruments were used for data collection in the present study:

Stroop Test Software: The Stroop Test was developed in 1935 by Ridley Stroop to measure selective attention and cognitive flexibility through visual processing. The reliability of this test has been reported to range from 0.80 to 0.91 using the test–retest method (Baezzat & Noorizadeh, 2018). The Persian software version of the Stroop Test was developed by the Sina Psychological Equipment Institute, adapted from the original card-based Stroop Test. In the present study, the computerized version of the test was used, which included four colors:

yellow, red, green, and blue. The stimuli consisted of 48 congruent stimuli (where the color of the word matches its meaning—for example, the word "red" displayed in red) and 48 incongruent stimuli (where the color of the word does not match its meaning—for example, the word "red" displayed in blue). The number of correct responses was considered the participant's score. The total of 96 congruent and incongruent words was presented sequentially and randomly. The participant's task was to indicate only the apparent color of each word, regardless of its semantic meaning. Each stimulus appeared on the screen for 2 seconds, with an interstimulus interval of 800 milliseconds. The interference score was calculated by subtracting the number of correct incongruent responses from the number of correct congruent responses. Moreover, a longer mean reaction time for incongruent stimuli compared to congruent ones was also considered an additional indicator of cognitive interference. The test–retest reliability of this measure has been reported between 0.80 and 0.91 (Safri Bolani, 2017). Alboghebish et al. (2016) reported both validity and reliability coefficients of 0.80. Similarly, in the study by Nyhus& Barceló (2009), test–retest reliability values of 0.80 and 0.85 were obtained. In the present study, the validity coefficient was also found to be 0.80.

Physical–Motor Literacy Enhancement Program: The *Physical–Motor Literacy Promotion Program* employed in this study was designed by the researcher based on the *Canadian Assessment of Physical Literacy (CAPL)* framework (adapted from the *CAPL Manual for Test Administration* with permission from Mark Tremblay; Francis, 2016; Healthy Active Living and Obesity Research Group, 2017; Longmuir et al., 2015; as cited in Nikkhoo, 2019) and informed by theoretical and empirical contributions from leading scholars in the field (including Whitehead (2001, 2013, 2019), Dutil (2018), Francis et al. (2016), Longmuir et al. (2015). The intervention consisted of 24 sessions, each lasting 80 minutes, structured to include 5 minutes of daily behavioral engagement, 5 minutes focused on self-confidence and motivation enhancement, 10 minutes devoted to knowledge and perception development, and 60 minutes dedicated to motor competence training.

Table 1 summarizes the sessions of the Physical–Motor Literacy Promotion Program. The content validity ratio of the program was 0.8, falling within the range of 0.8 to 1, indicating that the educational package has appropriate content validity (Abedi et al., 2025).

Marathon Pedometer: Used to assess daily activity and number of steps taken. The device was purchased via DigiKala online marketplace.

Table 1. Framework of the Physical–Motor Literacy Enhancement Program Sessions (Abedi et al., 2025)

Sessions	Content
Session 1	Introduction and establishment of a therapeutic relationship; explanation of rules and conditions for parents; instructions on the use of the pedometer and daily behavior worksheets; presenting the objectives of the sessions in simple language for children; completion of demographic forms and creation of individual files.
Session 2	Daily behavior: Review of daily activity patterns by the instructor and planning for movement enhancement; reporting average daily step counts recorded by the pedometer, sedentary time, moderate, and vigorous activity. Motor competence (initial assessment): Jumping, hopping, catching, throwing, skipping, hopping on one leg, kicking a ball, planking, shuttle run. Self-confidence and motivation: Discussion about liking or disliking motor and physical games. Knowledge and perception: Training on how to correctly increase heart rate during movement and identifying optimal levels.

