Int. j. adv. multidisc. res. stud. 2026; 6(2):1618-1630

Received: 01-03-2026
Accepted: 10-04-2026

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Effectiveness of School-Based Physical Activity Interventions on Health and Academic Outcomes among Children and Adolescents: A Systematic Review

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DOI: https://doi.org/10.62225/2583049X.2026.6.2.6145

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Abstract

Physical inactivity among school-aged children has become a critical public health and educational concern, with implications for both wellbeing and academic achievement. This study conducted a systematic review to evaluate the effectiveness of school-based physical activity interventions in improving health and academic outcomes among children and adolescents. Guided by PRISMA 2020 standards, peer-reviewed empirical studies published between 2020 and 2026 were systematically identified from major academic databases. A qualitative synthesis approach was employed to analyze evidence across diverse intervention models, including enhanced physical education, physically active learning, classroom movement breaks, and school-based sports programmes.

The findings indicate that school-based physical activity interventions consistently produce significant improvements in physical health outcomes, including cardiovascular fitness, body composition, and psychological wellbeing. In addition, substantial evidence demonstrates positive effects on cognitive functioning, particularly in areas such as attention, executive function, and classroom engagement.

While the impact on standardized academic achievement remains mixed he overall evidence suggests that physical activity either enhances or does not compromise academic performance. Interventions characterized by regular implementation, moderate-to-vigorous intensity, and integration within instructional practices were found to yield the most consistent benefits.

The study concludes that school-based physical activity interventions represent effective, scalable strategies for promoting holistic student development. Integrating structured physical activity into school systems offers a practical approach to simultaneously addressing public health challenges and improving educational outcomes.

Keywords: Adolescents, PRISMA, Neurophysiological

1. Introduction

Physical inactivity among children and adolescents has emerged as a critical global public health challenge with far-reaching implications for both health and educational outcomes. Contemporary lifestyles characterized by increased screen exposure, reduced outdoor activity, and prolonged sedentary classroom engagement have significantly contributed to declining physical activity levels among school-aged populations. Recent evidence indicates that a large proportion of children fail to meet recommended physical activity guidelines, thereby increasing their susceptibility to obesity, cardiovascular risk, and poor mental health outcomes (Guthold *et al*., 2020; Rhodes *et al*., 2020) [6, 14]. Beyond its health implications, physical inactivity has also been associated with diminished cognitive functioning and reduced academic engagement, highlighting the need for integrated interventions that address both physical and educational domains simultaneously.

Within this context, schools have been increasingly recognized as strategic and scalable environments for promoting physical activity among children and adolescents. As structured institutions with consistent access to large populations during critical developmental stages, schools provide a unique opportunity to embed physical activity within daily routines. School-based physical activity interventions—such as enhanced physical education programmes, physically active learning strategies, classroom movement breaks, and structured recess or sports initiatives—have been widely adopted as mechanisms for

increasing moderate-to-vigorous physical activity levels among students. Empirical evidence suggests that such interventions contribute to improvements in cardiovascular fitness, motor competence, and overall physical health, while also promoting psychological wellbeing and social development (Daly-Smith *et al*., 2020; Love *et al*., 2022) [3, 8].

In addition to these health-related benefits, a growing body of interdisciplinary research has examined the relationship between physical activity and academic outcomes. Emerging findings indicate that physical activity can positively influence cognitive processes such as attention, working memory, executive functioning, and cognitive flexibility—key determinants of learning and academic success. Neurophysiological mechanisms, including increased cerebral blood flow, enhanced neuroplasticity, and the release of neurotrophic factors, have been identified as pathways through which physical activity supports brain function and learning processes (Hillman *et al*., 2021 [7]; Álvarez-Bueno *et al*., 2022). Furthermore, recent systematic reviews and meta-analyses suggest that school-based physical activity interventions can improve academic achievement, particularly in mathematics and general academic performance, although the magnitude of these effects varies across contexts and outcome measures (Singh *et al*., 2021; Donnelly *et al*., 2022) [16, 4].

Despite this expanding evidence base, important inconsistencies and gaps remain in the literature. While the positive effects of physical activity on physical health outcomes are well established, findings related to academic performance are more heterogeneous. Some studies report meaningful improvements in academic achievement and classroom engagement, whereas others indicate modest or inconclusive effects, particularly when standardized test scores are used as outcome measures (Watson *et al*., 2021) [19]. These inconsistencies may be attributed to variations in intervention design, duration, intensity, and implementation fidelity, as well as differences in methodological approaches and outcome measurement tools across studies.

Another significant limitation in the existing literature is the fragmentation of research across disciplinary boundaries. Many studies have focused primarily on either health outcomes or academic outcomes in isolation, rather than examining the integrated effects of school-based physical activity interventions on both domains. Moreover, recent research developments—particularly in the post-COVID-19 context—have intensified concerns regarding declining physical activity levels among children and adolescents and have led to the emergence of innovative intervention models such as physically active classrooms and integrated movement-based learning strategies (Okely *et al*., 2021; Stockwell *et al*., 2021) [10, 17]. However, findings from these studies remain dispersed across public health, education, psychology, and sports science, making it difficult to derive a coherent and up-to-date understanding of intervention effectiveness.

