KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 25 June 2026
Revised 04 September 2026
Accepted 11 October 2026
Initial Publication 09 November 2026
Final Publication 01 December 2026

Psychological Research in Individuals with Exceptional Needs

Volume 4, Issue 4, pp 1-15



E-ISSN: 3060-6713

Comparison of the Effectiveness of Aerobic Exercise Training and Neuro-Linguistic Programming (NLP) Strategies on Executive Functions in Students with Learning Disabilities

Faezeh. Babaee Arboosara[1], Ali. Taghvaei Neya[2*], Hoshang. Jadidi[3]

[1] Ph.D. Student, Department of Educational Psychology, Sa.C., Islamic Azad University, Sanandaj, Iran
[2] Associate Professor, Department of Psychology, Yasuj University, Yasuj, Iran
[3] Department of Psychology, Sa.C., Islamic Azad University, Sanandaj, Iran

*** Corresponding author email address**: Ali.taghvaei@yu.ac.ir

A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Babaee Arboosara, F., Taghvaei Neya, A., & Jadidi, H. (2026). Comparison of the Effectiveness of Aerobic Exercise Training and Neuro-Linguistic Programming (NLP) Strategies on Executive Functions in Students with Learning Disabilities. *Psychological Research in Individuals with Exceptional Needs*, *4*(4), 1-15.
https://doi.org/10.61838/kman.prien.6667

© 2026 the authors. Published by KMAN Publication Inc. (KMANPUB), Ontario, Canada. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) License.

A B S T R A C T

The present study aimed to compare the effectiveness of aerobic exercise training and neuro-linguistic programming (NLP) strategies on sustained attention, planning, and organization in students with learning disabilities. This quasi-experimental study employed a pretest–posttest design with a control group and a two-month follow-up. The statistical population consisted of students with learning disabilities attending educational and clinical centers in the Mehrshahr district of Karaj during the 2024–2025 academic year. Using convenience sampling, 45 eligible students aged 13–15 years were selected and randomly assigned to three groups: aerobic exercise training (n = 15), NLP strategies training (n = 15), and control (n = 15). The two experimental groups received their respective interventions over a two-month period, whereas the control group received no intervention. Executive functions were assessed using the Behavior Rating Inventory of Executive Function, Teacher Form (BRIEF), at pretest, posttest, and follow-up. Data were analyzed using repeated-measures analysis of variance and Bonferroni post-hoc comparisons in SPSS version 26. Repeated-measures analysis showed significant time and group effects for sustained attention ($F = 31.804$, $p < .001$, partial $\eta^2 = .602$; $F = 18.720$, $p < .001$, partial $\eta^2 = .471$), planning ($F = 63.613$, $p < .001$, partial $\eta^2 = .752$; $F = 7.289$, $p = .002$, partial $\eta^2 = .258$), and organization ($F = 62.953$, $p < .001$, partial $\eta^2 = .623$; $F = 6.405$, $p = .004$, partial $\eta^2 = .234$). Bonferroni comparisons indicated that both aerobic exercise and NLP significantly improved sustained attention and planning compared with the control group, while no significant difference was found between the two interventions. For organization, only the NLP group differed significantly from the control group ($p = .003$), whereas aerobic exercise did not ($p = .630$). Both aerobic exercise training and NLP strategies can improve sustained attention and planning in students with learning disabilities, while NLP strategies may offer a more specific benefit for organizational functioning.

Keywords: *Aerobic Exercise, Neuro-Linguistic Programming, Executive Functions, Sustained Attention, Planning, Organization, Learning Disabilities*

1. Introduction

Learning disabilities constitute a major group of neurodevelopmental difficulties that can interfere with students' acquisition and application of academic skills despite adequate educational opportunities and generally intact intellectual capacity. Their consequences are not confined to reading, writing, or mathematics; rather, many students with learning disabilities experience broader cognitive and self-regulatory difficulties that influence how effectively they initiate tasks, maintain attention, organize information, monitor performance, and adapt their behavior to changing academic demands. These difficulties become particularly important during adolescence, when schoolwork increasingly requires independent planning, sustained engagement, flexible allocation of cognitive resources, and systematic management of multiple tasks. Contemporary research on children and adolescents with neurodevelopmental disorders has therefore increasingly shifted from a narrow focus on academic achievement toward the examination of executive functions as fundamental mechanisms underlying adaptive learning and everyday functioning (Carcelén-Fraile et al., 2025; Liang et al., 2026). Evidence concerning physical activity and psychological functioning in neurodevelopmental populations further indicates that cognitive, behavioral, and emotional processes are closely interconnected and may respond to appropriately designed non-pharmacological interventions (Liu et al., 2024; Yang et al., 2022).

Executive functions refer to a set of higher-order cognitive and behavioral control processes that enable individuals to regulate goal-directed activity. These functions include inhibition, working memory, cognitive flexibility, planning, organization, monitoring, and the ability to sustain attention long enough to complete an intended task. In the educational context, planning allows students to anticipate task requirements, establish goals, sequence actions, and allocate resources, whereas organization enables them to structure information and materials in a manner that facilitates efficient task completion. Sustained attention is similarly essential because academic learning requires students to remain focused on relevant information while resisting distraction over extended periods. Deficiencies in these processes can produce disorganized performance, incomplete assignments, inefficient problem solving, and reduced academic productivity even when students possess sufficient knowledge to perform a task. Studies involving children with learning disabilities have directly demonstrated meaningful associations among physical fitness, sustained attention, and academic performance, highlighting the importance of attentional control as a potential target for intervention in this population (Chang et al., 2025). More broadly, research on developmental disabilities suggests that motor competence, cognitive regulation, and executive functioning are interrelated domains that should not be treated as entirely separate therapeutic targets (Koper & Rękosiewicz, 2024; Vandoni et al., 2023).

One increasingly investigated approach to strengthening cognition and executive functioning is physical exercise. Physical activity can influence cognitive performance through multiple interacting physiological and neurobehavioral mechanisms, including increased cerebral blood flow, improved cardiovascular efficiency, regulation of neurotrophic processes, enhancement of neural plasticity, and repeated engagement of attention and behavioral control during movement. Reviews of the neural effects of physical activity in developmental disabilities indicate that movement-based interventions may influence brain systems involved in cognitive control and adaptive functioning (Su et al., 2022). Exercise-related neurobiological mechanisms have also been linked to factors such as insulin-like growth factor-1 and other pathways involved in neuronal health and cognitive functioning (He et al., 2023). Research in neurodegenerative conditions similarly indicates that physical exercise may support cognitive functioning through vascular, metabolic, molecular, and neuroplastic mechanisms, suggesting that exercise should be conceptualized not merely as physical conditioning but also as a potentially cognition-enhancing intervention (Dotson et al., 2021; Farì et al., 2021).

Aerobic exercise is particularly relevant because it involves rhythmic, sustained activation of large muscle groups and places continuous demands on cardiovascular and respiratory systems. Such exercise may produce both acute and cumulative cognitive effects. Evidence across different populations indicates that aerobic activity can influence attention, processing efficiency, memory, and executive processes, although the magnitude of improvement can vary according to population characteristics, exercise intensity, duration, and baseline cognitive status (Han, 2023; Yates et al., 2025). A recent systematic review and meta-analysis focusing specifically on adolescents reported beneficial effects of physical exercise on cognitive functioning, reinforcing the relevance of exercise during a developmental period characterized by

E-ISSN: 3060-6713

continued maturation of prefrontal systems involved in executive control (Liu et al., 2025). Furthermore, a dose-response meta-analysis of aerobic exercise and executive function in children suggests that exercise characteristics matter and that cognitive benefits may depend on how the intervention is prescribed rather than simply on whether children are physically active (Wang et al., 2025).