Session 3	Daily behavior: as in Session 2. Motor competence (initial assessment): Same items as Session 2. Self-confidence and motivation: Discussion about being active or passive in motor games. Knowledge and perception: Introduction to the importance and definition of muscle building and muscular endurance.
Session 4	Daily behavior: as in Session 2. Motor competence (initial assessment): Same items. Self-confidence and motivation: Discussion about enjoying physical games and having fun during motor activities. Knowledge and perception: Training on types of aerobic exercises.
Session 5	Daily behavior: as in Session 2. Motor competence: Plank exercise, shuttle run (PACR), CAMSA movements. Self-confidence and motivation: Discussion about performing well or poorly in sports. Knowledge and perception: Introduction to the definition and types of anaerobic exercises.
Session 6	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Discussion about the ease or difficulty of learning motor games. Knowledge and perception: Training on cardiorespiratory fitness.
Session 7	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Discussion about reasons for being active and types of physical activities. Knowledge and perception: Instruction on how to acquire skills in motor training.
Session 8	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Discussion about feelings associated with being active. Knowledge and perception: Teaching motor concepts through storytelling; children complete the missing parts of the story.
Session 9	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Review of strategies for being active. Knowledge and perception: Children create a real story about the benefits of motor exercises and physical fitness.
Session 10	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Discussion of barriers and benefits of being active. Knowledge and perception: Training on self-awareness in motor activities; children answer: *In the past week, how many days did you engage in at least 60 minutes of physical activity?*
Session 11	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Review of physical benefits of being active. Knowledge and perception: Visual introduction to the brain and its functions.
Session 12	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Review of psychological benefits of being active. Knowledge and perception: Training on the role of exercise in facilitating brain activity and learning.
Session 13	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Review of the effects of being active on learning. Knowledge and perception: Brain fitness training through physical activity.
Session 14	Daily behavior: as in Session 2. Motor competence: Plank, shuttle run (PACR), CAMSA. Self-confidence and motivation: Review of the effects of physical activity and fitness in different life settings (school, home, etc.). Knowledge and perception: Brain fitness training through physical activity.
Session 15	Daily behavior: as in Session 2. Motor competence (final assessment): Jumping, hopping, catching, throwing, skipping, hopping on one leg, kicking a ball, planking, shuttle run. Self-confidence and motivation: Definition of self-confidence and motivation and their relation to physical activity. Knowledge and perception: Brain fitness training through physical activity.
Sessions 16–24	Repetition of Sessions 7 onward.

Captain's Log Cognitive Rehabilitation Software (2018): The Captain's Log cognitive training software was developed by Sandford and Brown to enhance a wide range of cognitive skills through diverse brain-training exercises. It comprises three main training modules: learning skills, problem-solving skills, and working memory. The software is grounded in extensive cognitive training research and is designed to support individuals with brain injuries, children with learning disabilities due to genetic developmental delays, children with neurochemical imbalances such as ADHD, children affected by prenatal cocaine exposure, and individuals who have experienced stroke.

This program includes approximately 2,000 exercises and tasks at different levels to strengthen various cognitive functions. Captain's Log is considered one of the most comprehensive tools available, as it not only improves basic cognitive skills but also higher-order cognitive processes, guided by its unique built-in assessment system. This system can evaluate an individual across nine domains of cognitive functioning and subsequently propose a tailored training program. A major advantage of the program lies in its ability to enhance 22 basic and higher-level cognitive skills, designed for participants aged 5 years and older.

The skills targeted include attention, working memory, short-term memory, mental processing speed, response inhibition, impulse control, auditory skills, problem-solving, conceptual reasoning, fine motor speed and control, as well as visual–spatial classification and sequencing. Training modules are categorized into three developmental levels: Silver (ages 6–11), Gold (ages 12–16), and Diamond (ages 17 and above).

Previous research (Kotwal, Burns, & Montgomery, 1996) demonstrated the effectiveness of the program for children with attention-deficit/hyperactivity disorder (ADHD). Its validity was confirmed, and follow-up assessments showed the persistence of treatment effects over seven months (Royatvand Ghiasvand & Amiri Majd, 2019). Tasks are organized hierarchically and adjust in difficulty according to individual performance, progressing step by step. Completion of each task is reinforced with immediate rewards such as short musical clips, attractive images, and engaging visual effects.

Because the software is not available in Persian, task instructions were provided by the therapist. For auditory tasks, a trained instructor translated and presented the stimuli simultaneously with the computer prompts, enabling the child to respond appropriately.

In the present study, participants underwent 24 sessions of computer-based cognitive rehabilitation (60 minutes each), delivered three times per week over eight weeks, with the intervention protocol tailored according to each child's initial assessment outcomes.

Results

To analyze the data and compare the effectiveness of the physical–motor literacy enhancement program and computer-based cognitive rehabilitation on selective attention in children with learning disabilities, analysis of covariance (ANCOVA) was performed. The demographic characteristics of the participants, separated by intervention and control groups, are presented in Table 2.

Table 2. Demographic Characteristics of the Participants by Experimental and Control Groups

Variable	Group	Category	Frequency	Percentage
Age	Experimental1	7–11 years	7	46.6%
		11–15 years	8	53.3%
	Experimental2	7–11 years	7	46.6%
		11–15 years	8	53.3%
	Control	7–11 years	7	46.6%

		11–15 years	8	53.3%
Gender	Experimental1	Female	7	46.6%
		Male	8	53.3%
	Experimental2	Female	7	46.6%
		Male	8	53.3%
	Control	Female	7	46.6%
		Male	8	53.3%

The mean and standard deviation of pretest and posttest scores of selective attention in the experimental and control groups are presented in Table 3.

Table 3. Mean and Standard Deviation of Selective Attention Scores

Variable	Stage	Group	Mean	Standard Deviation
Selective Attention	Pretest	Physical–Motor Literacy Enhancement	58.86	10.26
		Computer-Based Cognitive Rehabilitation	60.13	9.99
		Control	40.46	11.57
	Posttest	Physical–Motor Literacy Enhancement	71.40	9.21
		Computer-Based Cognitive Rehabilitation	72.26	9.07
		Control	42.33	11.78

Descriptive results indicate that attention scores increased in both intervention groups compared to the control group, suggesting improvement following the interventions. The statistical significance of these differences was subsequently tested using inferential analysis. Normality of distribution in selective attention scores was examined using Kolmogorov–Smirnov and Shapiro–Wilk tests (see Table 4).