Additionally, emerging evidence highlights the importance of intervention characteristics—such as duration, intensity, and sustainability—in determining effectiveness. Studies consistently show that interventions involving regular moderate-to-vigorous physical activity and sustained implementation over time are more likely to produce significant improvements in both health and academic outcomes (Love *et al*., 2022) [8]. This underscores the need for a comprehensive synthesis of evidence that not only evaluates outcomes but also identifies the conditions under which school-based physical activity interventions are most effective.

In response to these gaps, the present study conducts a systematic review of peer-reviewed literature published between 2020 and 2026 to examine the effectiveness of school-based physical activity interventions in improving both health and academic outcomes among school-aged children and adolescents. Specifically, the study aims to synthesize current empirical evidence to: (i) assess the extent to which these interventions influence physical health indicators, cognitive functioning, and academic performance; and (ii) identify key characteristics of interventions associated with the most consistent and significant outcomes.

The significance of this study lies in its contribution to both educational policy and public health practice. Educational systems worldwide are increasingly challenged to balance academic performance demands with student wellbeing. In many contexts, emphasis on standardized testing has led to reduced time allocated for physical activity within school curricula. However, growing evidence suggests that limiting opportunities for movement may undermine the cognitive and physiological conditions necessary for effective learning. By providing an integrated and up-to-date synthesis of recent empirical findings, this study offers critical insights into how school-based physical activity interventions can support holistic child development, enhance educational outcomes, and inform evidence-based policy decisions.

2. Literaure Review

2.1 Conceptual Review

School-based physical activity interventions have gained increasing scholarly attention as multidimensional strategies for addressing declining physical activity levels among children and adolescents while simultaneously supporting broader developmental outcomes. Within the school context, physical activity refers to any bodily movement produced by skeletal muscles that results in energy expenditure and is intentionally integrated into the school day through structured or semi-structured programmes. These interventions typically include enhanced physical education, physically active learning, classroom-based activity breaks, active recess, and extracurricular sports initiatives. The school setting provides a uniquely controlled and equitable environment in which such interventions can be implemented at scale, ensuring consistent exposure to physical activity across diverse student populations (Daly-Smith *et al*., 2020; Love *et al*., 2022) [3, 8].

From a conceptual standpoint, school-based physical activity interventions constitute the primary independent construct in this study, influencing both health outcomes and academic outcomes among students. These interventions vary in structure, intensity, and pedagogical integration, yet they share a common objective: increasing students' engagement in moderate-to-vigorous physical activity within the constraints of the school timetable. Enhanced physical education programmes, for instance, focus on improving the quality, duration, and intensity of physical education lessons to maximize health benefits. In contrast, physically active learning approaches embed movement within academic instruction, thereby aligning physical

activity with cognitive engagement. Classroom activity breaks—often brief, structured bouts of movement—are designed to interrupt sedentary behavior and restore attentional focus, while active recess and school sports programmes provide additional opportunities for both structured and unstructured physical engagement (Norris *et al*., 2020; Watson *et al*., 2021) [9, 19].

The conceptualization of health outcomes within this framework extends beyond traditional measures of physical fitness to include psychological and physiological dimensions of wellbeing. Empirical evidence consistently demonstrates that regular participation in school-based physical activity interventions contributes to improvements in cardiovascular fitness, muscular strength, body composition, and metabolic health among children and adolescents (Álvarez-Bueno *et al*., 2022; Páez-Maldonado *et al*., 2020 [12]). In addition to these physical benefits, increasing attention has been directed toward the mental health outcomes associated with physical activity. Recent studies indicate that engagement in regular physical activity is associated with reduced symptoms of anxiety and depression, improved emotional regulation, and enhanced self-esteem among school-aged populations (Biddle *et al*., 2021; Rodriguez-Ayllon *et al*., 2020) [2, 15]. These psychological outcomes are particularly salient in light of rising global concerns regarding youth mental health.

The physiological mechanisms underlying these health outcomes further reinforce the conceptual importance of school-based physical activity interventions. Regular moderate-to-vigorous physical activity enhances cardiovascular efficiency, improves metabolic functioning, and supports musculoskeletal development. Importantly, physical activity also stimulates neurobiological processes, including increased cerebral blood flow and the release of neurotrophic factors such as brain-derived neurotrophic factor (BDNF), which are critical for neural growth and cognitive functioning (Hillman *et al*., 2021) [7]. These mechanisms suggest that the benefits of physical activity extend beyond physical health, influencing brain function in ways that are directly relevant to learning and academic performance.

Academic outcomes represent a second central construct within the conceptual framework of this study. These outcomes encompass both traditional indicators of academic achievement—such as standardized test scores and grades—and broader measures of cognitive and behavioral functioning, including attention, executive functioning, classroom engagement, and learning readiness. Contemporary educational research increasingly recognizes that academic performance is shaped not only by instructional quality but also by students' physical and psychological wellbeing (Donnelly *et al*., 2022; Singh *et al*., 2021) [4, 16]. Consequently, physical activity has been conceptualized as a critical factor that can enhance cognitive processes essential for learning.