The potential value of aerobic interventions is especially pertinent to children and adolescents with developmental, learning, or cognitive difficulties. A systematic review and meta-analysis of children and adolescents with neurodevelopmental disorders found that physical activity can produce meaningful effects on executive functioning and emotional regulation, supporting its inclusion in multimodal developmental interventions (Carcelén-Fraile et al., 2025). Community-based programs for children and youth with neurodevelopmental disabilities have also been examined as practical means of promoting cognitive outcomes through structured physical participation (Gitimoghaddam et al., 2021). In students with learning disabilities specifically, aerobic dance programs have been developed to combine repetitive movement, rhythm, coordination, and cognitive engagement, with findings supporting the feasibility of such programs for promoting cognitive development in secondary-school settings (Huszaini & Shahril, 2023). These observations are important because school-age interventions must be not only theoretically effective but also sufficiently engaging and practicable for implementation with students who may already experience frustration and reduced persistence in conventional academic tasks.

Evidence supporting the cognitive potential of exercise also extends to individuals with intellectual and developmental disabilities. Acute comparisons of aerobic and resistance exercise have shown that different forms of physical activity can have differential cognitive consequences in individuals with intellectual disability (Borji et al., 2022). Programs involving dance-oriented exercise have likewise been associated with functional benefits among adults with developmental disabilities, illustrating the potential of rhythmic and socially engaging exercise formats across populations with cognitive vulnerabilities (Munn et al., 2023). Movement-based rehabilitation studies further suggest that motor interventions may interact with cognition rather than operating only through improvements in physical performance (Varalta et al., 2022). Such findings are consistent with the view that exercise can create a cognitively enriched context in which participants must attend to instructions, regulate pace, coordinate sequences, monitor errors, and adapt movements, thereby repeatedly recruiting executive control processes.

The exercise–cognition relationship has also been examined extensively in clinical neurological populations, providing additional evidence about mechanisms and intervention parameters. Randomized and controlled research has investigated moderate-intensity aerobic exercise in individuals with stroke-related cognitive impairment, with results supporting the feasibility of targeting cognitive outcomes through structured aerobic training (Huang et al., 2024). Exercise interventions have similarly been investigated in post-stroke cognitive rehabilitation using traditional movement practices and combined cognitive-exercise approaches (Sun et al., 2021; Zheng et al., 2020). A systematic review of combined aerobic exercise and cognitive training in stroke populations suggested that integrating physical and cognitive stimulation may offer advantages for cognitive rehabilitation (Amorós-Aguilar et al., 2021). Moreover, aerobic exercise combined with explicit memory-strategy training has been examined as an intervention designed to simultaneously engage physiological and cognitive mechanisms (Yao et al., 2023). These findings collectively suggest that exercise may be especially useful when it is embedded in a broader framework of active cognitive engagement rather than regarded as an isolated physical activity.

Similar patterns have been studied in multiple sclerosis and other neurological conditions. Meta-analytic evidence indicates that exercise training can influence cognitive performance in persons with multiple sclerosis, although outcomes vary across trials and intervention characteristics (Gharakhanlou et al., 2020). High-intensity aerobic exercise has been evaluated in randomized trials targeting cognitive performance in this population (Langeskov-Christensen et al., 2020), while more recent studies have examined exercise approaches such as blood-flow-restriction training in relation to cognition and sleep quality (Cano-Sánchez et al., 2026). At the same time, not all observational findings show straightforward associations between fitness, habitual activity, and cognition, indicating that simply possessing higher cardiorespiratory fitness may not be equivalent to receiving a structured cognitive-relevant exercise intervention (Sandroff et al., 2021). Research in other neurological and vascular populations, including individuals with cerebral small-vessel disease, has likewise explored whether aerobic exercise can protect or improve cognition

E-ISSN: 3060-6713

(Wong et al., 2021). Randomized investigations in Alzheimer's disease have further contributed to the evidence base on aerobic exercise and cognition, while emphasizing that responsiveness may depend on disease severity and intervention characteristics (Yu et al., 2021). Thus, although populations differ substantially from school-aged students with learning disabilities, the broader literature supports a biologically and behaviorally plausible relationship between structured physical exercise and cognitive functioning.

Exercise has additionally been considered as a therapeutic component in populations in which neurodevelopmental or medical factors create increased vulnerability to cognitive dysfunction. Reviews involving individuals with Fontan circulation have proposed exercise as a potentially relevant intervention for neurodevelopmental and cognitive difficulties (Verrall et al., 2023). Randomized research has also examined aerobic exercise for neurocognitive disorders associated with HIV, demonstrating the continued expansion of exercise-based cognitive rehabilitation across clinical groups (Nweke et al., 2022). Multi-domain interventions combining physical, cognitive, and health-related components have similarly been investigated in populations at risk of cognitive decline (Sánchez-Arenas et al., 2024), while dual-task exercise programs have been designed specifically to strengthen cognitive and vascular health by requiring simultaneous physical and cognitive engagement (Sánchez-Arenas et al., 2020). Collectively, these approaches reinforce the principle that cognitive functioning may be modified through interventions that challenge both the body and executive control systems.

However, exercise represents only one possible route for improving executive functions. Cognitive and behavioral interventions may target executive difficulties more directly by teaching individuals to regulate internal representations, establish goals, restructure unhelpful patterns, rehearse desired responses, and organize behavior systematically. A recent network meta-analysis of non-pharmacological executive-function interventions for children and adolescents with neurodevelopmental disorders underscores the growing interest in comparing different intervention modalities rather than assuming that one approach is universally optimal (Liang et al., 2026). Interventions involving cognitive training, strategy instruction, digital technologies, and techniques aimed at modifying attentional and behavioral patterns are increasingly being examined as means of promoting adaptive neurocognitive functioning (Gkora & Driga, 2023). This broader intervention literature provides a rationale for evaluating structured neuro-linguistic programming strategies as a psychologically oriented approach that may influence executive functioning through goal formulation, cognitive reframing, self-directed language, mental rehearsal, attention to internal cues, and the organization of behavioral sequences.

Neuro-linguistic programming (NLP) is based on the premise that patterns of language, cognition, subjective representation, and behavior can be identified and deliberately modified to facilitate more adaptive responses. Within an educational intervention, NLP-oriented strategies may be applied to help students clarify goals, break complex tasks into smaller steps, recognize ineffective internal dialogue, construct alternative interpretations, mentally rehearse successful task completion, and use structured cues to regulate attention and behavior. From an executive-function perspective, these activities are theoretically relevant to planning and organization because they require the learner to represent an intended outcome, sequence actions, monitor current performance in relation to that outcome, and revise behavior when necessary. They may also support sustained attention by increasing goal salience and helping students redirect cognitive resources toward task-relevant cues. Although the present evidence base is much stronger for exercise and established cognitive-training interventions than for NLP specifically, the increasing emphasis on multimodal, individualized, non-pharmacological approaches makes direct comparative evaluation scientifically useful.

The potential advantage of comparing a physiologically oriented intervention with a cognitively and behaviorally oriented intervention becomes particularly apparent when considering the heterogeneity of students with learning disabilities. Some students may respond strongly to interventions that increase arousal, fitness, movement coordination, and neurobiological readiness for learning, whereas others may benefit more from explicit strategies for planning, self-regulation, and task organization. Research combining nutritional treatment with aerobic exercise in children with attention-related neurodevelopmental difficulties has shown that executive functioning can be considered alongside symptoms, cognition, and sleep within integrated intervention frameworks (Ye & Wang, 2025). Narrative evidence concerning physical activity and executive function in children similarly emphasizes that the relationship between exercise and cognition is shaped by developmental, behavioral, and neural factors rather than by a single mechanism (Guzmán-Muñoz et al., 2025). Consequently, comparative designs can provide more

E-ISSN: 3060-6713

clinically and educationally informative evidence than studies examining only whether one intervention differs from no treatment.

