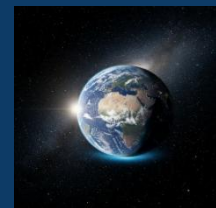




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Regular Physical Activity, Cognitive Function and Academic Performance in Children and Adolescents: Implications for Physical Education and School Health Promotion

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Abstract

Introduction and purpose: Regular physical activity is a central component of healthy development in children and adolescents and has also been proposed as a factor that may contribute to cognitive and educational outcomes. The aim of this narrative review was to summarize current evidence on the relationship between regular physical activity, cognitive function and academic performance in school-aged children and adolescents, with particular attention to physical education, school-based interventions and school health promotion.

Brief description of the state of knowledge: The reviewed literature indicates that physical activity is associated with selected cognitive benefits, particularly executive functions, attention, working memory and classroom behavior. Systematic reviews, meta-analysis and intervention studies suggest that regular, structured and cognitively engaging activity can improve learning readiness and may produce neutral to small or moderate positive effects on academic achievement. However, the evidence remains heterogeneous and appears to depend on age, activity type, intensity, duration, baseline fitness, cognitive engagement, school context and outcome measurement.

Summary: Physical activity should not be framed as a competitor to academic learning. Physical education, active breaks, active lessons, extracurricular sport and active commuting can instead be integrated into a comprehensive strategy aimed at improving school health promotion and the quality of learning environments. Future studies should clarify dose-response relationships and identify the most effective types of activity for different developmental stages.

Keywords: physical activity; child; adolescent; cognition; executive function; academic performance

1. Introduction and purpose

Physical activity is a fundamental component of health and development during childhood and adolescence. It supports physical fitness, motor competence, cardiovascular health, psychosocial well-being and the prevention of risks associated with sedentary behavior. In recent years, increasing attention has been paid to the potential contribution of physical activity to cognitive function and academic performance. This topic is relevant to sport science, pedagogy, public health and school health promotion because children and adolescents spend a substantial part of their day in educational settings, where sedentary behavior is common and academic demands are high.

The relationship between physical activity, cognition and school performance has been examined for more than two decades. Early meta-analytic evidence indicated a positive association between physical activity and cognition in children [1]. Subsequent reviews and meta-analyses reported that physical activity and physical fitness are often related to better cognitive outcomes and selected indicators of school achievement, although the magnitude and consistency of these effects vary across studies [2-6]. More recent work has placed

particular emphasis on executive functions, attention, cognitively engaging activity and school-based interventions [7-13].

The topic is closely aligned with the profile of Quality in Sport because it links physical culture with health, education, practical implementation and the quality of school-based health promotion. Physical education, active lessons, active breaks and extracurricular sport should not be viewed only as recreational activities; they can also be regarded as components of educational quality and health-oriented school policy. A school environment that supports regular movement may contribute to physical health, psychosocial functioning and learning readiness.

Cognitive function is a broad construct that includes attention, working memory, inhibitory control, cognitive flexibility, processing speed and memory. These processes are essential for learning, classroom behavior and self-regulation. Academic performance is similarly multidimensional and may include grades, standardized test scores, subject-specific achievement, teacher evaluations and classroom engagement. Because these outcomes are shaped by family background, school quality, sleep, nutrition, motivation and mental health, the relationship between movement and academic achievement should be interpreted with caution.

Although several systematic reviews and meta-analyses have examined the relationship between physical activity, cognition and academic achievement, their findings remain heterogeneous and are often difficult to translate into practical school recommendations [6,8,9,13]. Therefore, this narrative review focuses not only on the evidence itself but also on its practical interpretation for physical education, school-based health promotion and the quality of learning environments.

The aim of this narrative review was to summarize current evidence on the relationship between regular physical activity, cognitive function and academic performance in children and adolescents. Attention was paid to school-based interventions, executive functions, physical education, cognitively engaging activity and practical implications for improving health promotion and learning environments in schools.

2. Materials and methods

This article is a narrative review. Its aim was to synthesize and interpret selected scientific literature on physical activity, cognitive function and academic performance in children and adolescents. The review was not designed as a systematic review or meta-analysis; therefore, no formal PRISMA procedure or quantitative synthesis was applied. Nevertheless, the selection of literature was guided by relevance to the topic, scientific quality, methodological value, recency and contribution to practical interpretation.