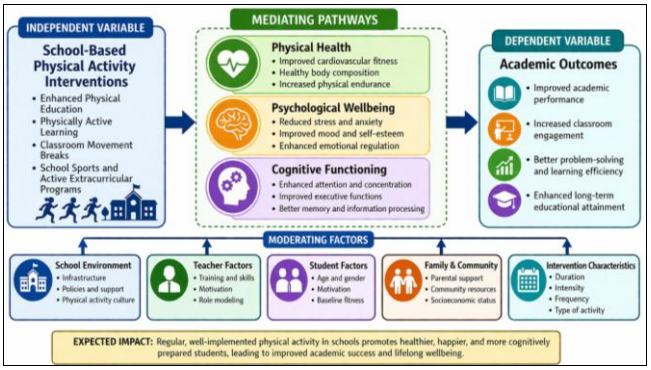
One of the key mechanisms linking physical activity to academic outcomes is its effect on executive functioning, which includes cognitive processes such as working memory, inhibitory control, and cognitive flexibility. These functions are essential for goal-directed behavior, problem-solving, and sustained attention in classroom settings. Empirical studies have shown that regular engagement in physical activity enhances these cognitive processes by improving neural efficiency and connectivity within brain regions associated with executive control (Hillman *et al*., 2021 [7]; Álvarez-Bueno *et al*., 2022). As a result, students who participate in school-based physical activity interventions often demonstrate improved concentration, better classroom behavior, and enhanced capacity to process and retain information.

Another important dimension of academic outcomes is classroom engagement, which reflects students' active participation, motivation, and attentiveness during instructional activities. Prolonged sedentary behavior has been associated with cognitive fatigue and reduced attentional capacity, both of which can negatively affect learning outcomes. Integrating physical activity into classroom routines—through strategies such as active learning or movement breaks—can mitigate these effects by increasing alertness and promoting cognitive readiness (Watson *et al*., 2021) [19]. Physically active learning approaches, in particular, have been shown to enhance both engagement and knowledge retention by combining motor activity with cognitive tasks, thereby activating multiple learning pathways simultaneously (Daly-Smith *et al*., 2020; Norris *et al*., 2020) [3, 9].

Conceptually, the relationship between school-based physical activity interventions, health outcomes, and academic outcomes can be understood as a dynamic and interdependent process. Physical activity interventions increase students' participation in movement-based activities, leading to improvements in physical health and psychological wellbeing. These improvements, in turn, enhance cognitive functioning and behavioral regulation, which ultimately contribute to improved academic performance. This relationship is not strictly linear but is influenced by several moderating factors, including intervention intensity, duration, implementation fidelity, student age, and school-level support (Love *et al*., 2022; Watson *et al*., 2021) [8, 19].

Furthermore, recent research emphasizes that the effectiveness of school-based physical activity interventions depends on the degree to which they are integrated into the broader educational environment. Interventions that are embedded within daily school routines—rather than implemented as isolated or short-term programmes—tend to produce more consistent and sustained outcomes. Whole-school approaches that combine policy support, teacher engagement, and structured programme delivery have been identified as particularly effective in promoting both physical activity participation and educational outcomes (Daly-Smith *et al*., 2020) [3].

Overall, the conceptual perspective underpinning this study positions school-based physical activity interventions as multifaceted strategies capable of influencing both health and academic domains simultaneously. By integrating movement into the school day through diverse and context-sensitive approaches, these interventions address the dual challenges of physical inactivity and declining student engagement. Understanding the conceptual relationships among physical activity, health, and academic performance is therefore essential for designing interventions that promote holistic student development. This conceptual foundation provides a critical basis for examining the theoretical explanations and empirical evidence presented in subsequent sections of this study.



Source: Author's conceptualization based on Daly-Smith *et al.* (2020) [3], Hillman *et al.* (2021) [7], Álvarez-Bueno *et al.* (2022), and Love *et al.* (2022) [8].

Fig 1: Conceptual Framework of School-Based Physical Activity Interventions and Their Effects on Health and Academic Outcomes

This figure illustrates the conceptual relationships underlying the study, showing how school-based physical activity interventions function as the primary independent variable influencing student outcomes. The framework highlights key mediating pathways—including physical health, psychological wellbeing, and cognitive functioning—through which physical activity impacts academic outcomes such as academic performance, classroom engagement, and problem-solving ability. The model also incorporates moderating factors, including school environment, teacher support, student characteristics, and implementation conditions, which influence the effectiveness of interventions.

Explanatory Note on the Conceptual Framework

The conceptual framework presented in Fig 1 provides a structured representation of the relationships between school-based physical activity interventions and student outcomes, highlighting the mechanisms through which these interventions influence both health and academic performance. The framework positions school-based physical activity interventions as the primary independent variable, encompassing strategies such as enhanced physical education, physically active learning, classroom movement breaks, and school sports programmes.

Central to the framework are the mediating pathways—physical health, psychological wellbeing, and cognitive functioning—through which physical activity exerts its effects. Improvements in physical health, including cardiovascular fitness and body composition, contribute to overall physiological functioning and energy regulation. Simultaneously, enhanced psychological wellbeing, reflected in reduced stress, improved mood, and better emotional regulation, supports students' readiness to engage in learning activities. These physical and psychological benefits collectively influence cognitive functioning, particularly in areas such as attention, memory, and executive functioning, which are critical for effective learning and academic performance.

The framework further illustrates that academic outcomes—such as academic achievement, classroom engagement, and problem-solving ability—are not direct products of physical activity alone but are shaped through these interconnected mediating processes. This highlights the indirect yet significant role of physical activity in enhancing educational outcomes.

In addition, the model incorporates moderating factors, including school environment, teacher support, student characteristics, and intervention design features such as duration and intensity. These factors influence the effectiveness and sustainability of interventions, emphasizing that outcomes depend not only on the presence of physical activity programmes but also on the context in which they are implemented.