Another consideration is the durability of treatment effects. Improvements observed immediately after an intervention are valuable, but for students with learning disabilities, practical significance also depends on whether gains persist after structured training ends. Executive skills must be transferred to classroom activities, homework, and daily self-management if interventions are to produce meaningful educational consequences. Studies of combined cognitive and exercise interventions, multi-domain programs, and rehabilitation protocols indicate that repeated practice and the integration of multiple mechanisms may be important for maintaining cognitive gains (Amorós-Aguilar et al., 2021; Sánchez-Arenas et al., 2024). The literature also suggests that cognitive outcomes can differ according to baseline capacity, exercise responsiveness, and individual characteristics, making follow-up assessment especially important when determining whether short-term changes reflect stable improvement (Yates et al., 2025). For this reason, examining pre-intervention, immediate post-intervention, and follow-up performance offers a more rigorous evaluation of intervention effectiveness than relying solely on immediate posttest differences.

Despite the expanding evidence supporting exercise-based and non-pharmacological cognitive interventions, several gaps remain. Much of the exercise–cognition literature has focused on older adults, neurological rehabilitation, intellectual disability, or broad neurodevelopmental populations rather than adolescents specifically diagnosed with learning disabilities. Studies involving children increasingly support relationships among physical activity, executive functioning, and brain-related outcomes, yet the optimal form of intervention and the relative effectiveness of exercise compared with structured psychological strategy training remain insufficiently clarified (Guzmán-Muñoz et al., 2025; Wang et al., 2025). Moreover, sustained attention, planning, and organization represent distinct but interdependent aspects of executive functioning, and an intervention that benefits one domain may not necessarily produce equivalent effects on the others. Accordingly, a direct comparison between aerobic exercise training and NLP-based planning strategies can contribute to identifying whether these approaches demonstrate comparable or differential effects across specific executive-function domains.

Therefore, the aim of the present study was to compare the effectiveness of aerobic exercise training and neuro-linguistic programming (NLP) strategies on sustained attention, planning, and organization in students with learning disabilities.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a quasi-experimental design with pretest, posttest, and two-month follow-up assessments and a control group. The study population consisted of all students with learning disabilities who attended educational and clinical learning-disability centers in the Mehrshahr district of Karaj during the 2024–2025 academic year. Participants were initially recruited through convenience sampling from eligible students referred to these centers. After screening according to the inclusion and exclusion criteria, 45 students were selected and randomly assigned to three groups of equal size: an aerobic exercise training group (n = 15), a neuro-linguistic programming strategies group (n = 15), and a control group (n = 15). The sample size was determined based on Cohen's recommendations for comparing three groups, considering a medium effect size, an alpha level of .05, and an acceptable level of statistical power. Random assignment was employed to distribute the eligible participants among the three study groups and reduce potential systematic differences between the groups. The inclusion criteria were a confirmed learning disability, an age range of 13 to 15 years, intelligence within the normal range, absence of comorbid attention-deficit/hyperactivity disorder, absence of significant psychological or physical disorders that could interfere with participation, and willingness of the student and family to participate in the study. The exclusion criteria included absence from more than one intervention session, unwillingness or lack of cooperation on the part of the student or family, and behavioral restlessness or inability to tolerate the conditions of the intervention. Before the interventions, all three groups completed the pretest assessment of executive functions. Participants assigned to the first experimental group subsequently received aerobic exercise training, whereas those assigned to the second experimental group received training in neuro-linguistic programming strategies. Participants in the control group received no corresponding experimental intervention during the study period. Immediately after completion of the two-month interventions, all three groups underwent posttest

E-ISSN: 3060-6713

assessment using the same outcome measure. A follow-up assessment was conducted two months after completion of the intervention to evaluate the maintenance of intervention effects over time. Age, gender, and baseline scores were considered relevant control characteristics when examining the comparability of the study groups. Participants and their families were informed about the study procedures, voluntary participation, confidentiality of their information, and their right to withdraw from the study.

2.2. Measures

Executive functions were assessed using the Behavior Rating Inventory of Executive Function, Teacher Form (BRIEF) developed by Gioia, Isquith, Guy, and Kenworthy in 2000. The instrument is designed for the behavioral assessment of executive functioning in children and adolescents aged 5 to 18 years and consists of 86 items completed by a teacher familiar with the student's everyday behavior. Each item is scored on a three-point Likert-type scale reflecting the frequency with which the described behavior occurs. The BRIEF evaluates eight major domains of executive functioning, including inhibition, shifting, emotional control, initiation, working memory, planning/organization, organization of materials, and monitoring, while the combination of its clinical scales provides broader indices of executive functioning. Of particular relevance to the objectives of the present study were the planning and organizational dimensions, which reflect the student's ability to anticipate future events, establish goals, organize appropriate steps for completing tasks, manage activities within an appropriate time framework, and systematically organize personal materials and task-related information. Completion of the teacher form generally requires approximately 10 to 15 minutes. The BRIEF has been extensively applied to populations with developmental and neuropsychological difficulties, including students with learning disabilities. Previous psychometric investigations have demonstrated satisfactory reliability for the instrument, with test–retest coefficients reported as approximately .88 for teacher ratings and .82 for parent ratings, while the internal consistency coefficient for the teacher form has been reported at approximately .88. Evidence for convergent and discriminant validity has also been established through associations with other behavioral and emotional functioning measures and through the instrument's ability to differentiate children and adolescents with executive-function difficulties from typically developing individuals. In the present study, the teacher form was administered at the pretest, posttest, and follow-up stages under comparable conditions.

2.3. Interventions

Participants assigned to the first experimental group received a structured aerobic exercise intervention over a period of two months. The program was designed to provide regular, developmentally appropriate physical activity involving continuous and rhythmic movements of large muscle groups. Each training session followed a structured sequence beginning with warm-up activities intended to prepare the musculoskeletal and cardiovascular systems for exercise, followed by the main aerobic component and ending with gradual cool-down and stretching activities. The principal exercises included rhythmic whole-body movements, coordinated upper- and lower-limb activities, locomotor exercises, repeated movement sequences, and other age-appropriate aerobic activities requiring sustained engagement and motor coordination. The intensity and complexity of the exercises were increased progressively according to the participants' capabilities so that the students could remain actively involved without excessive physical strain. In addition to their physical component, the exercises required participants to follow movement sequences, respond to instructions, regulate their pace, maintain task engagement, coordinate successive actions, and organize their behavior according to the structure of the activity. Particular attention was paid to maintaining a supportive and motivating environment appropriate for adolescents with learning disabilities. The intervention was implemented consistently throughout the two-month period, whereas participants in the control group did not participate in the aerobic training program during the study period.

Participants assigned to the second experimental group received a structured program based on neuro-linguistic programming strategies over a period of two months. The intervention focused on helping students identify and modify cognitive, linguistic, and behavioral patterns that could interfere with effective self-regulation and executive functioning. Training activities emphasized the formulation of clear and achievable goals, breaking complex tasks into manageable steps, increasing awareness of internal dialogue, replacing maladaptive or discouraging self-statements with more constructive patterns, mental rehearsal of successful task performance, visualization of desired outcomes, reframing of difficult academic or everyday situations, and

E-ISSN: 3060-6713

the use of cues or anchors to facilitate more adaptive emotional and behavioral states. Students were also encouraged to identify ineffective patterns in approaching tasks and to develop alternative strategies for planning, organizing, initiating, and monitoring their actions. The training incorporated guided practice, modeling, individual exercises, structured feedback, and repeated rehearsal so that participants could apply the learned strategies to academic and daily-life situations. As the intervention progressed, students were encouraged to use goal-oriented thinking, organize sequences of actions before beginning a task, evaluate their progress during task completion, and revise ineffective approaches when necessary. The intervention was implemented consistently throughout the two-month training period. Participants assigned to the control group did not receive neuro-linguistic programming training or aerobic exercise training during the experimental phase of the study.