A targeted literature search strategy was used to identify and organize relevant publications. PubMed, Web of Science, Scopus and Google Scholar were searched for publications issued between 2003 and 2026, with additional priority given to systematic reviews and meta-analyses published between 2023 and 2026. The following combinations of terms were used: 'physical activity' AND 'children' AND 'cognitive function'; 'physical activity' AND 'academic performance' AND 'adolescents'; 'exercise' AND 'executive functions' AND 'school'; 'physical education' AND 'academic achievement'; 'active lessons' AND 'cognition'; 'active commuting' AND 'academic achievement'; and 'cognitively engaging physical activity' AND 'executive function'.

The literature considered for this review included systematic reviews, meta-analyses, umbrella reviews, randomized controlled trials, school-based intervention studies and selected observational studies. Publications were included if they addressed physical activity, exercise, physical education, cognition, executive functions, academic performance, academic achievement or school functioning in children or adolescents and had an available DOI.

Studies and reviews that were not directly related to cognition, school functioning or physical activity in developmental populations were not prioritized.

The final bibliography included 30 scientific publications. It incorporated early and general reviews [1,2], systematic reviews and meta-analyses on physical activity, cognition and academic achievement [3-13], school-based physical activity and educational intervention literature [14-19], theoretical and mechanistic literature on exercise and brain function [20], evidence concerning motor skills [21], intervention and experimental studies examining acute exercise, executive function and brain activation [22-24], one article from *Quality in Sport* and one article from *Journal of Education, Health and Sport* [25,26], and additional evidence on school-based activity, active commuting, critical review findings and psychosocial pathways [27-30]. All references were formatted in a numbered style with full DOI links.

3. Description of the state of knowledge

3.1. Physical activity in children and adolescents

Physical activity in childhood and adolescence includes a broad range of behaviors. It may occur during physical education classes, active play, recess, active commuting, organized sport, recreational exercise, family activities, extracurricular training and classroom-based movement. In research, physical activity is commonly described in terms of frequency, duration, intensity and context. Moderate-to-vigorous physical activity is particularly important for health-related outcomes, but cognitive and educational effects may also depend on motor complexity, enjoyment, social interaction and cognitive engagement.

Children and adolescents differ from adults in movement patterns and developmental needs. Their activity is often intermittent, play-based and influenced by family, peers and school culture. Because school reaches almost all children, it is a key setting for promoting regular movement. Physical education is the traditional school-based format, but it can be complemented by active breaks, active lessons, active recess and extracurricular sport. These approaches challenge the assumption that improving academic performance requires reducing opportunities for movement.

Physical fitness may mediate the relationship between physical activity and cognitive outcomes. Fitness reflects repeated exposure to movement and may be a more stable indicator than self-reported activity. Motor competence may also be relevant because complex motor tasks require planning, sequencing, inhibition and adaptation. A systematic review reported links between motor skills and cognitive skills in typically developing children aged 4 to 16 years [21].

3.2. Cognitive function and possible mechanisms

Several mechanisms may explain how physical activity influences cognition. Biological explanations include improved cardiorespiratory fitness, increased cerebral blood flow, neurochemical changes, neuroplasticity and functional changes in brain networks involved in attention and executive control. Although direct mechanistic research in children is still developing, broader neuroscience literature supports the view that exercise can affect brain and cognitive function [20].

Executive functions are among the most frequently studied outcomes in this field. They include inhibitory control, working memory and cognitive flexibility. These functions enable students to focus attention, remember instructions, resist distraction and adapt to new learning tasks. A meta-analysis found that physical activity may have beneficial effects on executive functions, attention and academic performance in preadolescent children [7]. More recent reviews suggest that cognitively engaging physical activity is particularly promising for improving executive function in children and adolescents [10,11].

The distinction between general physical activity and cognitively engaging physical activity is important. Walking, running and aerobic exercise may improve arousal, mood and

physiological readiness for learning. Activities that require coordination, strategy, rule-following, inhibition, decision-making and peer interaction may provide additional cognitive stimulation. Examples include team games, dance, coordinative exercise, martial arts and rule-changing games. Such activities can activate self-regulatory processes similar to those required in the classroom.

The proposed pathways linking physical activity with cognition and educational outcomes are presented in Figure 1. The model emphasizes that regular physical activity may influence learning through biological, psychological and social-school mechanisms. These pathways may improve executive functions, attention and working memory, which in turn can support classroom behavior, learning readiness and academic performance. The strength of these pathways is likely moderated by age, baseline fitness, intervention intensity, duration, cognitive engagement and school context.