Table 4. Normality Tests of Selective Attention Scores (Kolmogorov–Smirnov and Shapiro–Wilk)

Variable	Stage	Group	Kolmogorov–Smirnov Statistic	Sig.	Shapiro–Wilk Statistic	Sig.
Selective Attention	Pretest	Physical–Motor Literacy Enhancement	0.213	0.065	0.890	0.067
		Computer-Based Cognitive Rehabilitation	0.212	0.067	0.890	0.067
		Control	0.118	0.200	0.944	0.431
	Posttest	Physical–Motor Literacy Enhancement	0.163	0.200	0.915	0.163
		Computer-Based Cognitive Rehabilitation	0.171	0.200	0.917	0.170
		Control	0.144	0.200	0.934	0.315

The results of both tests yielded significance levels greater than 0.05, confirming the assumption of normal distribution of the data. Furthermore, Levene's test indicated homogeneity of variances across groups ($p = 0.05$), supporting the assumption of equal variances for subsequent ANCOVA. The assumption of homogeneity of variances was examined using Levene's test. Results are presented in Table 5.

Table 5. Results of Levene's Test for Equality of Variances in Selective Attention Scores

Variable	Stage	F	df1	df2	Sig.
Selective Attention	Posttest	0.603	2	42	0.552

Levene's test indicated that the variances between groups were homogeneous ($p > 0.05$), thereby meeting the assumption of equal variances. Subsequently, analysis of covariance (ANCOVA) was conducted to compare the effectiveness of the interventions, with pretest scores entered as a covariate. Results are summarized in Table 6.

Table 6. Results of ANCOVA Comparing the Effectiveness of Physical–Motor Literacy Enhancement and Computer-Based Cognitive Rehabilitation on Selective Attention

Variable	Source of Variation	SS	df	MS	F	p-value	Eta²
Selective Attention	Pretest	3379.255	1	3379.255	148.243	p < 0.001	0.783
	Group	1028.733	2	514.366	22.564	p < 0.001	0.524
	Error	934.612	41	22.795			

The results in Table 6 indicate that there were significant differences among the three groups ($F = 22.564$, $p < 0.001$, $\eta^2 = 0.524$) in posttest selective attention scores after controlling for pretest performance. To identify where the differences occurred, Bonferroni post hoc tests were conducted (Table 7).

Table 7. Bonferroni Post Hoc Test Results for Pairwise Comparisons of Selective Attention Scores

Variable	Comparison Groups	Mean Difference	Std. Error	Sig.
Selective Attention	Physical–Motor Literacy Enhancement vs. Control	13.549	2.160	p < 0.001
	Computer-Based Cognitive Rehabilitation vs. Control	13.347	2.212	p < 0.001
	Physical–Motor Literacy Enhancement vs. Computer-Based Cognitive Rehabilitation	0.202	1.746	1.000

As shown in Table 7, both the physical–motor literacy enhancement program and computer-based cognitive rehabilitation significantly improved selective attention scores compared to the control group ($p < 0.001$). However, there was no significant difference between the two intervention groups ($p = 1.000$). These results suggest that both interventions were equally effective in enhancing selective attention in children with learning disabilities, with no superiority of one intervention over the other.

Discussion and Conclusion

The present study aimed to compare the effectiveness of the Physical–Motor Literacy Promotion Program and computer-based cognitive rehabilitation on selective attention in children with learning disabilities. The results of the analysis of covariance revealed that there was no significant difference between the effectiveness of the physical–motor literacy intervention and the computer-based cognitive rehabilitation intervention in improving attention.