Overall, the framework reflects a dynamic and integrative system in which physical activity interventions operate through multiple pathways to promote holistic student development. It provides a conceptual basis for understanding how health, cognitive, and educational outcomes are interrelated within school settings and guides the interpretation of empirical findings in this study.

2.2 Theoretical Review

The effectiveness of school-based physical activity interventions in improving health and academic outcomes can be better understood through relevant theoretical frameworks that explain how environmental structures, behavioral processes, and cognitive mechanisms interact to influence student development. Given the multidimensional nature of physical activity interventions, no single theory sufficiently captures their complexity. This study therefore draws on two complementary theoretical perspectives—Social Ecological Theory and Cognitive Load Theory—to provide a comprehensive explanation of how school-based physical activity interventions influence both physiological health outcomes and cognitive processes associated with academic performance.

The Social Ecological Theory offers a broad framework for understanding how individual behaviors are shaped by interactions across multiple levels of influence, including individual, interpersonal, organizational, community, and policy environments. Originally developed by Bronfenbrenner and widely applied in health promotion research, the theory emphasizes that behavior is not solely a function of individual choice but is significantly influenced by environmental structures and social contexts (Golden & Earp, 2020) [5]. Within the context of school-based physical activity, this perspective highlights the critical role of the school environment as an institutional setting where policies, infrastructure, and social interactions converge to shape students' physical activity behaviors.

At the organizational level, schools function as structured environments that can either facilitate or constrain students' opportunities for physical activity. The availability of facilities, the quality of physical education programmes, teacher attitudes, and school policies all influence the extent to which students engage in regular movement. Empirical research demonstrates that schools with supportive policies, well-designed physical activity programmes, and active teacher involvement are more successful in promoting sustained physical activity among students (Daly-Smith *et al.*, 2020; Love *et al.*, 2022) [3, 8]. From a Social Ecological perspective, school-based physical activity interventions are effective because they modify environmental conditions, making physical activity more accessible, routine, and socially reinforced.

Furthermore, the theory underscores the importance of interpersonal influences, particularly peer interactions and teacher support, in shaping children's behavior. Students are more likely to participate in physical activity when it is

socially encouraged and embedded within the school culture. Interventions that foster collaborative activities, inclusive participation, and positive reinforcement from teachers can strengthen students' motivation and engagement in physical activity (Watson *et al*., 2021) [19]. At the policy level, national and institutional guidelines on physical education and school health programmes further influence the implementation and sustainability of physical activity interventions. By addressing multiple levels of influence simultaneously, the Social Ecological framework explains why school-based interventions can produce more consistent and population-wide effects compared to individual-level behavior change strategies.

Beyond its implications for physical activity behavior, the Social Ecological Theory also provides insight into how supportive school environments contribute to academic outcomes. Schools that prioritize student wellbeing through integrated health promotion strategies tend to foster positive learning environments characterized by improved classroom behavior, stronger teacher-student relationships, and increased student engagement. These contextual factors are associated with enhanced academic motivation and learning outcomes (Álvarez-Bueno *et al*., 2022). Thus, the ecological perspective suggests that improvements in academic performance may arise not only from direct cognitive effects of physical activity but also from broader changes in the school environment that support both health and learning.

While the Social Ecological Theory explains the environmental and behavioral determinants of physical activity, Cognitive Load Theory provides a complementary explanation for the cognitive mechanisms through which physical activity influences learning and academic performance. Cognitive Load Theory, developed by Sweller and widely applied in educational psychology, posits that human working memory has a limited capacity for processing information. When cognitive demands exceed this capacity, learning becomes inefficient, resulting in reduced comprehension and retention (Sweller *et al*., 2020) [18]. Effective instructional strategies therefore aim to optimize cognitive load by enhancing cognitive resources and reducing unnecessary mental strain.

Within this framework, physical activity can be conceptualized as a mechanism that enhances cognitive capacity and reduces mental fatigue. Regular engagement in physical activity has been shown to improve cerebral blood flow, stimulate neurogenesis, and promote the release of neurochemicals such as dopamine and brain-derived neurotrophic factor (BDNF), all of which support neural plasticity and cognitive functioning (Hillman *et al*., 2021) [7]. These physiological changes contribute to improvements in attention, memory, and executive functioning—key cognitive processes required for effective learning. By enhancing these cognitive capacities, physical activity can indirectly reduce cognitive load during academic tasks, enabling students to process and retain information more efficiently.

Empirical studies support this theoretical linkage between physical activity and cognitive performance. Research indicates that students who engage in regular physical activity demonstrate improved executive functioning, including better inhibitory control, working memory, and cognitive flexibility (Donnelly *et al*., 2022; Singh *et al*., 2021) [4, 16]. These cognitive skills are essential for academic success, as they enable students to focus attention, manage distractions, and organize information during complex learning tasks. In addition, short bouts of physical activity integrated into classroom instruction—such as movement breaks—have been shown to improve immediate attention and on-task behavior, suggesting that physical activity can help restore depleted cognitive resources during prolonged periods of sedentary learning (Norris *et al*., 2020) [9].

