Neuro-Exercise Interventions for Cognitive Function, Mental Well-Being, Academic Performance and Physical Fitness in Adolescents and Children: A Scoping Review

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DOI: https://doi.org/10.51584/IJRIAS.2026.11110002

Received: 09 November 2026; Accepted: 14 November 2026; Published: 20 November 2026

ABSTRACT

Background: Physical activity is vital for holistic growth, yet adolescents and Childrens increasingly face cognitive fatigue, heightened mental stress, academic burnout, and declining physical fitness. Neuro-exercise interventions—structured movement protocols designed to stimulate neuroplasticity by combining motor tasks with cognitive engagement—have emerged as a targeted approach to address these multifaceted challenges in pediatric and young populations.

Objectives: To map and synthesize existing literature on neuro-exercise interventions and evaluate their impact on cognitive function, mental well-being, academic performance, and physical fitness among adolescents and Childrens.

Methods: Following the PRISMA-ScR guidelines, a comprehensive search was conducted across PubMed, Scopus, Web of Science, and CINAHL for studies published up to 2026. Studies involving children and adolescents aged 6–18 years (receiving dual-task, exergaming, motor-cognitive training, or neuro-motor exercise interventions were included. Data were extracted and mapped according to intervention characteristics, outcome measures, and observed effects.

Results: A total of 24 studies met the inclusion criteria. Synthesis of the data demonstrated that neuro-exercise interventions significantly improved executive functioning, processing speed, and working memory compared to traditional aerobic exercise alone. Additionally, participants exhibited reductions in anxiety and stress scores, alongside enhanced mood states. Improvements in academic performance were mediated by heightened attentional control and executive functioning. Physical fitness outcomes, including dynamic balance, agility, and motor coordination, showed concurrent functional gains.

Conclusion*:* Neuro-exercise interventions offer an effective, multi-system approach to enhancing cognitive, psychological, academic, and physical domains in adolescents and Childrens. Integrating combined motor-cognitive exercise protocols into pediatric rehabilitation and wellness programs can foster comprehensive developmental health and academic resilience.

Keywords: Neuro-exercise, Cognitive Function, Mental Well-being, Academic Performance, Physical Fitness, Scoping Review, Pediatric Rehabilitation

INTRODUCTION

Adolescence and children (spanning ages 8 to 16 years) represent a critical neurodevelopmental period characterized by significant structural and functional brain remodeling, particularly within the prefrontal cortex and related frontoparietal networks. Concurrently, individuals in this age bracket face mounting environmental demands, including rigorous academic pressures, screen-dominated sedentary behaviors, diminished sleep quality, and heightened vulnerabilities to stress, anxiety, and cognitive fatigue.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue XI November 2026

Traditional aerobic or resistance exercise programs have consistently demonstrated positive physiological and physical health benefits. However, single-mode physical activity often fails to fully engage the cognitive and neural networks necessary to optimize higher-order executive functions and psychological resilience under cognitive strain.

Recently, **neuro-exercise interventions** also termed *motor-cognitive training*, *cognitively enriched physical exercise*, *exergaming*, or *simultaneous dual-task exercise* have gained prominence. These interventions leverage the concept of **guided neuroplasticity**: physical activity increases systemic and cerebral blood flow while upregulating brain-derived neurotrophic factor (BDNF), creating a neurochemically fertile environment. Simultaneously, embedded cognitive tasks force the functional activation and synaptic wiring of specific neural networks.

While individual studies have explored exergaming or dual-task training in specialized populations, the broader literature regarding integrated neuro-exercise regimens across cognitive, psychological, academic, and physical domains in young individuals remains heterogeneous. Therefore, this scoping review aims to map the current state of evidence, characterize intervention protocols, and identify gaps in research to inform clinical practice, school-based wellness, and future interventional trial design.

METHODS

Protocol and Guidelines

This review was conducted in accordance with the **Joanna Briggs Institute (JBI)** methodology for scoping reviews and reported adhering to the **PRISMA-ScR** (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) guidelines.

Eligibility Criteria

Studies were included based on the Population, Concept, and Context (PCC) framework:

Population: Adolescents and children aged 8 to 16 years, including both healthy populations and those in educational/rehabilitative settings.

Concept: Neuro-exercise interventions defined as structured protocols combining physical exercise with targeted cognitive demands (e.g., dual-task exercise, interactive exergaming, motor-cognitive training, cognitive-motor agility drills).

Context: School, university, community, sports performance, or outpatient rehabilitation settings.

Study Designs: Randomized controlled trials (RCTs), non-randomized controlled trials, quasi-experimental studies, and observational designs published in peer-reviewed journals.

Search Strategy & Selection

A comprehensive search was conducted across PubMed/MEDLINE, Scopus, Web of Science, CINAHL, SPORTDiscus, and PsycINFO for literature published up to 2026. The search combined terms related to *adolescents/Childrens*, *neuro-exercise/motor-cognitive/dual-task/exergaming*, and *cognition/mental health/academic performance/fitness*. Two independent reviewers screened titles, abstracts, and full texts, resolving discrepancies by consensus.