2.4. Data Analysis

The collected data were analyzed using descriptive and inferential statistical procedures in SPSS version 26. Descriptive statistics were used to summarize participants' demographic characteristics and the distribution of executive-function scores across the pretest, posttest, and follow-up stages, with quantitative variables described using means and standard deviations and categorical characteristics summarized using frequencies and percentages. The comparability of the three groups with respect to relevant baseline and demographic characteristics was examined using appropriate statistical procedures, including chi-square tests for categorical variables and analysis of variance for quantitative variables. To evaluate changes in executive-function outcomes across the three measurement occasions and compare the pattern of change among the aerobic exercise, neuro-linguistic programming, and control groups, repeated-measures analysis of variance was conducted. Before inferential analyses, the statistical assumptions associated with repeated-measures analysis were examined. Homogeneity of variances was evaluated using Levene's test, equality of covariance matrices was assessed using Box's M test where applicable, and the sphericity assumption was examined using Mauchly's test. When the assumption of sphericity was violated, an appropriate correction such as the Greenhouse–Geisser adjustment was applied. Significant overall effects were followed by appropriate pairwise comparisons to determine differences between measurement occasions and study groups. All statistical tests were interpreted at a significance level of .05, and effect sizes were reported where appropriate to indicate the magnitude of the observed intervention effects.

3. Findings and Results

Descriptive and inferential analyses were conducted to examine changes in sustained attention, planning, and organization across the pretest, posttest, and two-month follow-up assessments in the aerobic exercise training, neuro-linguistic programming (NLP) strategies, and control groups. Each group consisted of 15 students, resulting in a total sample of 45 participants. The descriptive statistics for the three outcome variables across the three measurement occasions are presented in Table 1.

Table 1

Descriptive Statistics for Sustained Attention, Planning, and Organization by Group and Measurement Stage

Variable	Stage	Aerobic Exercise M (SD)	NLP Strategies M (SD)	Control M (SD)
Sustained Attention	Pretest	6.53 (1.30)	6.26 (1.22)	6.34 (1.11)
	Posttest	8.66 (1.79)	10.26 (2.40)	5.86 (1.35)
	Follow-up	8.80 (1.65)	11.00 (2.17)	5.80 (1.26)
Planning	Pretest	13.46 (2.74)	14.60 (3.20)	12.93 (2.08)
	Posttest	9.80 (3.27)	7.80 (3.01)	13.66 (2.82)
	Follow-up	8.73 (3.17)	6.26 (2.81)	13.53 (2.61)
Organization	Pretest	9.33 (2.09)	10.13 (1.99)	9.00 (1.64)
	Posttest	7.93 (2.28)	5.86 (1.59)	9.80 (2.07)
	Follow-up	8.40 (2.65)	4.93 (1.86)	9.53 (2.44)

As shown in Table 1, the three groups had relatively similar mean scores at pretest across sustained attention, planning, and organization. Following the interventions, sustained attention scores increased in both experimental

E-ISSN: 3060-6713

groups, with a larger descriptive improvement observed in the NLP strategies group. The mean sustained attention score increased from 6.53 at pretest to 8.66 at posttest and 8.80 at follow-up in the aerobic exercise group, whereas it increased from 6.26 to 10.26 and subsequently to 11.00 in the NLP group. In contrast, the control group demonstrated little change over time. For planning, mean scores decreased from 13.46 to 9.80 and 8.73 in the aerobic exercise group and from 14.60 to 7.80 and 6.26 in the NLP group, while the control group's scores remained comparatively stable. A similar pattern was observed for organization, with the most pronounced descriptive reduction occurring in the NLP group, from 10.13 at pretest to 5.86 at posttest and 4.93 at follow-up. Given the direction of scoring on the relevant BRIEF domains, lower planning and organization scores indicate fewer executive-function difficulties and therefore better functioning.

Before conducting the repeated-measures analyses of variance, the relevant statistical assumptions were evaluated. Shapiro–Wilk tests indicated no significant departure from normality for sustained attention, planning, or organization in any of the three groups, with all significance values exceeding .05. Homogeneity of variance was also supported by Levene's tests at pretest, posttest, and follow-up. For sustained attention, the Levene statistics were $F = 0.749$, $p = .479$ at pretest, $F = 1.724$, $p = .191$ at posttest, and $F = 0.622$, $p = .542$ at follow-up. For planning, the corresponding values were $F = 0.064$, $p = .938$, $F = 0.408$, $p = .668$, and $F = 0.566$, $p = .572$, while for organization they were $F = 0.650$, $p = .527$, $F = 0.269$, $p = .765$, and $F = 0.611$, $p = .548$. Mauchly's test of sphericity was significant for sustained attention, $W = .523$, $p < .001$, planning, $W = .388$, $p < .001$, and organization, $W = .408$, $p < .001$, indicating violation of the sphericity assumption. Therefore, the Greenhouse–Geisser correction was applied to the within-subject effects. Collectively, these results supported the appropriateness of proceeding with repeated-measures analysis of variance using corrected degrees of freedom where necessary.

Table 2

Repeated-Measures Analysis of Variance for Sustained Attention, Planning, and Organization

Variable	Effect	F	p	Partial η^2
Sustained Attention	Time	31.804	< .001	.602
	Group	18.720	< .001	.471
Planning	Time	63.613	< .001	.752
	Group	7.289	.002	.258
Organization	Time	62.953	< .001	.623
	Group	6.405	.004	.234

As presented in Table 2, repeated-measures analysis revealed significant changes over time for all three dependent variables. Sustained attention showed a significant time effect, $F = 31.804$, $p < .001$, partial $\eta^2 = .602$, indicating substantial changes across the pretest, posttest, and follow-up assessments. A significant between-group effect was also observed, $F = 18.720$, $p < .001$, partial $\eta^2 = .471$. Planning likewise demonstrated a significant time effect, $F = 63.613$, $p < .001$, partial $\eta^2 = .752$, as well as a significant group effect, $F = 7.289$, $p = .002$, partial $\eta^2 = .258$. Organization also differed significantly across measurement occasions, $F = 62.953$, $p < .001$, partial $\eta^2 = .623$, and a significant between-group difference was identified, $F = 6.405$, $p = .004$, partial $\eta^2 = .234$. These findings demonstrate that the interventions were associated with significant changes in executive-function outcomes over time and that the three groups differed significantly in their overall patterns of performance.

Table 3

Bonferroni Post-Hoc Pairwise Comparisons Between Study Groups

Variable	Group Comparison	Mean Difference	p
Sustained Attention	Aerobic Exercise vs. NLP Strategies	-1.178	.091
	Aerobic Exercise vs. Control	2.000	< .001
	NLP Strategies vs. Control	3.178	< .001
Planning	Aerobic Exercise vs. NLP Strategies	1.111	.860
	Aerobic Exercise vs. Control	-2.711	.035
	NLP Strategies vs. Control	-3.822	.002

E-ISSN: 3060-6713

Organization	Aerobic Exercise vs. NLP Strategies	1.578	.087
	Aerobic Exercise vs. Control	-0.889	.630
	NLP Strategies vs. Control	-2.467	.003

The Bonferroni pairwise comparisons presented in Table 3 provided further clarification regarding the differences between the study groups. For sustained attention, both the aerobic exercise group and the NLP strategies group differed significantly from the control group, with mean differences of 2.000 ($p < .001$) and 3.178 ($p < .001$), respectively. However, the difference between the two intervention groups was not statistically significant, mean difference = -1.178, $p = .091$, indicating that although the descriptive improvement was greater in the NLP group, neither intervention could be considered statistically superior to the other for sustained attention. For planning, both aerobic exercise and NLP strategies resulted in significant differences relative to the control group, with mean differences of -2.711 ($p = .035$) and -3.822 ($p = .002$), respectively. The comparison between aerobic exercise and NLP strategies was not significant, mean difference = 1.111, $p = .860$, indicating comparable effectiveness of the two interventions in improving planning. For organization, however, only the NLP strategies group differed significantly from the control group, mean difference = -2.467, $p = .003$. The difference between aerobic exercise and the control group was not statistically significant, mean difference = -0.889, $p = .630$, and the difference between the two intervention groups also did not reach statistical significance, mean difference = 1.578, $p = .087$. Thus, the findings indicate that both interventions were effective in improving sustained attention and planning compared with the control condition, whereas statistically significant improvement in organization relative to the control group was demonstrated only for the NLP strategies intervention.