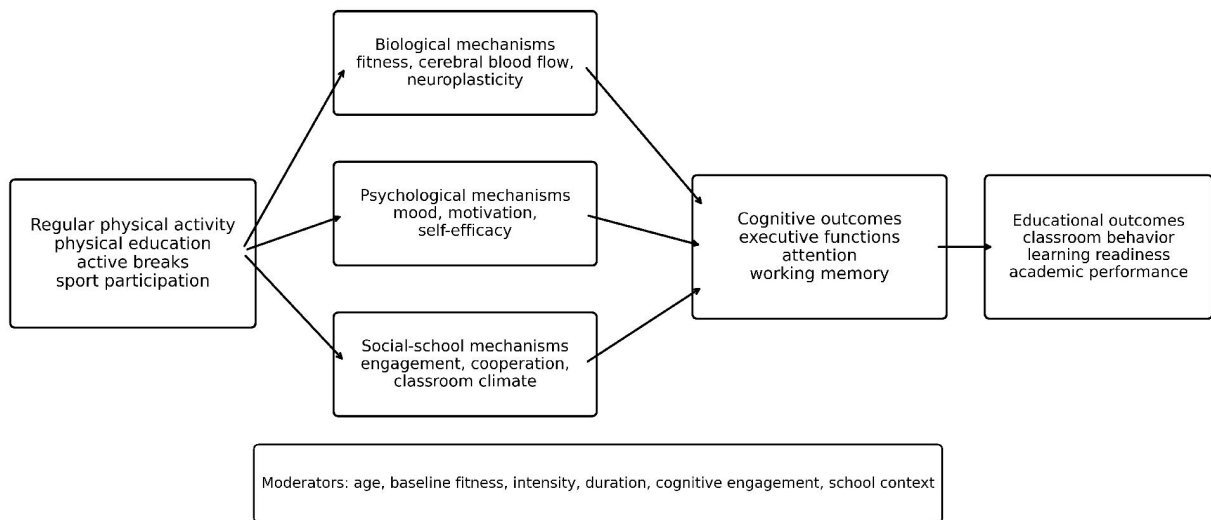


Figure 1. Proposed pathways linking regular physical activity with cognitive function and academic performance in children and adolescents.

Acute exercise may influence cognitive performance. Research indicates that a single bout of physical activity can affect cognitive control and academic achievement measures in preadolescent children [22]. Longer-term interventions provide additional evidence. The FITKids randomized controlled trial showed that an after-school physical activity program improved executive control and influenced brain function in children [23]. Another randomized controlled trial found that exercise improved executive function and achievement and altered brain activation in children with overweight [24]. These studies are important because they support causal interpretation more strongly than cross-sectional research.

Psychological mechanisms should also be considered. Physical activity may improve mood, motivation, self-efficacy, self-regulation, peer relationships and classroom engagement. A recent adolescent study suggested that the association between physical activity and academic performance may be partly mediated by self-regulation and self-efficacy [30]. Although observational evidence cannot establish causality, it highlights psychosocial pathways that are highly relevant to physical education practice.

3.3. Physical activity and academic performance

Academic performance is a complex outcome influenced by biological, psychological, social and educational factors. Nevertheless, many reviews suggest that physical activity is generally positively associated with academic achievement or, at minimum, does not

negatively affect school performance. This is important because schools may reduce physical education or recess in an attempt to increase time for traditional academic subjects.

A systematic review that included methodological quality assessment reported a generally positive association between physical activity and school performance, although the authors emphasized limitations in the available evidence [3]. A broader systematic review concluded that physical activity, fitness, cognition and academic achievement are connected, but that differences in study design and measurement contribute to heterogeneity [4]. Meta-analytic and umbrella-review evidence indicates that the effects of physical activity on academic achievement are typically small, heterogeneous and dependent on the outcome assessed [5,6].

More recent evidence is consistent with this interpretation. A 2025 systematic review and meta-analysis of school-based physical activity interventions reported positive effects on academic achievement, particularly in mathematics and overall academic performance [13]. However, the findings also suggest that intervention features such as duration, intensity and activity type are important. Physical activity should therefore not be presented as a universal solution for academic difficulties, but as a supportive component of a broader educational and health strategy.

The relationship between physical activity and school outcomes can also be considered within physical education itself. A study published in *Journal of Education, Health and Sport* reported that physical activities influenced physical education learning outcomes among students [26]. Although that study focused on physical education learning outcomes rather than general academic achievement, it supports the view that movement-based education can have measurable educational value. It also reinforces the concept of physical education as both a health-promoting and educational discipline.