No research has been conducted on the effectiveness of the Physical–Motor Literacy Program on improving attention. The Physical–Motor Literacy Promotion Program, which focuses on four areas: daily behavior, motor competence, self-confidence and motivation, and knowledge and perception, was developed by the researcher, and its effectiveness on selective attention was evaluated (Abedi et al., 2025). The results of the study showed that the program had a significant impact on improving attention. This result is consistent with the results of several studies that have confirmed the effectiveness of physical activity in enhancing executive functions, particularly attention, as well as brain structure and function. In this regard, Sarli et al. (2014) & Hashemi Malekshah et al. (2021) confirmed the positive effects of physical–motor activities on attention improvement. Research has confirmed the effectiveness of motor programs on learning disabilities and their significant role in enhancing mathematical learning in children, as well as the impact of exercise on strengthening various cognitive learning processes in children with specific learning disorders (Engelsman, 2003; Ramos, 2004; as cited in Saleh Targh & Fakharian, 2019). Additionally, studies by Verret et al. (2012) and Schmith et al. (2013) have confirmed the positive effects of physical–motor activities on attention improvement. Increased physical activity has a positive impact on academic performance, significantly improving the mathematical and spelling performance of elementary school children (Mullender-Wijnsma et al., 2016). Furthermore, correctly implemented physical activity interventions can improve academic progress (Alvarez-Bueno et al., 2017). Positive effects of physical activity on executive functions, attention, and academic performance have been found in children (De Griff et al., 2018). Physical activity is positively correlated with academic performance due to its impact on self-esteem and depression reduction (Kayani et al., 2018). No study inconsistent with the present research was found. The explanation for these results could be that physical activity improves brain functions, including memory and attention (Egger et al., 2019). Brain structures of children who are physically fit are different from those who are less fit. For example, they have larger bilateral hippocampus volumes and bigger basal ganglia (Chaddock et al., 2012). Physical activity is a potential solution for increasing behavioral engagement, which in turn stimulates and strengthens learning (Harvey et al., 2018). For children and adolescents (5 to 17 years old), physical activity for over 60 minutes every day can offer health benefits such as promoting growth and improving physical fitness, including coordination and motor skills, flexibility, and body posture balance, as well as developing vital brain connections that improve focus and thinking skills. Physical activity increases neurotransmitters such as dopamine, epinephrine, and norepinephrine in the brain, thus facilitating and impacting attention performance (Hashemi Malekshah et al., 2021). Furthermore, psychomotor skills are critical mediating functions that create complex and goal-directed systems, which serve as the foundation for cognition (Saleh Targh et al., 2021). A lack of diverse motor experiences can delay motor and cognitive development. Typically, a child who is perceptually weak faces major difficulties in the ability to perceive, interpret data and stimuli, and compare them to baseline data (Gallahue, Ozmun, & Goodway, 2011), and success in learning mathematics and reading is greatly influenced by fine motor skills (Ahmadi et al., 2010; as cited in Saleh Targh et al., 2019).

Computer-based cognitive rehabilitation has also been effective in improving attention, a result consistent with the studies of Ranjbar et al. (2019) and Afshari & Rezaei (2019). Considering the neural pathways involved in cognitive tasks, it seems that computer-based cognitive rehabilitation, due to the presence of various visual and auditory stimuli, engages sensory areas (for processing sensory inputs), the prefrontal cortex (for processing task complexity and selecting appropriate strategies for task response), and ultimately motor areas (for generating motor feedback) simultaneously (Ranjbar et al., 2019). On the other hand, cognitive rehabilitation training enhances neuronal flexibility in areas responsible for executive functions. Specifically, exercises, especially at a young age, foster new synaptic connections between neural networks related to the task, ultimately improving the individual's ability in that domain (Serne Class & Springer-Charlot, 2015; as cited in Mahrogi et al., 2021). Chen, Mitra, & Schlaghecken (2008) also reported positive effects of computer-based cognitive rehabilitation on cognitive functions, such as memory, attention, and executive functions, in individuals with various brain injuries. In this context, it can be said that this intervention, through computer games, attracts children due to its visual and auditory effects, utilizing engaging and exciting design and color schemes. Moreover, despite the visual appeal, the simplicity of the interface and the relatively easy instructions of the computer games designed for cognitive interventions make it possible for students to engage with the software using basic computer skills, such as pressing a few keys. Thus, after receiving and understanding the necessary instructions, students can complete a therapy session without continuous face-to-face interaction with the therapist, become aware of their mistakes, correct them, and receive immediate reinforcement for providing correct answers. It seems that the feeling of independence from others and autonomy in completing steps and tasks contributes to a sense of self-efficacy and greater motivation, which in turn enhances the student's engagement and leads to a more active and involved progression of the intervention process.

No research has been found comparing the effectiveness of computer-based cognitive rehabilitation with the Physical–Motor Literacy Promotion Program; however, among the existing research, only one study compared two types of cognitive rehabilitation interventions: computer-based rehabilitation and neuropsychological exercises. The present study does not align with the results of Ranjbar et al. (2019), who reported a greater effectiveness of computer-based cognitive rehabilitation. Additionally, the current results are inconsistent with those of Ghasemian Moghadam, Sohrabi & Taheri (2018), who compared computer-based working memory rehabilitation with the multi-sensory Fernald method for improving executive functions in dyslexic students. These researchers concluded that computer-based working memory rehabilitation had a greater impact on executive functions (as measured by the Wisconsin Card Sorting Test) compared to the multi-sensory Fernald method.