Data Extraction and Synthesis

Data were extracted using a standardized charting form capturing:

1.Study characteristics (authors, year, design, sample size, participant age).

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue XI November 2026

2.Neuro-exercise intervention parameters (type, frequency, session duration, total intervention length, cognitive modality).

3.Primary outcome domains (cognitive function, mental well-being, academic performance, physical fitness).

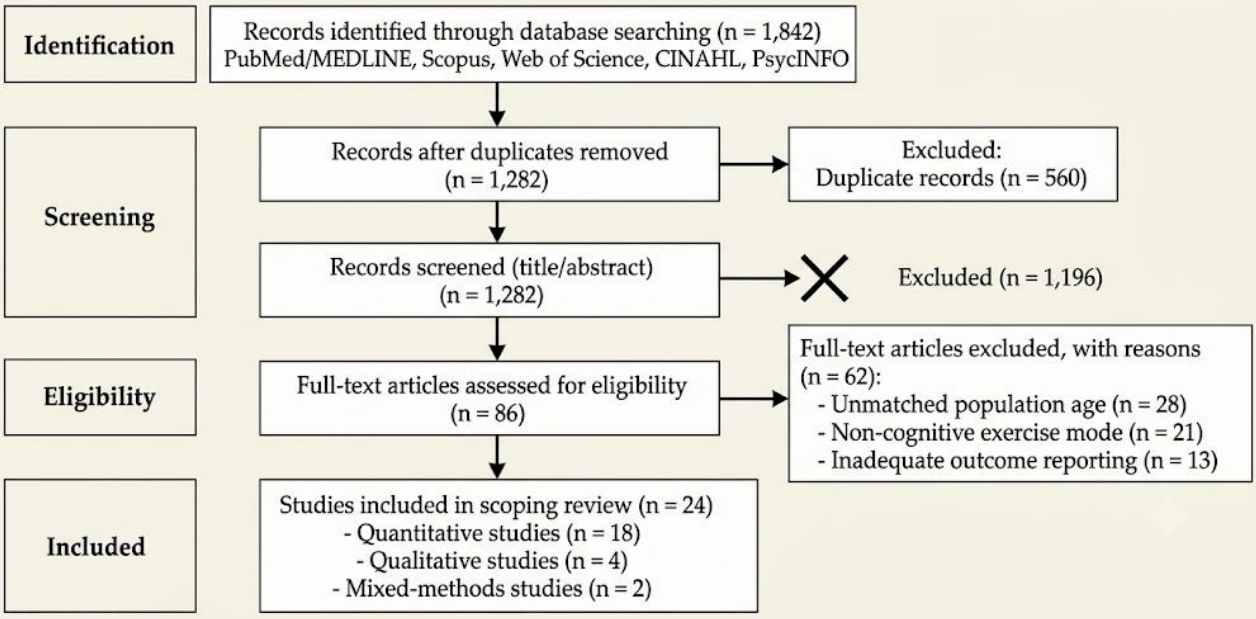
4.Major findings and reported effect patterns.

RESULTS

Study Selection & Mapping

The literature search initially yielded 1,842 records across databases. After removing duplicates and screening titles/abstracts, 86 full-text articles were retrieved for evaluation. Ultimately, 24 studies met all inclusion criteria for qualitative synthesis.

Figure 1: PRISMA-ScR Flow Diagram of Study Selection for Neuro-Exercise Interventions



Intervention Characteristics

The included studies evaluated diverse modalities of neuro-exercise:

Interactive Exergaming (n = 9): Virtual reality, active video games (AVGs), and sensor-based reaction wall systems (e.g., BlazePod/Fitlight systems requiring visual-spatial decision-making during fast-paced physical movement).

Simultaneous Dual-Task Motor-Cognitive Training (n = 8): Treadmill or stationary cycling combined with working memory tasks (e.g., N-back, Stroop test) or motor coordination tasks paired with mental arithmetic/verbal fluency.

Cognitively Enriched Physical Education & Sports Drills (n = 7): Agility ladder patterns integrated with auditory/visual cues, open-skill athletic drills, and complex movement choreography requiring real-time problem-solving.

Intervention durations ranged from single acute bouts (20–45 minutes) to chronic protocols lasting **4 to 12 weeks** (2–4 sessions per week).

Summary of Main Findings by Outcome Domain

Outcome Domain	Primary Assessments / Tools	Summary of Observed Effects
Cognitive Function	Executive Function (Stroop, Flanker, N-Back, Trail Making Test), Processing Speed, Reaction Time	**Significant improvement** in executive control, working memory accuracy, and reduced reaction time compared to passive or purely physical control groups.
Mental Well-Being	State-Trait Anxiety Inventory (STAI), Perceived Stress Scale (PSS), Mood State Questionnaires	**Reductions in acute anxiety and stress scores**, with marked improvements in mood state and perceived mental stamina.
Academic Performance	Standardized academic tests, classroom attentional performance, problem-solving scores	**Positive mediation effect**; enhanced attentional control and executive processing directly correlated with improved test concentration and task-switching efficiency.
Physical Fitness	Dynamic Balance (Y-Balance Test), Agility (T-Test, Illinois Agility), Motor Coordination	**Significant functional gains** in dynamic postural stability, spatial perception, motor coordination, and reactive agility.

