

Comparing the Effectiveness of Physical–Motor Literacy Promotion Program and rehabilitation on Selective Attention in Children with Learning Disabilities

Abstract

Introduction and Objective: Learning disabilities are often associated with difficulties in information processing, concentration, and attentional control. The present study aimed to compare the effectiveness of a physical–motor literacy promotion program and Computer-assisted 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 7–10 years with learning disabilities in Shahrood during the academic year 2022–2023, 40 participants were selected through convenience sampling and randomly assigned to three groups: physical–motor literacy enhancement program, computer-based cognitive rehabilitation, and control (10 children per group). The instruments were 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 showed no significant difference between the effectiveness of the physical–motor literacy promotion program and the computer-based cognitive rehabilitation in improving attention scores. the physical–motor literacy promotion 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 promotion 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 promotion Program; Computer-Based Cognitive Rehabilitation; Selective Attention; Learning Disabilities

Introduction

Learning disability is a common developmental disorder in childhood (Chiarenza, ۲۰۲۱). It is identified in approximately ۵% of school-aged children, while some researchers argue that the actual prevalence may reach ۱۵–۲۰% (Setiawati et al., ۲۰۲۳). In Iran, the overall prevalence is estimated at ۶,۷۵% (Siavoshifar et al., ۲۰۲۰). 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., ۲۰۲۰). 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., ۲۰۲۳). 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., ۲۰۱۶). Deficits in this process influence other cognitive functions, particularly learning (van der Fels et al., ۲۰۱۹). 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, ۲۰۱۸). For the treatment of attention deficits, various approaches such as cognitive therapy, behavioral therapy, and pharmacotherapy have been suggested (Shahmohammadi et al., ۲۰۱۹). However, research regarding motor-based interventions remains limited, despite evidence indicating that play and movement can improve attention and concentration (Higgs et al., ۲۰۱۹). Movement improves cognitive functions by affecting neuroplasticity (the waxy nature of the brain), which provides the basis for improving learning performance. Physical activities improve cognitive abilities by affecting neuroplasticity by facilitating neuroplasticity, improving a person's cognitive abilities to interact effectively with the environment (Soltani et al., ۲۰۲۵). Researchers have shown that regular physical activity controls the maintenance, growth, and differentiation of synapses and neurons. Angiogenesis improves cognitive functions such as processing speed, controls, planning, and working memory (Mirshekari et al., ۲۰۲۵). One of the signs of the relationship and effect of motor activity on cognitive functions is the release of catecholamines, adrenaline (epinephrine) and noradrenaline (norepinephrine) in the blood during physical and physiological activity, which increases neurotransmitters in the brain (Soltani et al., ۲۰۲۵). aerobic exercise increases arousal and catecholamine, which is associated with the brain's frontal cortex and affects executive functions (Mirshekari et al., ۲۰۲۵). Motor exercises increase norepinephrine and dopamine in the brain, both of which have a positive effect on people's attention and thinking. Also, exercise and activity can increase brain adrenaline, and adrenaline, in turn, stimulates other body systems, one of the important results of which is the increase in brain endorphins, which is very important for improving and strengthening attention (Soltani et al., ۲۰۲۵). 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., ۲۰۲۵).

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., ۲۰۲۲). 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., ۲۰۱۹).

Meanwhile, the rapid advancement of digital technologies has transformed various aspects of healthcare, including rehabilitation (Herren et al., ۲۰۲۰). 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, ۲۰۲۰).

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., ۲۰۲۰). Through computer interaction and mouse-based tasks, this software provides training in working memory, problem-solving abilities, and attention skills (Wiest et al., ۲۰۲۲). Neuroplasticity has been recognized as the underlying mechanism contributing to its effectiveness (Rossignoli -Palomeque et al., ۲۰۱۸).

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 ۷ to ۱۰ years with learning disabilities in Shahrud who had been referred to rehabilitation clinics during the ۲۰۲۲–۲۰۲۳ academic year. After reviewing the clinical records and contacting the parents, a total of ۴۰ children with learning disabilities were identified through convenience sampling. The groups were matched in terms of intelligence, gender and age. Then, the sample was assigned to the groups through a random number table 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 (۱۰ children in each group). The inclusion criteria for the children were being between ۷ and ۱۰ 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 ۲۴ sessions of ۸۰ minutes each, including ۵ minutes of daily behavior, ۵ minutes of self-confidence and motivation, ۱۰ minutes of knowledge and perception, and ۶۰ 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 ٢٤ sessions of ٦٠ 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 ٢٧. The following instruments were used for data collection in the present study:

Stroop Test Software: The Stroop Test was developed in ١٩٣٥ by Ridley Stroop to measure selective attention and cognitive flexibility through visual processing. The reliability of this test has been reported to range from ٠,٨٠ to ٠,٩١ using the test-retest method (Baezzat & Noorizadeh, ٢٠١٨). 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 ٤٨ congruent stimuli (where the color of the word matches its meaning—for example, the word “red” displayed in red) and ٤٨ 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 ٩٦ 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 ٢ seconds, with an interstimulus interval of ٨٠٠ 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 ٠,٨٠ and ٠,٩١ (Safri Bolani, ٢٠١٧). Alboghebish et al. (٢٠١٦) reported both validity and reliability coefficients of ٠,٨٠. Similarly, in the study by Nyhus & Barceló (٢٠٠٩), test-retest reliability values of ٠,٨٠ and ٠,٨٥ were obtained. In the present study, the validity coefficient was also found to be ٠,٨٠.