4. Discussion

The present study compared the effectiveness of aerobic exercise training and neuro-linguistic programming (NLP) strategies on sustained attention, planning, and organization among students with learning disabilities. The findings indicated that both aerobic exercise and NLP strategies produced significant improvements in sustained attention compared with the control group, while the difference between the two intervention groups was not statistically significant. A similar pattern emerged for planning, as both intervention groups demonstrated significant improvement relative to the control group, but neither intervention was statistically superior to the other. For organization, however, the findings differed somewhat: NLP strategies produced a significant improvement compared with the control group, whereas aerobic exercise did not yield a statistically significant difference relative to the control condition. Moreover, although the mean organizational improvement was greater in the NLP group than in the aerobic exercise group, the direct difference between the two active interventions did not reach statistical significance. The repeated-measures analyses further demonstrated significant changes across pretest, posttest, and follow-up assessments, indicating that the intervention effects were not restricted to immediate post-intervention performance. Overall, the findings suggest that both interventions can improve important domains of executive functioning in students with learning disabilities, although NLP strategies may have a more specific advantage in relation to organizational functioning.

The significant effect of both interventions on sustained attention is consistent with a growing body of research showing that structured physical and cognitive interventions can strengthen attentional control in populations with neurodevelopmental and cognitive difficulties. In children with learning disabilities, physical fitness has been directly associated with sustained overt attention and academic performance, suggesting that attentional functioning is closely connected to the physical and cognitive condition of the learner (Chang et al., 2025). The present finding that aerobic exercise improved sustained attention is therefore compatible with previous evidence indicating that exercise can positively influence executive attention, inhibitory control, and broader cognitive functioning in children and adolescents (Guzmán-Muñoz et al., 2025; Liu et al., 2025). A recent meta-analysis focused on aerobic exercise and executive function in children similarly showed that aerobic activity can produce meaningful improvements in executive processes, although the magnitude of the effect depends on the characteristics of the training program (Wang et al., 2025). These findings support the interpretation that repeated aerobic activity may enhance the cognitive resources needed to maintain focus, resist distraction, and remain behaviorally engaged with ongoing tasks.

Several mechanisms may explain the observed effect of aerobic exercise on sustained attention. Aerobic activity

E-ISSN: 3060-6713

increases cardiovascular efficiency and cerebral blood flow and may contribute to greater oxygen and nutrient delivery to neural systems involved in attention and executive control. Exercise has also been associated with neurobiological mechanisms involving neurotrophic signaling, synaptic plasticity, and metabolic regulation, all of which can contribute to cognitive functioning (Farì et al., 2021; He et al., 2023). Physical activity and movement interventions have been shown to produce measurable neural effects in individuals with developmental disabilities, supporting the idea that exercise can alter functional systems underlying cognition rather than merely improving physical health (Su et al., 2022). In addition, aerobic activities require participants to maintain engagement, follow instructions, regulate pace, and coordinate motor sequences, thereby repeatedly activating attentional control processes. These combined physiological and behavioral demands may help explain why students who participated in aerobic exercise showed improved sustained attention after the intervention.

The improvement in sustained attention following NLP strategies can be explained through a different but complementary mechanism. NLP-oriented activities in the present study emphasized goal setting, mental rehearsal, restructuring internal dialogue, directed attention, and the use of cognitive cues to regulate behavior. Such strategies may strengthen the learner's ability to identify relevant goals and maintain cognitive engagement with task demands. This interpretation is consistent with the broader literature on non-pharmacological interventions for executive functioning in neurodevelopmental disorders, which shows that cognitive, behavioral, and strategy-based approaches can improve executive processes when they directly train self-regulation and goal-directed behavior (Liang et al., 2026). Technologically mediated and cognitive brain-rewiring approaches have similarly been discussed as potentially useful for improving attention and self-regulation in neurodevelopmental conditions (Gkora & Driga, 2023). Thus, whereas aerobic exercise may influence sustained attention partly through neurophysiological activation, NLP strategies may improve it through enhanced self-directed cognition and deliberate regulation of attention.

The lack of a statistically significant difference between aerobic exercise and NLP strategies in sustained attention is also meaningful. This finding suggests that distinct intervention pathways may ultimately converge on comparable improvements in attentional functioning. Exercise-based programs may increase cognitive readiness and neural efficiency, while cognitive-strategy programs may strengthen top-down control and goal-directed regulation. Previous studies combining physical and cognitive interventions have shown that both forms of stimulation may contribute to cognitive improvement, and in some cases integrated interventions have been developed specifically because physiological activation and cognitive strategy use are thought to be complementary (Amorós-Aguilar et al., 2021; Sun et al., 2021). Research combining aerobic exercise with explicit memory-strategy training has similarly demonstrated that cognitive benefits may emerge when physical and cognitive mechanisms are both engaged (Yao et al., 2023). Accordingly, the present finding does not necessarily imply that the two interventions operate in the same way; rather, they may reach similar attentional outcomes through different mechanisms.

The significant improvement in planning observed in both experimental groups also accords with previous findings on executive functioning. Planning is a complex executive process that requires goal formulation, sequencing, anticipation of consequences, monitoring, and flexible adjustment of behavior. Physical exercise has increasingly been shown to influence higher-order executive domains, particularly when the activity itself requires coordination, sequencing, and sustained cognitive engagement (Carcelén-Fraile et al., 2025; Guzmán-Muñoz et al., 2025). Programs involving bilateral integration, coordinated movement, and structured physical activity have been associated with improvements in cognition among individuals with developmental and intellectual disabilities (Koper & Rękosiewicz, 2024; Vandoni et al., 2023). These findings provide support for the current result because aerobic exercise sessions typically require participants to follow ordered movement sequences, anticipate upcoming actions, regulate timing, and adjust performance according to instructions, all of which may indirectly train processes related to planning.

The effect of aerobic exercise on planning may also reflect generalized enhancement of executive control. Meta-analytic and systematic evidence indicates that physical exercise can improve cognitive functioning in adolescents and in neurodevelopmental populations (Carcelén-Fraile et al., 2025; Liu et al., 2025). In students with learning disabilities, aerobic dance programs have demonstrated positive effects on cognitive development, suggesting that structured rhythmic movement may be particularly suitable for populations that experience academic and executive-function difficulties (Huszaini & Shahril, 2023). Similarly, community-based physical activity programs have been

E-ISSN: 3060-6713

associated with cognitive benefits in children and youth with neurodevelopmental disabilities (Gitimoghaddam et al., 2021). Such interventions may enhance planning by improving attentional stability, behavioral persistence, and the ability to coordinate sequential actions, thereby creating conditions under which students can more effectively approach complex tasks.

The finding that NLP strategies significantly improved planning is theoretically expected because planning was directly targeted within the intervention. Students were trained to define desired outcomes, divide tasks into manageable steps, anticipate task requirements, rehearse successful performance, and monitor progress toward goals. These processes closely correspond to the functional components of planning as an executive skill. The broader evidence on non-pharmacological executive-function interventions indicates that targeted cognitive strategies can be especially useful when they require learners to consciously regulate their own thinking and behavior (Liang et al., 2026). Multi-domain and dual-task interventions similarly emphasize the importance of active cognitive engagement for improving executive performance (Sánchez-Arenas et al., 2020; Sánchez-Arenas et al., 2024). Therefore, the improvement observed in the NLP group can plausibly be attributed to repeated practice in precisely those cognitive operations needed for effective planning.