Cognitive Load Theory also provides a theoretical basis for understanding the effectiveness of physically active learning approaches. Physically active learning integrates movement into academic instruction, allowing students to engage in both cognitive and physical processes simultaneously. This approach can enhance learning by distributing cognitive demands across multiple sensory and motor systems, thereby reducing overload within working memory. Studies have shown that physically active learning can improve both student engagement and knowledge retention, as it promotes deeper cognitive processing and sustained attention (Daly-Smith *et al*., 2020) [3]. By incorporating movement into instructional design, such approaches align with Cognitive Load Theory's emphasis on optimizing cognitive efficiency during learning.

In addition to cognitive processes, physical activity also influences emotional and psychological states, which indirectly affect learning outcomes. High levels of stress and anxiety are known to impair cognitive functioning and increase cognitive load, thereby reducing academic performance. Regular physical activity has been associated with reduced stress, improved mood, and enhanced emotional regulation among children and adolescents (Biddle *et al*., 2021) [2]. These psychological benefits create more favorable conditions for learning by enabling students to concentrate more effectively and engage more fully in academic tasks.

The integration of Social Ecological Theory and Cognitive Load Theory provides a comprehensive theoretical framework for understanding the multifaceted impact of school-based physical activity interventions. While the Social Ecological perspective explains how environmental and institutional factors shape students' opportunities for physical activity, Cognitive Load Theory elucidates the internal cognitive mechanisms through which physical activity enhances learning and academic performance. Together, these frameworks highlight that effective school-based interventions must operate at both environmental and cognitive levels—creating supportive contexts for physical activity while simultaneously enhancing the cognitive processes that underpin academic success.

Overall, this theoretical synthesis underscores the importance of adopting a holistic approach to school-based physical activity interventions. By recognizing the interplay between environmental structures, behavioral influences, physiological mechanisms, and cognitive processes, the study provides a robust theoretical foundation for interpreting empirical findings on the relationship between physical activity, health, and academic outcomes. This integrated perspective is essential for designing interventions that not only increase physical activity participation but also maximize their broader developmental benefits for students.

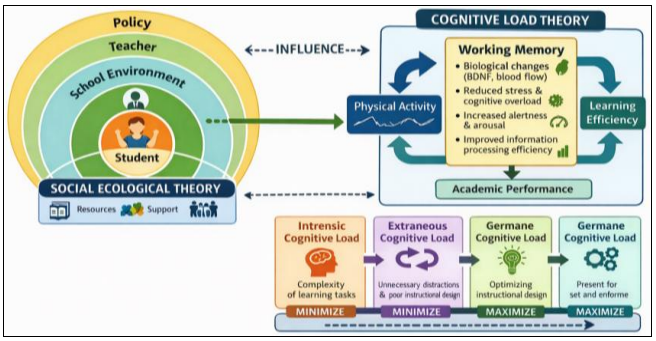


Fig 2: Theoretical Integration Model Linking Social Ecological Theory and Cognitive Load Theory in School-Based Physical Activity Interventions

This figure presents an integrated theoretical model illustrating how school-based physical activity interventions influence student outcomes through the combined mechanisms of Social Ecological Theory and Cognitive Load Theory. The model demonstrates how multiple environmental layers—policy, school context, and teacher support—shape students' engagement in physical activity, while cognitive processes such as working memory, attention, and information processing mediate learning efficiency. The integration highlights how supportive school environments and structured physical activity reduce cognitive load, enhance cognitive functioning, and ultimately improve academic performance.

2.3 Empirical Review

Empirical research on school-based physical activity interventions has expanded significantly in recent years, reflecting increasing recognition of their potential to simultaneously enhance physical health and academic outcomes among children and adolescents. This growing body of literature encompasses randomized controlled trials, quasi-experimental studies, and systematic reviews that examine the effects of structured physical activity programmes implemented within school environments. While the overall evidence base suggests positive associations between school-based physical activity and student outcomes, the magnitude and consistency of these effects vary depending on intervention characteristics, study design, and contextual factors.

A substantial portion of empirical studies has focused on the academic and cognitive benefits of school-based physical activity interventions. Recent meta-analyses provide strong evidence that regular participation in physical activity is associated with improvements in academic achievement, particularly in areas such as mathematics and general cognitive performance (Álvarez-Bueno *et al*., 2022; Singh *et al*., 2021 [16]). These findings are supported by large-scale systematic reviews indicating that structured physical activity interventions do not compromise instructional time but instead enhance learning by improving cognitive readiness and classroom engagement (Watson *et al*., 2021) [19]. Importantly, such studies demonstrate that physical activity can be effectively integrated into school curricula without negatively affecting academic priorities, thereby addressing a key concern among educators and policymakers.

Experimental and quasi-experimental studies further elucidate the cognitive mechanisms underlying these academic improvements. Donnelly *et al*. (2022) [4] found that students participating in school-based physical activity programmes exhibited significant enhancements in executive functioning, including improvements in working memory, attention control, and cognitive flexibility. Similarly, Singh *et al*. (2021) [16] reported that physical activity interventions contribute to measurable gains in cognitive performance by stimulating neurophysiological processes associated with brain development. These findings reinforce the notion that physical activity plays a critical role in supporting the cognitive processes necessary for effective learning.