3.4. School-based physical activity interventions

Schools are among the most important settings for implementing physical activity interventions because they reach children from diverse socioeconomic backgrounds. School-based strategies include physical education, active breaks, active lessons, recess programs, after-school programs and whole-school approaches. Their effectiveness depends on frequency, duration, intensity, teacher involvement, student motivation and integration with the curriculum.

Classroom-based physical activity has substantial practical value. A classroom-based program increased physical activity and improved on-task behavior in children [16]. On-task behavior is a relevant outcome because it may mediate later learning. When students are more attentive and less disruptive after movement breaks, teachers may be able to create a more effective learning environment.

Physically active academic lessons combine movement with curriculum content. They can increase activity while maintaining or reinforcing academic instruction. Studies and reviews indicate that active lessons can function as both physical activity and educational interventions, although methods and outcomes vary [17-19]. Meta-analytic evidence on classroom-based physical activity interventions suggests potential benefits for physical activity and selected academic outcomes, while also highlighting heterogeneity in intervention design [15].

Large school-based trials show that implementation in real educational settings is feasible but complex. The Active Smarter Kids cluster-randomized controlled trial examined the effects of school-based physical activity on academic performance and showed that such interventions can be delivered in schools, although effects may vary according to subgroup and outcome [27]. Therefore, school-based physical activity should be carefully designed rather than added to the school day in an unstructured manner.

A consistent practical message is that movement opportunities should not be viewed as lost academic time. When planned appropriately, physical activity can support health and may also improve attention, classroom engagement and learning readiness. Implementation quality is essential. Teacher training, administrative support, safe spaces, inclusive activities and realistic schedules are needed for sustainable programs.

Table 1. Summary of selected literature included in the narrative review.

No.	Study, design and population/context	Main findings	Limitations / practical implications
1	Sibley and Etnier, 2003; meta-analysis; children	Early quantitative evidence supported a positive relationship between physical activity and cognition.	Useful as historical background; older literature and heterogeneous study designs limit current applicability.
2	Fedewa and Ahn, 2011; meta-analysis; children	Physical activity and fitness were associated with achievement and cognitive outcomes.	Supports broad rationale, but later reviews provide stronger and more specific evidence.
3	Singh et al., 2012; systematic review; school-aged youth	Reported generally positive associations between physical activity and school performance.	The authors emphasized methodological limitations and the need for stronger designs.
4	Donnelly et al., 2016; systematic review; children	Comprehensive synthesis linking physical activity, fitness, cognition and academic achievement.	Central reference for the review; findings remain heterogeneous across outcomes.
5	Alvarez-Bueno et al., 2017; meta-analysis; children/adolescents	Suggested positive effects of physical activity on academic achievement, with variation by outcome.	Useful for academic outcomes; effects should be interpreted as modest rather than universal.
6	Barbosa et al., 2020; umbrella review; children/adolescents	Higher-level synthesis is found generally null to small or moderate effects on academic achievement.	Important for balanced interpretation and avoiding overstatement.
7	de Greeff et al., 2018; meta-analysis; preadolescent children	Physical activity showed beneficial effects on executive functions, attention and academic performance.	Especially relevant to mechanisms and school readiness.

No.	Study, design and population/context	Main findings	Limitations / practical implications
8	Singh et al., 2019; systematic review and expert panel	Provided evidence-based recommendations on physical activity interventions and cognitive/academic performance.	Useful for practical recommendations; intervention heterogeneity remains important.
9	Vasilopoulos et al., 2023; multilevel meta-analysis; childhood	Reported effects of physical activity interventions on cognition and academic achievement.	Adds contemporary quantitative synthesis; supports careful interpretation of effect sizes.
10	Mao et al., 2024; systematic review/meta-analysis	Cognitively engaging physical activity was associated with improvements in executive function.	Supports recommendation to include complex, game-like and decision-rich activities.
11	Cabral et al., 2025; meta-analysis; children	Cognitively challenging physical activity showed small favorable effects on core executive functions.	Strengthens novelty and current relevance; effects are small and comparator choice matters.
12	Liu et al., 2025; systematic review/meta-analysis; adolescents	Exercise interventions improved adolescent cognitive function, including attention and executive domains.	Important for adolescent-specific interpretation; bias and heterogeneity still require caution.
13	He et al., 2025; systematic review/meta-analysis; school-based interventions	School-based physical activity positively affected academic achievement, especially mathematics and overall performance.	Very relevant for school policy; heterogeneity suggests that duration and intensity matter.
14	Rasberry et al., 2011; systematic review; school-based activity	Physical education and school-based activity were generally not detrimental to academic performance.	Supports the argument that movement should not be reduced to protect academic time.