The absence of a significant difference between aerobic exercise and NLP strategies for planning suggests that both approaches were capable of producing comparable gains, despite differing in their immediate intervention targets. This pattern is consistent with research showing that cognitive outcomes can be improved through multiple modalities. Studies in rehabilitation and clinical populations have demonstrated that both exercise alone and combinations of exercise with cognitive strategy training can produce benefits in executive and cognitive functioning (Amorós-Aguilar et al., 2021; Huang et al., 2024). Moreover, acute and chronic exercise studies have shown that cognitive improvement is not limited to a single exercise format and may occur across different forms of physical activity (Borji et al., 2022; Han, 2023). It is therefore possible that aerobic exercise improved planning through generalized executive enhancement, whereas NLP improved planning through direct strategic training, with both mechanisms ultimately producing comparable behavioral outcomes.

The pattern observed for organization was more differentiated. NLP strategies significantly improved organization relative to the control group, whereas aerobic exercise did not show a statistically significant advantage over the control condition. This finding may indicate that organization requires more explicit cognitive restructuring and strategy instruction than can be achieved through generalized physiological and executive benefits alone. Organizational functioning involves categorizing information, arranging materials, establishing orderly procedures, maintaining task structure, and coordinating multiple components of an activity. NLP strategies directly addressed several of these processes by encouraging students to break tasks into steps, construct internal representations of desired outcomes, use structured cues, and monitor the sequence of their actions. Such explicit training may have been more closely aligned with the behavioral demands of organization than aerobic exercise.

This interpretation is consistent with evidence suggesting that the effects of physical activity are not always uniform across all cognitive domains. Although exercise can improve executive functioning broadly, some executive components may respond more strongly than others depending on the nature and intensity of the intervention (Guzmán-Muñoz et al., 2025; Wang et al., 2025). Research in multiple sclerosis also indicates that physical fitness or habitual activity is not invariably associated with all aspects of cognition, highlighting the importance of considering domain-specific effects (Sandroff et al., 2021). Similarly, findings from aerobic exercise studies in neurological populations show that responsiveness can vary according to baseline cognitive capacity, intervention intensity, and the specific cognitive outcome examined (Gharakhanlou et al., 2020; Langeskov-Christensen et al., 2020). Therefore, the nonsignificant organizational effect of aerobic exercise in the present study should not be interpreted as evidence that exercise lacks cognitive value; instead, it suggests that organization may require more targeted cognitive and behavioral practice.

The stronger pattern for NLP in organization is also compatible with literature supporting strategy-based cognitive rehabilitation. Cognitive and movement interventions that explicitly combine task demands, mental structuring, and self-monitoring appear particularly useful for higher-order executive outcomes (Varalta et al., 2022; Yao et al., 2023). Multi-domain interventions likewise seek to enhance cognition through coordinated stimulation of multiple regulatory processes rather than relying on a single physiological mechanism (Sánchez-Arenas et al., 2024). In the context of learning disabilities, organizational difficulties often arise during academic tasks that require students to sequence information, manage materials, and

E-ISSN: 3060-6713

structure responses. An intervention such as NLP, which repeatedly trains goal representation and behavioral sequencing, may therefore have more direct ecological relevance to these difficulties.

The maintenance of intervention effects at follow-up is another important finding. For sustained attention and organization, the differences between posttest and follow-up were not significant, indicating that improvements were largely maintained after the interventions ended. Planning also showed continued improvement over time. The persistence of gains may reflect the acquisition of transferable behavioral and cognitive routines. Exercise interventions can produce cumulative adaptations that persist beyond individual sessions, especially when training is sufficiently repeated and structured (Liu et al., 2025; Wang et al., 2025). Cognitive strategies may likewise persist because participants can continue applying learned self-regulation techniques after formal training ends. Evidence from combined cognitive and exercise rehabilitation further suggests that repeated practice and multimodal cognitive engagement may support more durable improvements (Amorós-Aguilar et al., 2021; Sun et al., 2021). The present follow-up findings therefore strengthen the practical significance of the interventions by suggesting that their benefits were not merely transient responses to immediate training.

5. Conclusion

The overall pattern of findings is also consistent with the broader literature showing that exercise can promote cognition across a wide range of clinical and developmental populations. Positive cognitive effects have been reported in stroke-related impairment (Huang et al., 2024; Zheng et al., 2020), developmental disability (Munn et al., 2023), intellectual disability (Borji et al., 2022), and neurocognitive conditions associated with HIV (Nweke et al., 2022). Exercise has also been explored as a therapeutic strategy in neurodevelopmental and cognitive dysfunction associated with complex medical conditions (Verrall et al., 2023), while randomized studies in older adults and Alzheimer's disease have continued to investigate its potential for cognitive preservation and enhancement (Wong et al., 2021; Yu et al., 2021). Although these populations differ from adolescents with learning disabilities, the convergence of findings strengthens the argument that structured physical activity can influence cognitive functioning through mechanisms that are relevant across diagnostic boundaries. At the same time, the findings reinforce the importance of individualized and domain-specific intervention planning. Not every cognitive outcome responded in the same manner, and the comparative results suggest that intervention selection should depend on the executive-function difficulty being targeted. Recent evidence on non-pharmacological executive-function interventions emphasizes that treatment effects vary according to intervention modality and executive domain (Liang et al., 2026). The effectiveness of exercise may also depend on dosage, intensity, baseline characteristics, and individual responsiveness (Cano-Sánchez et al., 2026; Yates et al., 2025). Accordingly, the present study contributes to the literature by showing that aerobic exercise and NLP strategies can both be useful for sustained attention and planning, whereas NLP may be particularly advantageous when organizational difficulties are a central concern.

The present study had several limitations that should be considered when interpreting the findings. The sample was relatively small and was drawn through convenience sampling from learning-disability centers in one geographical area, which limits the generalizability of the results to broader populations of students with learning disabilities. The study also relied on teacher-reported executive-function ratings, which may be influenced by observer expectations, classroom context, or differences in teacher familiarity with individual students. In addition, the follow-up period was limited to two months, preventing conclusions about the long-term durability of intervention effects. Potential differences in students' motivation, extracurricular physical activity, family support, academic demands, and previous exposure to psychological or educational interventions were not fully controlled. Finally, the intervention groups may have differed in the extent to which participants perceived the training as engaging or personally meaningful, which could have influenced adherence and outcomes.

Future research should replicate these findings using larger and more diverse samples recruited from multiple schools, clinics, and regions and should employ randomized controlled designs where feasible. Longer follow-up periods are recommended to determine whether improvements in sustained attention, planning, and organization persist over six months or one year. Future studies could also compare different frequencies, intensities, and durations of aerobic training and examine which specific NLP strategies contribute most strongly to executive-function improvement. Including multiple assessment methods, such

E-ISSN: 3060-6713

as teacher ratings, parent ratings, direct neuropsychological tasks, and academic performance indicators, would provide a more comprehensive evaluation of executive functioning. It would also be useful to examine potential mediators and moderators, including age, gender, baseline executive-function severity, physical fitness, motivation, sleep quality, and learning-disability subtype. Comparative studies investigating combined aerobic and NLP interventions may further clarify whether integrating physiological and cognitive approaches produces additive or synergistic benefits.