In addition to general physical activity programmes, a growing body of empirical research has examined the effectiveness of physically active learning interventions. These approaches integrate movement directly into academic instruction, allowing students to engage in physical activity while processing educational content. Evidence suggests that physically active learning strategies can significantly improve classroom engagement, attentional control, and knowledge retention (Daly-Smith *et al*., 2020; Norris *et al*., 2020) [3, 9]. For instance, studies have shown that incorporating movement into mathematics or language lessons enhances both participation and comprehension, as students benefit from the simultaneous activation of cognitive and motor processes. These findings highlight the potential of integrated intervention models to achieve dual outcomes without requiring additional instructional time.

Beyond academic and cognitive outcomes, a large body of empirical research has documented the physical health benefits associated with school-based physical activity interventions. Numerous studies report significant improvements in cardiovascular fitness, body composition, and overall physical health among students who participate in structured physical activity programmes. Páez-Maldonado *et al*. (2020) [12] demonstrated that school-based interventions significantly improve cardiorespiratory fitness and reduce body mass index among children, while Love *et al*. (2022) [8] found that programmes involving regular moderate-to-vigorous physical activity produce the most consistent improvements in physical fitness outcomes. These findings are particularly important in light of the increasing prevalence of childhood obesity and sedentary behavior globally.

In addition to physical health outcomes, empirical studies increasingly emphasize the psychological benefits of school-based physical activity interventions. Regular participation in physical activity has been associated with improvements in mental health, including reductions in anxiety and depressive symptoms, enhanced mood, and improved emotional regulation (Biddle *et al*., 2021) [2]. These psychological benefits are not only important in their own right but also have indirect implications for academic performance, as improved emotional wellbeing is associated with greater motivation, concentration, and classroom participation. Thus, the empirical literature suggests that physical activity interventions contribute to a holistic improvement in student wellbeing, encompassing physical, cognitive, and emotional domains.

Despite the generally positive findings reported across empirical studies, notable inconsistencies remain within the literature. One major source of variation relates to differences in intervention design and implementation. School-based physical activity programmes vary widely in terms of structure, intensity, duration, and delivery methods.

Some interventions focus on enhancing physical education curricula, while others emphasize classroom-based activity breaks, extracurricular sports, or integrated learning approaches. This heterogeneity complicates direct comparisons across studies and contributes to variation in reported outcomes (Watson *et al*., 2021) [19].

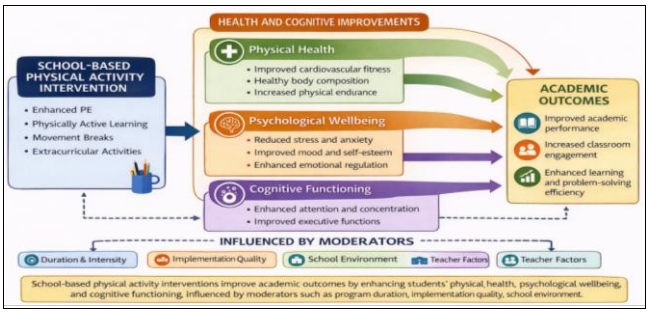
Another important methodological challenge concerns the measurement of academic outcomes. Studies employ diverse indicators, including standardized test scores, teacher assessments, classroom observations, and self-reported measures of academic performance. Research indicates that studies using objective measures such as standardized test scores tend to report smaller effect sizes compared to those using observational or subjective measures (Watson *et al*., 2021) [19]. This variation in measurement approaches limits the comparability of findings and may partially explain inconsistencies in the reported relationship between physical activity and academic achievement.

Furthermore, contextual factors within school environments play a critical role in shaping the effectiveness of physical activity interventions. Factors such as school infrastructure, availability of resources, teacher training, and institutional support influence both the implementation and sustainability of interventions. Schools with well-developed physical education programmes, supportive leadership, and adequate facilities are generally more successful in integrating physical activity into daily routines. In contrast, schools facing resource constraints, high academic pressure, or limited teacher capacity may struggle to implement interventions effectively (Daly-Smith *et al*., 2020) [3]. These contextual differences highlight the importance of considering environmental and institutional factors when evaluating intervention outcomes.

Emerging empirical evidence also underscores the importance of intervention intensity and duration in determining effectiveness. Studies consistently show that interventions involving regular moderate-to-vigorous physical activity and sustained implementation over time produce stronger and more consistent improvements in both health and academic outcomes (Love *et al*., 2022) [8]. Longitudinal research further suggests that sustained exposure to physical activity interventions leads to cumulative benefits in cognitive functioning and academic performance, whereas short-term interventions may yield limited or transient effects (Hillman *et al*., 2021) [7]. These findings emphasize the need for long-term, systematically integrated programmes rather than isolated or short-duration initiatives.

Overall, the empirical literature provides strong support for the effectiveness of school-based physical activity interventions in promoting improvements in health, cognitive functioning, and academic outcomes among students. While variations in intervention design, measurement approaches, and contextual factors contribute to inconsistencies in findings, the majority of studies indicate that structured physical activity programmes have positive and meaningful effects across multiple domains. The evidence therefore suggests that integrating physical activity into school environments represents a viable and evidence-based strategy for addressing both public health challenges and educational objectives.

However, the review of empirical studies also highlights the need for further research using standardized methodologies, rigorous experimental designs, and long-term evaluation frameworks. Future studies should aim to reduce heterogeneity in intervention design and outcome measurement while exploring the mechanisms through which physical activity influences academic performance. Such research will be essential for identifying the most effective intervention models and ensuring that school-based physical activity programmes are implemented in ways that maximize their impact on both student health and educational achievement.