In explaining these results, it can be stated that the effectiveness of motor therapies depends on multiple factors. Existing motor therapies have been designed without a comprehensive understanding of human movement, and without considering the behavioral, cognitive, and motivational-emotional aspects, they have focused merely on repeating specific movements. In contrast, the need to change an individual's movement lifestyle in the form of daily behavior, along with having knowledge and understanding of movement, achieving motor competence, and being motivated to continue the required motor behaviors, seems essential. Therefore, motor therapies can be critiqued from this perspective, and the Physical–Motor Literacy Program can be considered a more comprehensive motor intervention that has addressed some of the shortcomings of previous motor interventions, filling the gaps left by them and showing favorable effectiveness in comparison to computer-based cognitive rehabilitation interventions.

In explaining these results, it can be said that regular physical activity likely leads to modifications in hippocampal adaptations, which play a significant role in learning and memory. Studies indicate that physical activity can affect brain physiology by increasing the growth of brain capillaries, blood flow, oxygen, the production and growth of nerve cells in the hippocampus (the center for learning and cognitive functions), neurotransmitter levels, neural connectivity, network density, and brain tissue volume. These changes improve cognitive functions such as attention, information processing, and working memory. Tomographic results indicate a lower metabolism rate and less blood flow in the brains of individuals with learning disabilities compared to healthy individuals. Research shows that individuals who participate in exercise programs activate regions of the frontal and parietal cortices of the brain, which are involved in cognitive activities. The greater an individual's physical fitness, the more cognitive benefits they gain (Ghasemian Moghadam, Sohrabi & Taheri, 2018).

The overall results of this study highlight the importance of promoting active behavior in children, as physical activity serves as a proposed pathway for developing motor skills and, consequently, enhancing executive functions, particularly attention. Given the strong evidence that physical activity, which includes both motor tasks and cognitive functions, has significant effects on cognitive outcomes in children and adolescents (such as memory, attention, academic progress, etc.), the need for comprehensive motor programs is evident. These programs can continue to play a crucial role in addressing the issues of physical inactivity and executive function problems in both children and adults.

Computer-based cognitive rehabilitation also creates conditions for enhancing cognitive skills and increasing motivation by training and encouraging children to engage in cognitive tasks. This interest and motivation, in turn, naturally draw children's attention to performing more tasks. The increase in the capacity of executive function components allows many cognitive skills and communications to be processed more efficiently in the brain and, through experience and practice, lead to better growth (Gharashi & Abedi, 2025).

Therefore, both the Physical–Motor Literacy Promotion Program and computer-based cognitive rehabilitation can be utilized to improve attention in children with learning disabilities.

Although the results of the present study shed light on filling the gap in the literature by comparing the effectiveness of the Physical–Motor Literacy Promotion Program and computer-based cognitive rehabilitation on attention, certain limitations were identified, including: 1) lack of follow-up on the long-term effects of the intervention, 2) failure to examine the effectiveness of the treatment by gender, and 3) the absence of analysis on the effects of other potential moderators such as weight, age, etc. Future research is recommended to focus on examining other potential mediators or moderators (such as age, gender, and weight) and to include follow-up phases to assess the sustainability of the effectiveness of these interventions.

Based on the research background on motor therapies, it is suggested that this therapeutic method be used for children with various developmental disorders and to create a suitable environment for learning in healthy children through brain fitness. It is also recommended that in-service training programs be held in schools and learning disability centers to familiarize teachers, therapists, and counselors in special education with the function and importance of these intervention methods, and to encourage their application to address and reduce the challenges of students with learning disabilities. Furthermore, it is suggested that elementary school teachers and trainers, while focusing on learning precursors such as sensory-motor skills, study the mechanisms of the Physical–Motor Literacy method and, within the framework of this intervention approach, provide an easy, cost-effective, and practical program. With the support of parents, this approach could strengthen the cognitive functions of students, especially those with learning disabilities.

Limitations and Future Directions

Several limitations should be acknowledged. First, the study did not include follow-up assessments to examine the persistence of treatment effects. Second, the moderating effects of gender, age, and weight were not investigated. Future research is recommended to address these factors, assess long-term efficacy, and examine these interventions across different developmental disorders. Additionally, broader implementation in schools and special education centers, as well as training for teachers, therapists, and parents, could facilitate the integration of these methods into practice.

Acknowledgments

The authors gratefully acknowledge the guidance of supervisors and consultants, as well as the cooperation of the participating children and their parents.

Conflict of Interest

The authors declare no conflict of interest.

Funding

This study was conducted as part of a doctoral dissertation without external financial support.

Ethical Considerations

Prior to data collection, informed consent was obtained from parents, and participation was voluntary. Confidentiality was maintained, and no identifying information was recorded. Data were used solely for research purposes.

Data Availability

The corresponding author is willing to provide anonymized data upon reasonable request for academic purposes, subject to ethical considerations.