No.	Study, design and population/context	Main findings	Limitations / practical implications
15	Watson et al., 2017; systematic review/meta-analysis	Classroom-based physical activity improved activity outcomes and selected academic outcomes.	Useful for active lessons and active breaks; implementation quality is key.
16	Mahar et al., 2006; classroom intervention	Classroom activity increased physical activity and improved on-task behavior.	Directly relevant for learning readiness and classroom management.
17	Bartholomew and Jowers, 2011; active lessons	Physically active academic lessons can increase movement while preserving educational aims.	Supports integration of movement with curriculum content.
18	Donnelly and Lambourne, 2011; review	Classroom-based physical activity may support cognition and academic achievement.	Useful for practical school-based recommendations.
19	Norris et al., 2015; systematic review	Physically active lessons function as both activity and educational interventions.	Evidence varies by method; teacher training is important.
20	Hillman et al., 2008; neuroscience review	Outlined exercise-related mechanisms linking physical activity with brain and cognition.	Provides theoretical basis, though not limited to school interventions.
21	van der Fels et al., 2015; systematic review	Motor skills were related to cognitive skills in typically developing children.	Supports discussion of motor complexity and cognitively engaging movement.
22	Hillman et al., 2009; experimental study	Acute treadmill walking improved cognitive control and academic achievement measures.	Supports short active breaks; acute effects may not imply long-term achievement gains.
23	Hillman et al., 2014; randomized controlled trial	FITKids improved executive control and brain function.	Strong experimental evidence for structured after-school activity.

No.	Study, design and population/context	Main findings	Limitations / practical implications
24	Davis et al., 2011; randomized controlled trial	Exercise improved executive function and achievement in overweight children and altered brain activation.	Relevant to causal interpretation and vulnerable groups.
25	Mosciszko et al., 2025; Quality in Sport review	Discussed physical exercise as a therapeutic strategy for ADHD in children and adolescents.	Connects the topic to the target journal and attention-related outcomes.
26	Julianti et al., 2019; JEHS article	Physical activities influenced physical education learning outcomes.	Supports educational value of movement-based learning and satisfies journal-related citation strategy.
27	Resaland et al., 2016; cluster-randomized trial	School-based physical activity can be implemented at scale, with academic effects varying by outcome.	Highlights real-world implementation complexity.
28	Phansikar et al., 2019; systematic review	Active commuting evidence for cognition and academic achievement remains limited and inconsistent.	Useful for cautious recommendations on active transport.
29	Wassenaar et al., 2020; critical systematic review	Emphasized limitations in systematic-review evidence on chronic physical activity, cognition, brain and achievement.	Important for methodological balance and limitations section.
30	Che et al., 2026; observational mediation study; adolescents	Physical activity was linked with academic performance through self-regulation and self-efficacy pathways.	Adds a current psychosocial mechanism; cross-sectional design limits causal inference.

3.5. Adolescents, active commuting and developmental differences

Adolescence is a developmental period characterized by biological, psychological and social changes. It is also a period in which academic pressure increases, and physical activity

often decreases. This creates a challenge for schools and families. Physical activity may support mood, stress regulation, sleep and self-regulation, but adolescents may face barriers such as limited time, screen use, low motivation, peer pressure and reduced access to safe activity environments.

Recent adolescent-specific evidence indicates that exercise interventions may improve several cognitive domains, including attention, executive function, cognitive flexibility and working memory [12]. At the same time, adolescents may respond differently from younger children to physical activity interventions because autonomy, body image, social identity and academic pressure become increasingly important. Interventions for adolescents should therefore be age-appropriate, socially meaningful and autonomy-supportive.

Active commuting is one potential way to increase daily activity without adding extra scheduled sessions. Walking or cycling to school may contribute to daily movement and reduce sedentary behavior. However, a systematic review found that evidence on active commuting, cognition and academic achievement in children and adolescents remains limited and inconsistent [28]. Safety, distance, infrastructure and local culture strongly influence feasibility.