Source: Author's conceptualization based on Hillman *et al*. (2021) [7], Donnelly *et al*. (2022) [4], Álvarez-Bueno *et al*. (2022), and Biddle *et al*. (2021) [2]

Fig 3: Mechanism Pathway Linking School-Based Physical Activity Interventions to Academic Outcomes

This figure illustrates the underlying mechanisms through which school-based physical activity interventions influence academic outcomes among students. The model shows that participation in structured physical activity programmes leads to improvements in physical health, psychological wellbeing, and cognitive functioning. These interrelated pathways enhance key learning processes such as attention, executive functioning, and emotional regulation, which collectively contribute to improved academic performance, classroom engagement, and problem-solving ability. The diagram further highlights the role of moderating factors—such as intervention duration, intensity, implementation quality, and school context—in shaping the strength and sustainability of these effects.

3. Methodology

3.1 Research Design

This study adopts a systematic review design to synthesize empirical evidence on the effectiveness of school-based physical activity interventions in improving health and academic outcomes among school-aged children and adolescents. A systematic review approach is appropriate for this study because it enables the structured identification, critical appraisal, and synthesis of relevant studies using transparent and reproducible procedures (Page *et al*., 2021) [11].

The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, which provide a standardized framework for reporting systematic reviews. The PRISMA approach enhances methodological rigor by ensuring explicit documentation of the search strategy, study selection process, inclusion criteria, and synthesis procedures. This reduces selection bias and improves the transparency and replicability of the review.

3.2 Eligibility Criteria

The eligibility criteria for study inclusion were defined a

priori to ensure consistency and relevance to the research objectives.

Inclusion Criteria

Studies were included if they met the following criteria:
Published in peer-reviewed journals.
Published between January 2020 and April 2026 (date of final search).
Examined school-based physical activity interventions.
Included school-aged children or adolescents (primary or secondary education).
Reported outcomes related to at least one of the following:
Physical health (e.g., cardiovascular fitness, BMI, physical activity levels).
Cognitive outcomes (e.g., executive function, attention, memory).
Academic outcomes (e.g., test scores, grades, classroom engagement).
Written in English language.
Employed empirical research designs (e.g., randomized controlled trials, quasi-experimental studies, longitudinal studies).

Exclusion Criteria

Studies were excluded if they:
Focused on adult populations or university students.
Examined physical activity interventions outside school settings.
Did not report measurable health or academic outcomes.
Were non-peer-reviewed (e.g., conference abstracts, dissertations, editorials, book chapters).
Were review papers, unless used for background context rather than primary synthesis.

3.3 Information Sources

A comprehensive literature search was conducted across the following electronic databases:
Scopus
Web of Science
PubMed
ERIC (Education Resources Information Center)
Google Scholar
These databases were selected to ensure broad coverage across disciplines, including public health, education, psychology, and sports science.
In addition, reference lists of included studies were manually screened to identify additional relevant articles not captured through database searches (snowballing technique).

3.4 Search Strategy

A structured search strategy was developed using a combination of keywords and Boolean operators to capture relevant studies. The search terms were derived from the key concepts of the study: physical activity, school-based interventions, and academic/health outcomes.
Example Search String
("school-based physical activity" OR "school physical activity intervention" OR "physically active learning" OR "active classroom")
AND
("academic performance" OR "academic achievement" OR "cognitive outcomes" OR "executive function")
AND
("health outcomes" OR "physical fitness" OR "BMI" OR "mental health")
Search terms were adapted to suit the indexing systems of each database. Filters were applied to limit results to:
Publication years: 2020–2026
Language: English
Document type: Peer-reviewed articles
The final search was conducted in April 2026.

3.5 Study Selection Process

The study selection process followed the PRISMA four-stage flow:

Identification

All records retrieved from database searches were exported into a reference management system. Duplicate records were identified and removed.

Screening

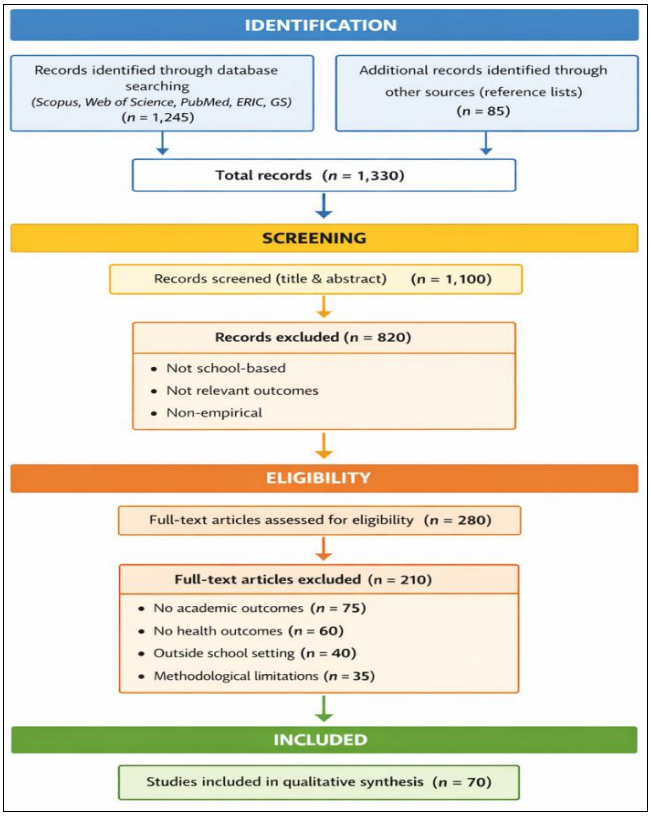
Titles and abstracts were screened against the inclusion and exclusion criteria. Irrelevant studies were excluded at this stage.