References

Abedi, S., Atadokht, A., Basharpour, S., & Narimani, M. (2025). Development of a physical and motor literacy enhancement program and its effectiveness on selective attention in children with learning disabilities. *Journal of Learning Disabilities, 14*(3), 43–55. [Persian]. https://doi.org/10.22098/jld.2025.16753.2243

Afshari, A., & Rezaei, R. (2019). The effectiveness of Sand Smart software on executive functions (focused attention, the ability to organize and plan, and auditory and visual working memory) in students with dyslexia. *Journal of Learning Disabilities, 8*(3), 152–158. https://doi.org/10.22098/jld.2019.787

Alboghebish, S., Shetab Boushehri, N., Danshfar, A., & Abedanzadeh, R. (2017). Assignment facilitation and significant interference of Stroop effect on psychological refractory period. *Neuropsychology, 2*(4), Series 7. https://dor.isc.ac/dor/20.1001.1.24765023.1395.2.7.6.4

Alvarez-Bueno, C., Pesce, C., Cavero-Redondo, I., Sanchez-Lopez, M., Martínez-Hortelano, J. A., & Martinez-Vizcaino, V. (2017). The effect of physical activity interventions on children's cognition and metacognition: A systematic review and meta-analysis. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(9), 729–738. https://doi.org/10.1016/j.jaac.2017.06.012

Baezzat, F., & Nourizade, N. (2018). The effect of learning and cognition program of University of Utah on sustained, selective, and shifting attention of children. *Quarterly Journal of Child Mental Health*, 5(3), 58–68. http://childmentalhealth.ir/article-1-325-en.html

Chaddock, L., Hillman, C. H., Pontifex, M. B., Johnson, C. R., Raine, L. B., & Kramer, A. F. (2012). Childhood aerobic fitness predicts cognitive performance one year later. *Journal of Sports Sciences*, 30(5), 421–430. https://doi.org/10.1080/02640414.2011.647706

Chen, Y. N., Mitra, S., & Schlaghecken, F. (2008). Sub-processes of working memory in the N-back task: An investigation using ERPs. *Clinical Neurophysiology*, 119(7), 1546–1559. https://doi.org/10.1016/j.clinph.2008.03.003

Chiarenza, G. A. (2021). Quantitative EEG in childhood attention deficit hyperactivity disorder and learning disabilities. *Clinical EEG and Neuroscience, 52*(2), 144–155. https://doi.org/10.1177/1550059420962343

De Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., & Hartman, E. (2018). Effects of physical activity on executive functions, attention, and academic performance in preadolescent children: A meta-analysis. *Journal of Science and Medicine in Sport, 21*(5), 501–507. https://doi.org/10.1016/j.jsams.2017.09.595

Dutil, C., Tremblay, M. S., Longmuir, P. E., & colleagues. (2018). Influence of the relative age effect on children's scores obtained from the Canadian assessment of physical literacy. *BMC Public Health, 18*(2), 1040. https://doi.org/10.1186/s12889-018-5895-6

Egger, F., Benzing, V., Conzelmann, A., & Schmidt, M. (2019). Boost your brain, while having a break! The effects of long-term cognitively engaging physical activity breaks on children's executive functions and academic achievement. *PLOS ONE*, 14(3), e0212482. https://doi.org/10.1371/journal.pone.0212482

Filippello, P., Buzzai, C., Messina, G., Mafodda, A. V., & Sorrenti, L. (2020). School refusal in students with low academic performances and specific learning disorder: The role of self-esteem and perceived parental psychological control. *International Journal of Disability, Development and Education, 67*(6), 592–607. https://doi.org/10.1080/1034912X.2019.1626006

Francis, C. E., Longmuir, P. E., Boyer, C., Andersen, L. B., Barnes, J. D., Boiarskaia, E., Cairney, J., Faigenbaum, A. D., Faulkner, G., Hands, B. P., Hay, J. A., Janssen, I., Katzmarzyk, P. T., Kemper, H. C. G., Knudson, D., Lloyd, M., McKenzie, T. L., Olds, T. S., Sacheck, J. M., ... Tremblay, M. S. (2016). The Canadian assessment of physical literacy: Development of a model of children's capacity for a healthy, active lifestyle through a Delphi process. *Journal of Physical Activity and Health, 13*(2), 214–222. https://doi.org/10.1123/jpah.2014-0597

Gallahue, D. L., Ozmun, J. C., & Goodway, J. (2011). Understanding motor development: Infants, children, adolescents, adults. Boston.

Gharashi, K., & Abdi, R. (2025). Enhancing executive functioning: The impact of cognitive rehabilitation on cochlear-implanted children. *Auditory and Vestibular Research, 34*(1), 88–96. https://doi.org/10.18502/avr.v34i1.17276

Ghasemian Moghadam, H., Sohrabi, M., & Taheri, H. (2018). The effect of Paaryaad perceptual-motor exercises on working memory of children with specific learning disorder. *Quarterly Journal of Child Mental Health*, 5(3), 102–114. [Persian].