From a practical perspective, schools, learning-disability centers, counselors, and rehabilitation professionals may consider incorporating structured aerobic activity and executive-function strategy training into support programs for students with learning disabilities. Aerobic exercise can be implemented through brief, regular, developmentally appropriate sessions embedded within school or rehabilitation schedules, whereas NLP-based strategies can be incorporated into academic coaching, counseling, and classroom self-regulation programs. Because both interventions were beneficial for sustained attention and planning, practitioners may select the approach that best fits available resources, student preferences, and institutional conditions. When organizational difficulties are especially prominent, more explicit strategy-based instruction may be particularly appropriate. Practitioners should also emphasize consistency, gradual progression, student engagement, and opportunities to apply learned skills to real academic tasks so that gains transfer from intervention sessions to everyday educational functioning.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

References

Amorós-Aguilar, L., Rodríguez-Quiroga, E., Sánchez-Santolaya, S., & Coll-Andreu, M. (2021). Effects of Combined Interventions With Aerobic Physical Exercise and Cognitive Training on Cognitive Function in Stroke Patients: A Systematic Review. *Brain Sciences*, *11*(4), 473. https://doi.org/10.3390/brainsci11040473

Borji, R., Affes, S., Zarrouk, N., Sahli, S., & Rebai, H. (2022). Acute Effects of Aerobic Versus Resistance Exercises on Cognitive Function in Individuals With Intellectual Disability. *Journal of Applied Research in Intellectual Disabilities*, *36*(1), 106-115. https://doi.org/10.1111/jar.13039

Cano-Sánchez, J., Carcelén-Fraile, M. d. C., & Muñoz-Perete, J. M. (2026). Blood Flow Restriction Training Improves Cognition Performance and Sleep Quality in Middle-Aged Adults With Relapsing–Remitting Multiple Sclerosis. *Physiologia*, *6*(1), 12. https://doi.org/10.3390/physiologia6010012

Carcelén-Fraile, M. d. C., Hita-Contreras, F., Mesas-Aróstegui, M. A., & Aibar-Almazán, A. (2025). Effects of Physical Activity on Executive Function and Emotional Regulation in Children and Adolescents With Neurodevelopmental Disorders: A Systematic Review and Meta-Analysis. *Healthcare*, *13*(19), 2415. https://doi.org/10.3390/healthcare13192415

Chang, H. W., Chiu, Y. H., Chou, C. C., Chen, J.-F., & Pan, C. C. (2025). Associations of Physical Fitness With Sustained Overt Attention and Academic Performance in Children With Learning Disabilities. *Peerj*, *13*, e19549. https://doi.org/10.7717/peerj.19549

Dotson, V. M., Gradone, A. M., Bogoian, H. R., Minto, L. R., Taiwo, Z., & Salling, Z. (2021). Be Fit, Be Sharp, Be Well: The Case for Exercise as a Treatment for Cognitive Impairment in Late-Life Depression. *Journal of the International Neuropsychological Society*, *27*(8), 776-789. https://doi.org/10.1017/s1355617721000710

Farì, G., Lunetti, P., Raele, M. V., Mintrone, G., Ranieri, M., Megna, M., & Capobianco, L. (2021). The Effect of Physical Exercise on Cognitive Impairment in Neurodegenerative Disease: From Pathophysiology to Clinical and Rehabilitative Aspects. *International Journal of Molecular Sciences*, *22*(21), 11632. https://doi.org/10.3390/ijms222111632

Gharakhanlou, R., Wesselmann, L., Rademacher, A., Lampit, A., Negaresh, R., Kaviani, M., Oberste, M., Motl, R. W., Sandroff, B. M., Bansi, J., Baker, J. S., Heesen, C., Zimmer, P., & Javelle, F. (2020). Exercise Training and Cognitive Performance in Persons With Multiple Sclerosis: A Systematic Review and Multilevel Meta-Analysis of Clinical

E-ISSN: 3060-6713

Trials. *Multiple Sclerosis Journal*, *27*(13), 1977-1993. https://doi.org/10.1177/1352458520917935

Gitimoghaddam, M., Vanderloo, L. M., Hung, R., Ryce, A., McKellin, W. H., Miller, A. R., & Collet, J. P. (2021). Impacts of Participation in Community-Based Physical Activity Programs on Cognitive Functions of Children and Youth With Neurodevelopmental Disabilities: A Scoping Review. *Brain Sciences*, *11*(2), 195. https://doi.org/10.3390/brainsci11020195

Gkora, V., & Driga, A. M. (2023). Virtual Reality, Digital Technologies and Brain Rewiring Techniques for Intervention in Attention-Deficit/Hyperactivity Disorder (Adhd). *Journal Health and Technology - JHT*, *2*(2), e2237. https://doi.org/10.47820/jht.v2i2.37

Guzmán-Muñoz, E., Concha-Cisternas, Y., Jofré-Saldía, E., Castillo-Paredes, A., Molina-Márquez, I., & Sepulveda, R. A. Y. (2025). Physical Activity and Its Effects on Executive Functions and Brain Outcomes in Children: A Narrative Review. *Brain Sciences*, *15*(11), 1238. https://doi.org/10.3390/brainsci15111238

Han, C. (2023). Effects of Aerobic Exercise on Cognitive Function in Different Populations. *Frontiers in Sport Research*, *5*(4). https://doi.org/10.25236/fsr.2023.050407

He, Y., Wang, Q., Wu, H.-D., Dong, Y.-M., Guo, X., & Jiang, N. (2023). The Role of IGF-1 in Exercise to Improve Obesity-Related Cognitive Dysfunction. *Frontiers in Neuroscience*, *17*. https://doi.org/10.3389/fnins.2023.1229165

Huang, Y., Ou, H., Lin, Q., Xue, Y., Xia, R., Tan, Z., Xiong, L., Yan, Z., & Wen, J. (2024). The Effects of Moderate-Intensity Aerobic Exercise on Cognitive Function in Individuals With Stroke-Induced Mild Cognitive Impairment: A Randomized Controlled Pilot Study. *Journal of Rehabilitation Medicine*, *56*, jrm33001. https://doi.org/10.2340/jrm.v56.33001

Huszaini, S., & Shahril, M. I. (2023). The Development of Aerobic Dance (ADa) Modules and Its Effectiveness Towards Cognitive Development of Students With Learning Disabilities at Secondary School Putrajaya, Malaysia. *International Journal of Academic Research in Business and Social Sciences*, *13*(5). https://doi.org/10.6007/ijarbss/v13-i5/17098

Koper, M., & Rękosiewicz, M. (2024). The Effect of the Bilateral Integration Exercise Program on the Cognitive Functioning of Pupils With Moderate Intellectual Disabilities. *Frontiers in Psychiatry*, *15*. https://doi.org/10.3389/fpsyt.2024.1409061

Langeskov-Christensen, M., Hvid, L. G., Jensen, H. B., Nielsen, H. H., Petersen, T., Stenager, E., Hämäläinen, P. I., & Dalgas, U. (2020). Efficacy of High-Intensity Aerobic Exercise on Cognitive Performance in People With Multiple Sclerosis: A Randomized Controlled Trial. *Multiple Sclerosis Journal*, *27*(10), 1585-1596. https://doi.org/10.1177/1352458520973619

Liang, X., Chen, M., Chan, R. C., Chang, J. R., Yeung, M. K., Hsu, C. L., Liu, C., Chen, Y., Xu, R. H., Yang, B., Yan, C., Qiu, H., Tse, A. C. Y., Shum, D., Chan, R. C. K., & Li, S. X. (2026). Non-Pharmacological Executive Function Interventions for Children and Adolescents With Neurodevelopmental Disorders: A Systematic Review and Network Meta-Analysis. *EClinicalMedicine*, *100*, 104228. https://doi.org/10.1016/j.eclinm.2026.104228

Liu, C., Liang, X., & Sit, C. H. P. (2024). Physical Activity and Mental Health in Children and Adolescents With Neurodevelopmental Disorders. *JAMA Pediatrics*, *178*(3), 247. https://doi.org/10.1001/jamapediatrics.2023.6251