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, ٢٠١٦; Healthy Active Living and Obesity Research Group, ٢٠١٧; Longmuir et al., ٢٠١٥; as cited in Nikkhoo, ٢٠١٩) and informed by theoretical and empirical contributions from leading scholars in the field (including Whitehead (٢٠٠١, ٢٠١٣, ٢٠١٩), Dutil (٢٠١٨), Francis et al. (٢٠١٦), Longmuir et al. (٢٠١٥)). The intervention consisted of ٢٤ sessions, each lasting ٨٠ minutes, structured to include ٥ minutes of daily behavioral engagement, ٥ minutes focused on self-confidence and motivation enhancement, ١٠ minutes devoted to knowledge and perception development, and ٦٠ minutes dedicated to motor competence training.

Table ١ summarizes the sessions of the Physical-Motor Literacy Promotion Program. The content validity ratio of the program was ٠,٨, falling within the range of ٠,٨ to ١, indicating that the educational package has appropriate content validity (Abedi et al., ٢٠٢٥).

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



Table ١. Framework of the Physical–Motor Literacy Enhancement Program Sessions (Abedi et al., ٢٠٢٥)

Sessions	Content
Session ١	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 ٢	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 ٣	Daily behavior: as in Session ٢. Motor competence (initial assessment): Same items as Session ٢. 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 ٤	Daily behavior: as in Session ٢. 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 ٥	Daily behavior: as in Session ٢. 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 ٦	Daily behavior: as in Session ٢. 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 ٧	Daily behavior: as in Session ٢. 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 ٨	Daily behavior: as in Session ٢. 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 ٩	Daily behavior: as in Session ٢. 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 ١٠	Daily behavior: as in Session ٢. 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: <i>In the past week, how many days did you engage in at least 60 minutes of physical activity?</i>

Session ۱۱	Daily behavior: as in Session ۲. 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 ۱۲	Daily behavior: as in Session ۲. 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 ۱۳	Daily behavior: as in Session ۲. 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 ۱۴	Daily behavior: as in Session ۲. 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 ۱۵	Daily behavior: as in Session ۲. 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 ۱۶-۲۴	Repetition of Sessions ۲ 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 ۲,۰۰۰ 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 ۲۲ basic and higher-level cognitive skills, designed for participants aged ۵ 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 ۶-۱۱), Gold (ages ۱۲-۱۶), and Diamond (ages ۱۷ and above).

Previous research (Kotwal, Burns, & Montgomery, ۱۹۹۶) 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, ۲۰۱۹). 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 ٢٤ sessions of computer-based cognitive rehabilitation (٦٠ 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 ٢.

Table ٢. Demographic Characteristics of the Participants by Experimental and Control Groups

Variable	Group	Category	Frequency	Percentage
Age	Experimental ^١	٧–١١ years	٧	٤٦,٦٪
		١١–١٥ years	٨	٥٣,٣٪
	Experimental ^٢	٧–١١ years	٧	٤٦,٦٪
		١١–١٥ years	٨	٥٣,٣٪
	Control	٧–١١ years	٧	٤٦,٦٪
		١١–١٥ years	٨	٥٣,٣٪
Gender	Experimental ^١	Female	٧	٤٦,٦٪
		Male	٨	٥٣,٣٪
	Experimental ^٢	Female	٧	٤٦,٦٪
		Male	٨	٥٣,٣٪
	Control	Female	٧	٤٦,٦٪
		Male	٨	٥٣,٣٪

The mean and standard deviation of pretest and posttest scores of selective attention in the experimental and control groups are presented in Table ٣.

Table ٣. Mean and Standard Deviation of Selective Attention Scores

Variable	Stage	Group	Mean	Standard Deviation
Selective Attention	Pretest	Physical–Motor Literacy Enhancement	٥٨,٨٦	١٠,٢٦
		Computer-Based Cognitive Rehabilitation	٦٠,١٣	٩,٩٩
		Control	٤٠,٤٦	١١,٥٧
	Posttest	Physical–Motor Literacy Enhancement	٧١,٤٠	٩,٢١
		Computer-Based Cognitive Rehabilitation	٧٢,٢٦	٩,٠٧
		Control	٤٢,٣٣	١١,٧٨

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 ٤).

Table ٤. 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	٠,٢١٣	٠,٠٦٥	٠,٨٩٠	٠,٠٦٧
		Computer-Based Cognitive Rehabilitation	٠,٢١٢	٠,٠٦٧	٠,٨٩٠	٠,٠٦٧
		Control	٠,١١٨	٠,٢٠٠	٠,٩٤٤	٠,٤٣١

Posttest	Physical–Motor Literacy Enhancement	٠,١٦٣	٠,٢٠٠	٠,٩١٥	٠,١٦٣
	Computer-Based Cognitive Rehabilitation	٠,١٧١	٠,٢٠٠	٠,٩١٧	٠,١٧٠
	Control	٠,١٤٤	٠,٢٠٠	٠,٩٣٤	٠,٣١٥

The results of both tests yielded significance levels greater than ٠,٠٥, confirming the assumption of normal distribution of the data. Furthermore, Levene's test indicated homogeneity of variances across groups ($p = ٠,٠٥$), 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 ٥.