Developmental differences should be considered when interpreting literature. Younger children may benefit from play-based and motor-rich activities, whereas adolescents may require programs that are more personally relevant and connected with health, social relationships or performance goals. Future interventions should therefore avoid a one-size-fits-all approach.

3.6. Limitations and heterogeneity of evidence

The evidence linking physical activity with cognition and academic performance is promising but heterogeneous. Studies differ in sample size, age, intervention duration, activity type, intensity, measurement of physical activity and assessment of cognitive or academic outcomes. Some studies focus on acute exercise, whereas others examine long-term interventions, fitness, active commuting or physical education. Outcomes also vary, ranging from attention and executive function to grades, standardized tests and classroom behavior.

This heterogeneity makes it difficult to formulate precise dose-response recommendations. A critical review of systematic reviews emphasized that evidence concerning chronic physical activity, academic achievement, cognition and the brain in children and adolescents requires careful interpretation [29]. It is therefore important not to overstate the findings. The most defensible conclusion is that physical activity may support cognitive and academic outcomes, especially under well-designed conditions, but the size and consistency of effects vary.

Causality is another limitation. Cross-sectional studies cannot determine whether active children perform better because of physical activity or because of other factors, such as family support, motivation, sleep, socioeconomic status or school quality. Intervention studies provide stronger evidence, but they may be affected by implementation variability, short duration, limited sample size or incomplete control of confounders. Despite these limitations, the literature consistently indicates that physical activity should not be reduced in schools because of concern that it will harm academic learning.

4. Applications for physical education and school practice

The reviewed evidence has practical implications for schools, physical education teachers, parents and public health professionals. First, physical education should be protected and strengthened. It is not only a recreational school subject but also a structured opportunity to promote health, motor competence, social development, self-regulation and learning readiness.

Second, short active breaks can be introduced during lessons. These breaks may improve on-task behavior and reduce sedentary time, especially during long periods of

classroom instruction. They should be brief, easy to organize and adapted to the availability of classroom space. Active breaks are likely to be most useful when teachers understand their purpose and use them consistently rather than as occasional entertainment.

Third, physically active academic lessons may be useful, particularly in primary school. They can combine movement with curriculum content and may increase engagement while maintaining educational goals. However, teachers need practical training to implement such lessons effectively. The aim is not to replace instruction with activity, but to integrate movement in a way that reinforces learning.

Fourth, cognitively engaging physical activity should be considered. Activities requiring coordination, reaction, inhibition, decision-making, rule adaptation and cooperation may be particularly useful for executive functions. This supports the inclusion of varied movement forms, including games, dance, coordinative tasks and team activities. Physical education classes should therefore include not only fitness development but also movement tasks that require planning, attention and flexible responses.

Fifth, school health policy should support inclusive physical activity. Not all students enjoy competitive sport. Programs should include recreational, non-competitive and enjoyable forms of movement so that students with different abilities, body types, health status and motivation levels can participate. This is especially important for students who are inactive, are overweight or experience attention and self-regulation difficulties.

Sixth, active commuting may be promoted when environmental conditions are safe. Cooperation between schools, families and local authorities is needed to improve walking and cycling infrastructure. Although evidence on academic outcomes is still limited, active commuting may contribute to daily physical activity and healthier routines.

Finally, physical activity should be understood as part of a broader quality strategy in school education. It cannot replace effective teaching, family support or psychological care, but it can contribute to a healthier and more engaging learning environment. For this reason, school-based physical activity should be considered a practical component of health promotion and educational quality rather than an obstacle to academic success.

5. Summary

Regular physical activity is an important element of healthy development in children and adolescents and may support selected cognitive and academic outcomes. The strongest evidence concerns executive functions, attention, classroom behavior and learning readiness. Evidence for direct improvement in academic achievement is positive but heterogeneous, with effects often described as null, small or moderate.

Physical activity should not be considered a competitor to academic learning. Physical education, active breaks, active lessons, extracurricular sport and active commuting can be integrated into school life without reducing educational quality. Well-planned and cognitively engaging activity may be especially valuable because it can stimulate both movement and self-regulatory processes.

Schools should promote regular, enjoyable and inclusive physical activity as part of a comprehensive strategy for health and educational quality. Future research should clarify dose-response relationships, identify the most effective types of activity for different age groups and examine long-term effects in real school settings. More high-quality randomized controlled trials are needed to determine which intervention components are most effective for cognition, academic performance and school functioning.