Harvey, S. P., Lambourne, K., & Greene, J. L. (2018). The effects of physical activity on learning behaviors in elementary school children: A randomized controlled trial. *Contemporary School Psychology*, 22(3), 303–312. https://doi.org/10.1007/s40688-017-0143-0

Hashemi Malekshah, S.H., Alizadeh, H., Rezayi, S., Asgari, M. (2021). Development of a Physical Activity Training Package and Evaluation of its Efficacy on Executive Functions in Children with Attention Deficit/ Hyperactivity Disorder. *J of Psychological Science*, 20(104), 1279-1294. http://psychologicalscience.ir/article-1-1334-en.html

Healthy Active Living and Obesity Research Group. (2017). Canadian Assessment of Physical Literacy: Manual for test administration (2nd ed.). Ottawa, ON. https://www.activehealthykids.org/wp-content/uploads/2022/04/capl-2-manual-en.pdf

Herren, S., Seebacher, B., Mildner, S., Riederer, Y., Pachmann, U., Böckler, N. S., Niedecken, S., Sgandurra, S. A., Bonati, L., Hotz, I., Schättin, A., Jurt, R., Brenneis, C., Lenfert, K., Behrendt, F., Schmidlin, S., Nacke, L., Schuster-Amft, C., & Martin-Niedecken, A. L. (2025). Exergame (ExerG)-based physical-cognitive training for rehabilitation in adults with motor and balance impairments: Usability study. *JMIR Serious Games, 13,* e66515. https://doi.org/10.2196/66515

Higgs, C., Cairney, J., Jurbala, P., Dudley, D., Way, R., & Mitchell, D. (2019). *Developing building a new normal for all Canadians: Physical literacy*. Sport for Life. https://sportforlife.ca

Hosseinkhanzadeh, A. A., Latif, M., & Taher, M. (2018). Comparison of the effectiveness of computer-assisted working memory rehabilitation and the multi-sensory method on improvement of executive functions of students with dyslexia. *Quarterly of Psychology of Exceptional Individuals, 8*(29). https://doi.org/10.22054/jpe.2018.21814.1558

Isbell, E., Stevens, C., Hampton Wray, A., Bell, T., & Neville, H. J. (2016). 5-HTTLPR polymorphism is linked to neural mechanisms of selective attention in preschoolers from lower socioeconomic status backgrounds. *Developmental Cognitive Neuroscience, 22,* 36–47. https://doi.org/10.1016/j.dcn.2016.10.002

Kayani, S., Kiyani, T., Wang, J., Sánchez, M., Kayani, S., & Qurban, H. (2018). Physical activity and academic performance: The mediating effect of self-esteem and depression. *Sustainability, 10,* 3633. https://doi.org/10.3390/su10103633

Kotwal, D. B., Burns, W. J., & Montgomery, D. D. (1996). Computer-Assisted Cognitive Training for ADHD: A Case Study: A Case Study. *Behavior Modification*, *20*(1), 85-96. https://doi.org/10.1177/01454455960201004

Longmuir, P. E., Boyer, C., Lloyd, M., Yang, Y., Boiarskaia, E., Zhu, W., & Tremblay, M. S. (2015). The Canadian Assessment of Physical Literacy: Methods for children in grades 4 to 6 (8 to 12 years). *BMC Public Health, 15,* 767. https://doi.org/10.1186/s12889-015-2106-6

Mahrogi, H., Tozandehjani, H., Nejat, H., & Bagherzadeh-Gholmakani, Z. (2021). Comparing the effectiveness of cognitive rehabilitation based on attention amplification and cognitive rehabilitation based on working memory amplification in cognitive emotion regulation and information processing speed of dyslexic students. *Neuropsychology*, 7(2), 73–92. https://doi.org/10.30473/clpsy.2020.52835.1544

Mullender-Wijnsma, M. J., Hartman, E., de Greeff, J. W., Doolaard, S., Bosker, R. J., & Visscher, C. (2016). Physically active math and language lessons improve academic achievement: A cluster randomized controlled trial. *Pediatrics, 137*(3), e20152743. https://doi.org/10.1542/peds.2015-2743

Nikkhoo, E. (2019). *The effect of relative age and physical maturity on physical literacy in children aged 8–12 years (Doctoral dissertation)*. Alzahra University, Tehran, Iran.

Nyhus, E., & Barceló, F. (2009). The Wisconsin Card Sorting Test and the cognitive assessment of prefrontal executive functions: a critical update. *Brain and cognition*, 71(3), 437–451. https://doi.org/10.1016/j.bandc.2009.03.005

Ranjbar, M. J., Basharpoor, S., Sobhi Gharamaleki, N., & Narimani, M. (2019). Comparing the effectiveness of computerized cognitive rehabilitation and neuropsychological exercises on improving working memory and continuous attention in students with dyslexia. *Quarterly of Psychology of Exceptional Individuals, 9*(34). https://doi.org/10.22054/jpe.2019.44751.2029

Rossignoli-Palomeque, T., Perez-Hernandez, E., & Gonzalez-Marques, J. (2018). Brain training in children and adolescents: Is it scientifically valid? *Frontiers in Psychology, 9,* 565. https://doi.org/10.3389/fpsyg.2018.00565