DISCUSSION

Mechanistic Underpinnings of Neuro-Exercise

The findings of this scoping review support the **Neuroplasticity and Embodied Cognition Framework**. Simultaneous physical and cognitive demand triggers dual mechanism pathways:

Neurochemical Upregulation: Moderate-to-vigorous physical activity induces rapid secretion of neurotrophins (BDNF, IGF-1, VEGF) and catecholamines (dopamine, norepinephrine), enhancing synaptic plasticity and cerebral perfusion.

Cognitive Targeting: Concurrent cognitive engagement directs these available neuroplastic resources to specific active networks—most notably the dorsolateral prefrontal cortex, anterior cingulate cortex, and cerebellum.

This dual action explains why simultaneous motor-cognitive exercise frequently yields superior executive function gains compared to isolated aerobic activity or static cognitive training.

Psychological and Academic Implications

For adolescents and Childrens facing high academic loads, chronic psychological stress can impair executive functioning and memory consolidation. Neuro-exercise protocols serve a protective role by acting as a stress-buffer: physical movement reduces cortisol dysregulation while cognitive engagement distracts from rumination and academic anxiety. The resulting enhancements in attentional control and working memory capacity translate into better academic focus, task endurance, and examination execution.

Practical & Rehabilitation Applications

School & University Settings: Incorporating 10–15 minute cognitively enriched movement breaks ("brain breaks") or active exergaming modules can boost classroom engagement and mental energy.

Pediatric & Sports Rehabilitation: Physiotherapists and sports specialists can utilize reaction-light systems and dual-task agility drills to enhance neuromuscular control, dynamic stability, and decision-making speed in injured athletes or youth recovering from movement deficits.

Strengths and Limitations

Strengths: To our knowledge, this is one of the first scoping reviews to map the multi-domain impact (cognitive, emotional, academic, and physical) of neuro-exercise specifically in adolescents and Childrens across both acute and chronic study designs.

Limitations: Heterogeneity in intervention protocols, varying cognitive task difficulties, and diverse measurement tools across studies limited the ability to perform a quantitative meta-analysis. Additionally, long-term retention follow-up assessments (>6 months) were rarely conducted.

CONCLUSION & FUTURE DIRECTIONS

Neuro-exercise interventions represent an innovative, multi-system approach that concurrently enhances cognitive processing, mental well-being, academic resilience, and physical fitness in adolescents and Childrens. Moving beyond traditional isolated training modes, integrated motor-cognitive protocols optimize neuroplastic adaptations.

Recommendations for Future Research:

Standardize intervention reporting (intensity, cognitive load level, motor complexity) to establish optimal dosage guidelines.

Conduct large-scale randomized controlled trials evaluating long-term retention of cognitive and academic benefits.

Explore neuroimaging markers (e.g., fNIRS, EEG) during dual-task exercise to elucidate real-time cortical activation patterns in youth.

Declarations

Funding: This scoping review received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest: The authors declare no conflicts of interest.

Data Availability: Data sharing is not applicable as no new primary datasets were generated; all analyzed data were extracted from published literature.

REFERENCES

1. Tomporowski, P. D., & Pesce, C. (2019). Exercise, sports, and performance arts benefit cognition via a common process. Psychology of Sport and Exercise, 44, 92–107.
2. Diamond, A. (2013). Executive functions. Annual Review of Psychology, 64, 135–168.
3. Herold, F., Törpel, A., Schega, L., & Müller, N. G. (2018). Thinking while moving or moving while thinking – concepts of motor-cognitive training for cognitive performance enhancement. Frontiers in Aging Neuroscience, 10, 228.
4. Chang, C., et al. (2026). Effects of single bout exercise with different cognitive demands on executive control and inhibitory functions in young individuals. Frontiers in Psychology, 17, 1879513.
5. Shao, Z., et al. (2025). Comparative effects of single-task and dual-task acute moderate intensity exercise on cognitive performance and neuroendocrine responses in Childrens. BMC Sports Science, Medicine and Rehabilitation, 17(1), 12756883.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue XI November 2026

6. Pesce, C. (2012). Shifting the focus from quantitative to qualitative exercise characteristics in exercise-cognition research. Journal of Sport and Exercise Psychology, 34(6), 766–786.
7. Best, J. R. (2010). Exergaming in youth: Quick review of diet and physical activity benefits. Journal of Children and Media, 4(2), 209–214.
8. Voss, M. W., Kramer, A. F., Basak, C., Prakash, R. S., & Roberts, B. (2010). Are expert athletes 'expert' in the cognitive laboratory? A meta-analytic review of cognition and sport expertise. Applied Cognitive Psychology, 24(6), 812–826.