Table ٥. Results of Levene's Test for Equality of Variances in Selective Attention Scores

Variable	Stage	F	df ^١	df ^٢	Sig.
Selective Attention	Posttest	٠,٦٠٣	٢	٤٢	٠,٥٥٢

Levene's test indicated that the variances between groups were homogeneous ($p > ٠,٠٥$), 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 ٦.

Table ٦. 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	Eta ²
Selective Attention	Pretest	٣٣٧٩,٢٥٥	١	٣٣٧٩,٢٥٥	١٤٨,٢٤٣	$p < ٠,٠٠١$	٠,٧٨٣
	Group	١٠٢٨,٧٣٣	٢	٥١٤,٣٦٦	٢٢,٥٦٤	$p < ٠,٠٠١$	٠,٥٢٤
	Error	٩٣٤,٦١٢	٤١	٢٢,٧٩٥			

The results in Table ٦ indicate that there were significant differences among the three groups ($F = ٢٢,٥٦٤$, $p < ٠,٠٠١$, $\eta^2 = ٠,٥٢٤$) in posttest selective attention scores after controlling for pretest performance. To identify where the differences occurred, Bonferroni post hoc tests were conducted (Table ٧).

Table ٧. 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	١٣,٥٤٩	٢,١٦٠	$p < ٠,٠٠١$
	Computer-Based Cognitive Rehabilitation vs. Control	١٣,٣٤٧	٢,٢١٢	$p < ٠,٠٠١$
	Physical–Motor Literacy Enhancement vs. Computer-Based Cognitive Rehabilitation	٠,٢٠٢	١,٧٤٦	١,٠٠٠

As shown in Table ٧, both the physical–motor literacy enhancement program and computer-based cognitive rehabilitation significantly improved selective attention scores compared to the control group ($p < ٠,٠٠١$). However, there was no significant difference between the two intervention groups ($p = ١,٠٠٠$). 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., ۲۰۲۵). 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. The results of the present study are consistent with the results of the following studies: The effectiveness of movement-based cognitive rehabilitation on orientation, learning memory, cognitive status, and attention in children with nonverbal learning disorders (Damehri et al., ۲۰۲۰). The effectiveness of cognitive-motor rehabilitation on improving attention and writing processes in children with learning disorders (Gary et al., ۲۰۱۲). The effectiveness of cognitive-motor rehabilitation on reading speed and cognitive flexibility in children with learning disabilities (Soltani et al., ۲۰۲۵). Also In this regard, Sarli et al. (۲۰۱۴) & Hashemi Malekshah et al. (۲۰۲۱) 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, ۲۰۰۳; Ramos, ۲۰۰۴; as cited in Saleh Targh & Fakharian, ۲۰۱۹). Additionally, studies by Verret et al. (۲۰۱۲) and Schmith et al. (۲۰۱۳) 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., ۲۰۱۶). Furthermore, correctly implemented physical activity interventions can improve academic progress (Alvarez-Bueno et al., ۲۰۱۷). Positive effects of physical activity on executive functions, attention, and academic performance have been found in children (De Griff et al., ۲۰۱۸). Physical activity is positively correlated with academic performance due to its impact on self-esteem and depression reduction (Kayani et al., ۲۰۱۸). 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., ۲۰۱۹). 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., ۲۰۱۲). Physical activity is a potential solution for increasing behavioral engagement, which in turn stimulates and strengthens learning (Harvey et al., ۲۰۱۸). For children and adolescents (۵ to ۱۷ years old), physical activity for over ۶۰ 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., ۲۰۲۱). 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., ۲۰۲۱). 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, ۲۰۱۱), and success in learning mathematics and reading is greatly influenced by fine motor skills (Ahmadi et al., ۲۰۱۰; as cited in Saleh Targh et al., ۲۰۱۹).

Computer-based cognitive rehabilitation has also been effective in improving attention, a result consistent with the studies of Ranjbar et al. (۲۰۱۹) and Afshari & Rezaei (۲۰۱۹). 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., ۲۰۱۹). 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, ۲۰۱۰; as cited in Mahrogi et al., ۲۰۲۱). Chen, Mitra, & Schlaghecken (۲۰۰۸) 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. (۲۰۱۹), who reported a greater effectiveness of computer-based cognitive rehabilitation. Additionally, the current results are inconsistent with those of Ghasemian Moghadam, Sohrabi & Taheri (۲۰۱۸), 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, ۲۰۱۸).

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, ۲۰۲۰).

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: ۱) lack of follow-up on the long-term effects of the intervention, ۲) failure to examine the effectiveness of the treatment by gender, and ۳) 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.

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Conflict of Interest

The authors declare no conflict of interest.

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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.

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