Disclosure

Author contributions

Conceptualization: D.S.; methodology: D.S. and M.P.; literature review: D.S., M.P., K.P., J.D. and M.K.; writing – original draft preparation: D.S. and M.P.; writing – review and editing: K.P., J.D. and M.K.; visualization: D.S.; supervision: D.S. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The author declares no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

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References

1. Sibley BA, Etnier JL. The relationship between physical activity and cognition in children: a meta-analysis. *Pediatric Exercise Science*. 2003;15(3):243-256. <https://doi.org/10.1123/pes.15.3.243>
2. Fedewa AL, Ahn S. The effects of physical activity and physical fitness on children's achievement and cognitive outcomes: a meta-analysis. *Research Quarterly for Exercise and Sport*. 2011;82(3):521-535. <https://doi.org/10.1080/02701367.2011.10599785>
3. Singh AS, Uijtdewilligen L, Twisk JWR, van Mechelen W, Chinapaw MJM. Physical activity and performance at school: a systematic review of the literature including a methodological quality assessment. *Archives of Pediatrics & Adolescent Medicine*. 2012;166(1):49-55. <https://doi.org/10.1001/archpediatrics.2011.716>
4. Donnelly JE, Hillman CH, Castelli D, Etnier JL, Lee S, Tomporowski P, et al. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Medicine & Science in Sports & Exercise*. 2016;48(6):1197-1222. <https://doi.org/10.1249/MSS.0000000000000901>
5. Alvarez-Bueno C, Pesce C, Caverio-Redondo I, Sanchez-Lopez M, Garrido-Miguel M, Martinez-Vizcaino V. Academic achievement and physical activity: a meta-analysis. *Pediatrics*. 2017;140(6):e20171498. <https://doi.org/10.1542/peds.2017-1498>
6. Barbosa A, Whiting S, Simmonds P, Scotini Moreno R, Mendes R, Breda J. Physical activity and academic achievement: an umbrella review. *International Journal of*

- Environmental Research and Public Health. 2020;17(16):5972. <https://doi.org/10.3390/ijerph17165972>
7. de Greeff JW, Bosker RJ, Oosterlaan J, Visscher C, Hartman E. Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. *Journal of Science and Medicine in Sport*. 2018;21(5):501-507. <https://doi.org/10.1016/j.jsams.2017.09.595>
 8. Singh AS, Saliasi E, van den Berg V, Uijtdewilligen L, de Groot RHM, Jolles J, et al. Effects of physical activity interventions on cognitive and academic performance in children and adolescents: a novel combination of a systematic review and recommendations from an expert panel. *British Journal of Sports Medicine*. 2019;53(10):640-647. <https://doi.org/10.1136/bjsports-2017-098136>
 9. Vasilopoulos F, Jeffrey H, Wu Y, Dumontheil I. Multi-level meta-analysis of physical activity interventions during childhood: effects of physical activity on cognition and academic achievement. *Educational Psychology Review*. 2023;35:59. <https://doi.org/10.1007/s10648-023-09760-2>
 10. Mao F, Huang F, Zhao S, Fang Q. Effects of cognitively engaging physical activity interventions on executive function in children and adolescents: a systematic review and meta-analysis. *Frontiers in Psychology*. 2024;15:1454447. <https://doi.org/10.3389/fpsyg.2024.1454447>
 11. Cabral M, Pournara I, Pontifex MB, Venetsanou F, Pesce C, Vazou S. A meta-analysis of physical activity interventions targeting executive functions in children: focus on cognitive and/or metabolic demands? *International Journal of Sport and Exercise Psychology*. 2025;1-23. <https://doi.org/10.1080/1612197X.2025.2510251>
 12. Liu L, Xin X, Zhang Y. The effects of physical exercise on cognitive function in adolescents: a systematic review and meta-analysis. *Frontiers in Psychology*. 2025;16:1556721. <https://doi.org/10.3389/fpsyg.2025.1556721>
 13. He H, Yang Y, Sun J, Wang F, Zhang W, Zhu F. Effects of school-based physical activity on academic achievement in children and adolescents: a systematic review and meta-analysis. *Frontiers in Public Health*. 2025;13:1651883. <https://doi.org/10.3389/fpubh.2025.1651883>
 14. Rasberry CN, Lee SM, Robin L, Laris BA, Russell LA, Coyle KK, et al. The association between school-based physical activity, including physical education, and academic performance: a systematic review of the literature. *Preventive Medicine*. 2011;52(Suppl 1):S10-S20. <https://doi.org/10.1016/j.ypmed.2011.01.027>
 15. Watson A, Timperio A, Brown H, Best K, Hesketh KD. Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*. 2017;14:114. <https://doi.org/10.1186/s12966-017-0569-9>
 16. Mahar MT, Murphy SK, Rowe DA, Golden J, Shields AT, Raedeke TD. Effects of a classroom-based program on physical activity and on-task behavior. *Medicine & Science in Sports & Exercise*. 2006;38(12):2086-2094. <https://doi.org/10.1249/01.mss.0000235359.16685.a3>
 17. Bartholomew JB, Jowers EM. Physically active academic lessons in elementary children. *Preventive Medicine*. 2011;52(Suppl 1):S51-S54. <https://doi.org/10.1016/j.ypmed.2011.01.017>
 18. Donnelly JE, Lambourne K. Classroom-based physical activity, cognition, and academic achievement. *Preventive Medicine*. 2011;52(Suppl 1):S36-S42. <https://doi.org/10.1016/j.ypmed.2011.01.021>
 19. Norris E, Shelton N, Dunsmuir S, Duke-Williams O, Stamatakis E. Physically active lessons as physical activity and educational interventions: a systematic review of methods and results. *Preventive Medicine*. 2015;72:116-125. <https://doi.org/10.1016/j.ypmed.2014.12.027>