Royatvand Ghiasvand, N., & Amiri Majd, M. (2019). Effectiveness of Captain's Log cognitive software on visual-spatial perception of students with specific learning disorders. *Journal of Exceptional Children, 19*(1), 5–14. http://joec.ir/article-1-749-fa.html

Sadati-Firoozabadi, S. & Abbasi, Sh. (2018). The effectiveness of sensory-motor integration therapy on reading problems in students with learning disabilities. *Journal of Learning Disabilities*. 8(2), 37-26. https://jld.uma.ac.ir/article_755.html

Safri Bolani, N. (2017). *Effectiveness of cognitive rehabilitation methods on improvement of attention dimensions and efficiency of reading of dyslexic students* [Unpublished doctoral dissertation]. University of Mazandaran.

Saleh Targh A., Fakharian A. (2019). The effect of movement literacy games on the academic achievement of children with learning disabilities. *Journal of Motor and Behavioral Sciences*, 2(3), 339-334. https://www.jmbs.ir/article_111132.html

Sarli, A., Shahbazi, M., Bagherzadeh, F. (2014). Investigate effectiveness of perceptual- motor tasks on visual and auditory attention of children with attention deficit hyperactivity disorder. *Motor Behavior*, 6(15), 47-60. https://mbj.ssrc.ac.ir/article_511.html?lang=en

Schmith, A. L., Hoza, B., Linnea, K., McQuade, J. D., Tomb, M., Vaughn, A. J., Shoulberg, E. K., & Hook, H. (2013). Pilot physical activity intervention reduces severity of ADHD symptoms in young children. *Journal of Attention Disorders*, 17(1), 70–82. https://doi.org/10.1177/1087054711417395

Setiawati, Y., Fithriyah, I., Wahyurini, M., Dianasari, N., Hartopo, D., Jessica, L., & Dala, A. G. F. M. (2023). Early detection of learning disorders and attention deficit/hyperactivity disorder among children in elementary school. *International Journal of Scientific Advances, 4*(6), 950–954. https://doi.org/10.51542/ijscia.v4i6.20

Shahmohammadi, M., Entesar Fomani Fomani, G., Hejazi, M., Asadzadeh, H. (2019). The effect of sensory integration program on non-verbal intelligence, focus attention and academic performance of students with mathematical learning disorder. Journal of Learning Disabilities. 9(1), 92-114. https://jld.uma.ac.ir/article_835.html

Siavoshifar, N., Tajali, P., Shariat Bagheri, M.M. (2019). The effectiveness of the Dawson-Guyer program on improving attention, working memory, and behavioral inhibition in dyslexic students. *Journal of Learning Disabilities*, 10(2), 110-129. https://jld.uma.ac.ir/article_1047.html

Spanou, M., Kaioglou, V., Pesce, C., Mavilidi, M. F., & Venetsanou, F. (2022). Move their brain: Motor competence mediates the relationship of physical activity and executive functions in children. *Applied Sciences, 12*(20), 10527. https://doi.org/10.3390/app122010527

Van Der Fels, I. M. J., Smith, J., de Bruijn, A. G. M., Bosker, R. J., Königs, M., Oosterlaan, J., & others. (2019). Relations between gross motor skills and executive functions, controlling for the role of information processing and lapses of attention in 8–10-year-old children. *PLOS ONE, 14*(10), e0224219. https://doi.org/10.1371/journal.pone.0224219

Verret, G. M., Berthiaume, C., Gardiner, P., & Béliveau, L. (2012). A physical activity program improves behavior and cognitive functions in children with ADHD: An exploratory study. *Journal of Attention Disorders*, 16(1), 71–80. https://doi.org/10.1177/1087054710379735

Whitehead, M. (2001). The concept of physical literacy. *European Journal of Physical Education, 6*(2), 127–138. https://doi.org/10.1080/1740898010060205

Whitehead, M. (2013). Definition of physical literacy and clarification of related issues. *Bulletin of the International Council of Sport Science and Physical Education, 65*, 29–34. https://doi.org/10.4324/9780203702697-2

Whitehead, M. (2019). Overview and recent developments in physical literacy. In M. Whitehead (Ed.), *Physical literacy across the world* (pp. 3–7). Routledge. https://doi.org/10.4324/9780203702697

Wiest, D. J., Wong, E. H., Bacon, J. M., Rosales, K. P., & Wiest, G. M. (2020). The effectiveness of computerized cognitive training on working memory in a school setting. *Applied Cognitive Psychology, 34*(2), 465–471. https://doi.org/10.1002/acp.3634

Wiest, G. M., Rosales, K. P., Looney, L., Wong, E. H., & Wiest, D. J. (2022). Utilizing cognitive training to improve working memory, attention, and impulsivity in school-aged children with ADHD and SLD. *Brain Sciences, 12*(2), 141. https://doi.org/10.3390/brainsci12020141