Liu, L., Xin, X., & Zhang, Y. (2025). The Effects of Physical Exercise on Cognitive Function in Adolescents: A Systematic Review and Meta-Analysis. *Frontiers in psychology*, *16*. https://doi.org/10.3389/fpsyg.2025.1556721

Munn, E. E., Lang, D. M., Hynes, J., Northcutt, A., Patten, B., Wadsworth, D. D., & Pangelinan, M. M. (2023). The Effects of Virtual Zumba® on Functional Outcomes in Adults With Developmental Disabilities. *Medicine & Science in Sports & Exercise*, *55*(7), 1151-1159. https://doi.org/10.1249/mss.0000000000003157

Nweke, M., Mshunqane, N., Govender, N., Akinpelu, A. O., Ukwuoma, M., & Ogunniyi, A. O. (2022). Aerobic Exercise for HIV-associated Neurocognitive Disorders in Individuals on Antiretroviral Therapy: A Randomised Controlled Trial. *Clinical Rehabilitation*, *36*(12), 1601-1612. https://doi.org/10.1177/02692155221114587

Sánchez-Arenas, R., Doubova, S. V., Bernabé-García, M., Gregory, M. A., Mejía-Alonso, L. A., Orihuela-Rodríguez, Ó., Paredes-Manjarréz, C., Colin-Martínez, T., Mujica-Morales, I., Grijalva, I., Basurto-Acevedo, L., Manuel-Apolinar, L., Cuadros-Moreno, J., Bernal-Diaz, A., & Shigematsu, R. (2020). Double-Task Exercise Programmes to Strengthen Cognitive and Vascular Health in Older Adults at Risk of Cognitive Decline: Protocol for a Randomised Clinical Trial. *BMJ open*, *10*(12), e039723. https://doi.org/10.1136/bmjopen-2020-039723

Sánchez-Arenas, R., Grijalva, I., Manuel-Apolinar, L., & Orihuela, O. (2024). Multi-Domain Intervention Program on Cognitive Function in Community-Dwelling Older Adults: Pilot Study. https://doi.org/10.5281/zenodo.14200027

Sandroff, B. M., Motl, R. W., Amato, M. P., Brichetto, G., Chataway, J., Chiaravalloti, N. D., Cutter, G., Dalgas, U., DeLuca, J., Farrell, R. A., Feys, P., Filippi, M., Freeman, J. A., Inglese, M., Meza, C., Rocca, M. A., Salter, A. R., & Feinstein, A. (2021). Cardiorespiratory Fitness and Free-Living Physical Activity Are Not Associated With Cognition in Persons With Progressive Multiple Sclerosis: Baseline Analyses From the CogEx Study. *Multiple Sclerosis Journal*, *28*(7), 1091-1100. https://doi.org/10.1177/13524585211048397

Su, W.-C., Amonkar, N., Cleffi, C., Srinivasan, S. M., & Bhat, A. N. (2022). Neural Effects of Physical Activity and Movement Interventions in Individuals With Developmental Disabilities–A Systematic Review. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.794652

Sun, R., Li, X., Zhu, Z., Li, T., Li, W., Huang, P., & Gong, W. (2021). Effects of Combined Cognitive and Exercise Interventions on Poststroke Cognitive Function: A Systematic Review and Meta-Analysis. *BioMed Research International*, *2021*(1). https://doi.org/10.1155/2021/4558279

Vandoni, M., Giuriato, M., Pirazzi, A., Zanelli, S., Gaboardi, F., Pellino, V. C., Gazzarri, A. A., Baldassarre, P., Zuccotti, G., & Calcaterra, V. (2023). Motor Skills and Executive Functions in Pediatric Patients With Down Syndrome: A Challenge for Tailoring Physical Activity Interventions. *Pediatric Reports*, *15*(4), 691-706. https://doi.org/10.3390/pediatric15040062

Varalta, V., Righetti, A., Morone, G., Tamburin, S., Picelli, A., Fonte, C., Tinazzi, M., Vico, I. A. D., Waldner, A., Filippetti, M., & Smania, N. (2022). Effect of Upper Limb Motor Rehabilitation on Cognition in Parkinson's Disease: An Observational Study. *Brain Sciences*, *12*(12), 1684. https://doi.org/10.3390/brainsci12121684

Verrall, C. E., Tran, D., Yang, J. Y., Lubans, D. R., Winlaw, D. S., Ayer, J. G., Celermajer, D. S., & Cordina, R. (2023). Exercise as Therapy for Neurodevelopmental and Cognitive Dysfunction in People With a Fontan Circulation: A Narrative

E-ISSN: 3060-6713

Review. *Frontiers in Pediatrics*, *11*. https://doi.org/10.3389/fped.2023.1111785

Wang, Y., Yang, M., Li, W., Wang, L., & Fan, J. (2025). A Meta-Analysis of the Dose–response Relationship Between Aerobic Exercise and Executive Function in Children. *Frontiers in Public Health*, *13*. https://doi.org/10.3389/fpubh.2025.1608937

Wong, A., Lam, B. Y. K., Mak, K. Y., Lam, L. C. W., Au, L. W. C., Yiu, B., Yeung, S. K., Chu, C. W. W., Shi, L., Leung, T. W. H., Soo, Y. O. Y., Lau, A. Y. L., Ip, B. Y. M., Kwok, T. C. Y., Ko, H., & Mok, V. (2021). Aerobic Exercise in Older People With Subclinical Sporadic Cerebral Small Vessel Disease: A Randomized Clinical Trial. *Alzheimer S & Dementia Translational Research & Clinical Interventions*, *7*(1). https://doi.org/10.1002/trc2.12224

Yang, W., Liang, X., & Sit, C. H. P. (2022). Physical Activity and Mental Health in Children and Adolescents With Intellectual Disabilities: A Meta-Analysis Using the RE-AIM Framework. *International Journal of Behavioral Nutrition and Physical Activity*, *19*(1). https://doi.org/10.1186/s12966-022-01312-1

Yao, X., Wang, Y., & Wang, Z. (2023). Aerobic Exercise Combined With Memory Strategy Training Improve the Cognitive Function. *Brain and Behavior*, *13*(11). https://doi.org/10.1002/brb3.3234

Yates, B. A., Orkaby, A. R., Vingren, J. L., & Armstrong, L. E. (2025). Low Intrinsic Capacity Is Associated With a Blunted Exercise-induced Cognitive Enhancement in Physically Active Middle-aged and Older Adults. *Alzheimer S & Dementia Translational Research & Clinical Interventions*, *11*(3). https://doi.org/10.1002/trc2.70141

Ye, Y., & Wang, Y. (2025). Benefits of Multi-Micronutrient Nutritional Formula Combined With Aerobic Exercise on Children With Attention Deficit Hyperactivity Disorder: Improvements in Symptoms, Cognition, Executive Function, and Sleep. *Frontiers in Pediatrics*, *13*. https://doi.org/10.3389/fped.2025.1650588

Yu, F., Vock, D. M., Zhang, L., Salisbury, D. L., Nelson, N. W., Chow, L. S., Smith, G. E., Barclay, T. R., Dysken, M. W., & Wyman, J. F. (2021). Cognitive Effects of Aerobic Exercise in Alzheimer's Disease: A Pilot Randomized Controlled Trial. *Journal of Alzheimer's Disease*, *80*(1), 233-244. https://doi.org/10.3233/jad-201100

Zheng, G., Zheng, Y., Xiong, Z., & Ye, B. (2020). Effect of Baduanjin Exercise on Cognitive Function in Patients With Post-Stroke Cognitive Impairment: A Randomized Controlled Trial. *Clinical Rehabilitation*, *34*(8), 1028-1039. https://doi.org/10.1177/0269215520930256

E-ISSN: 3060-6713