20. Hillman CH, Erickson KI, Kramer AF. Be smart, exercise your heart: exercise effects on brain and cognition. *Nature Reviews Neuroscience*. 2008;9(1):58-65. <https://doi.org/10.1038/nrn2298>
21. van der Fels IMJ, te Wierike SCM, Hartman E, Elferink-Gemser MT, Smith J, Visscher C. The relationship between motor skills and cognitive skills in 4-16 year old typically developing children: a systematic review. *Journal of Science and Medicine in Sport*. 2015;18(6):697-703. <https://doi.org/10.1016/j.jsams.2014.09.007>
22. Hillman CH, Pontifex MB, Raine LB, Castelli DM, Hall EE, Kramer AF. The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children. *Neuroscience*. 2009;159(3):1044-1054. <https://doi.org/10.1016/j.neuroscience.2009.01.057>
23. Hillman CH, Pontifex MB, Castelli DM, Khan NA, Raine LB, Scudder MR, et al. Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics*. 2014;134(4):e1063-e1071. <https://doi.org/10.1542/peds.2013-3219>
24. Davis CL, Tomporowski PD, McDowell JE, Austin BP, Miller PH, Yanasak NE, et al. Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized controlled trial. *Health Psychology*. 2011;30(1):91-98. <https://doi.org/10.1037/a0021766>
25. Mościszko K, Kałuska J, Hakało D, Ignatiuk-Chilkiewicz M, Sokół A, Nowicka K, et al. Physical exercise as a therapeutic strategy for ADHD in children and adolescents. *Quality in Sport*. 2025;43:62414. <https://doi.org/10.12775/QS.2025.43.62414>
26. Julianti E, Dlis F, Asmawi M. The effect of physical activities on physical education learning outcomes. *Journal of Education, Health and Sport*. 2019;9(11):100-109. <https://doi.org/10.12775/JEHS.2019.09.11.007>
27. Resaland GK, Aadland E, Moe VF, Aadland KN, Skrede T, Stavnsbo M, et al. Effects of physical activity on schoolchildren's academic performance: the Active Smarter Kids cluster-randomized controlled trial. *Preventive Medicine*. 2016;91:322-328. <https://doi.org/10.1016/j.ypmed.2016.09.005>
28. Phansikar M, Ashrafi SA, Khan NA, Massey WV, Mullen SP. Active commute in relation to cognition and academic achievement in children and adolescents: a systematic review and future recommendations. *International Journal of Environmental Research and Public Health*. 2019;16(24):5103. <https://doi.org/10.3390/ijerph16245103>
29. Wassenaar TM, Williamson W, Johansen-Berg H, Dawes H, Roberts N, Foster C, et al. A critical evaluation of systematic reviews assessing the effect of chronic physical activity on academic achievement, cognition and the brain in children and adolescents: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*. 2020;17:79. <https://doi.org/10.1186/s12966-020-00959-y>
30. Che L, Liu D, Tie C. Physical activity and academic performance in adolescents: chain mediation through self-regulation and self-efficacy with gender and urban-rural differences. *Frontiers in Education*. 2026;10:1686270. <https://doi.org/10.3389/feduc.2025.1686270>