Eligibility

Full-text articles of potentially relevant studies were retrieved and assessed in detail to confirm eligibility.

Inclusion

Studies meeting all criteria were included in the final synthesis.
To enhance methodological rigor, the selection process was conducted systematically using predefined criteria. Any ambiguities in study eligibility were resolved through careful reassessment of study objectives, methodology, and reported outcomes.



Source: Adapted from PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 Statement (Page *et al.*, 2021) [11]; authors' compilation.

Fig 4: PRISMA 2020 Flow Diagram of Study Selection Process

This figure illustrates the systematic process used to identify, screen, assess eligibility, and include studies in the review. The diagram presents the number of records retrieved from multiple databases, the removal of duplicate records, the screening of titles and abstracts, full-text eligibility assessment, and the final number of studies included in the qualitative synthesis of school-based physical activity interventions and their effects on health and academic outcomes.

3.6 Data Extraction

Data from the included studies were systematically extracted using a structured data extraction framework. The following information was recorded:
Author(s) and year of publication
Study location and context
Study design (e.g., RCT, quasi-experimental)
Sample size and participant characteristics
Type of physical activity intervention
Duration and intensity of intervention
Outcome measures (health, cognitive, academic)

Key Findings

This standardized approach ensured consistency in capturing relevant information across studies and facilitated comparative analysis.

3.7 Quality Assessment (Risk of Bias)

To ensure the reliability of the synthesized evidence, included studies were critically appraised for methodological quality and risk of bias.
Randomized controlled trials were assessed based on criteria such as:
Randomization procedures
Allocation concealment
Outcome measurement validity
Non-randomized studies were evaluated based on:
Study design rigor
Control of confounding variables
Reliability of outcome measures
The quality assessment process enabled the identification of potential methodological limitations within individual studies and informed the interpretation of findings.

3.8 Data Synthesis and Analysis

Given the heterogeneity of study designs, intervention types, and outcome measures, a narrative (qualitative) synthesis approach was adopted. This approach is appropriate when statistical meta-analysis is not feasible due to variability across studies (Popay *et al*., 2020) [13].
The synthesis involved:
Thematic categorization of findings into:
Health outcomes
Cognitive outcomes
Academic outcomes
Comparative analysis across studies to identify:
Consistencies and patterns
Variations in outcomes
Influencing factors (e.g., intervention duration, intensity)
Analytical interpretation of how intervention characteristics and contextual factors influence effectiveness.
This approach allowed for a comprehensive understanding of the evidence while accounting for methodological diversity.

3.9 Conceptual Model

The analytical framework guiding this review is based on the relationship between school-based physical activity interventions and student outcomes.
Independent Variable: School-Based Physical Activity Interventions.
Dependent Variables:
Health Outcomes (e.g., cardiovascular fitness, BMI, mental wellbeing).
Academic Outcomes (e.g., academic achievement, cognitive functioning, classroom engagement).
The model assumes that increased participation in structured physical activity leads to improvements in physical health, which in turn supports cognitive functioning and academic performance.

3.10 Ethical Considerations

As this study is based on the analysis of previously published research, it does not involve direct human participation and therefore does not require ethical approval. However, ethical standards were maintained by ensuring accurate citation, proper acknowledgment of sources, and faithful representation of original findings.

Table 1: Characteristics of Included Studies

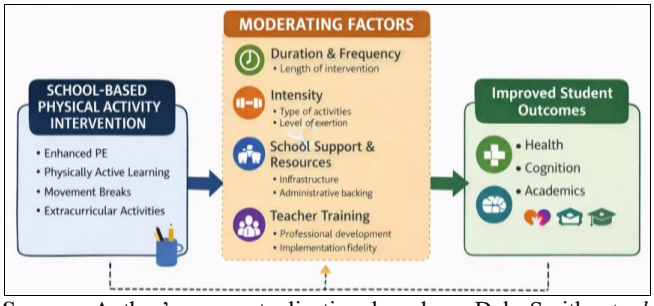
Author(s) & Year	Country/ Setting	Study Design	Sample Characteristics	Intervention Type	Duration & Intensity	Outcome Measures	Key Findings
Álvarez-Bueno et al. (2022)	Multi-country (meta-analysis)	Systematic Review & Meta-analysis	School-aged children	General school-based PA interventions	Varies (moderate–vigorous PA emphasized)	Academic performance, cognitive function	Significant improvement in academic achievement, especially mathematics and
Donnelly et al. (2022)	USA/International	Systematic Review	Children and adolescents	Structured PA programmes	Long-term interventions	Cognitive function, academic achievement	Improved executive functioning and modest academic gains
Singh et al. (2021)	International	Meta-analysis	Children & adolescents	PA interventions (varied)	Regular PA exposure	Executive function, academic performance	Positive effects on cognitive flexibility, memory, and academic outcomes
Watson et al. (2021)	International	Systematic Review & Meta-analysis	School-aged children	Classroom-based PA interventions	Short bouts (daily/weekly)	Academic engagement, PA levels	Improved classroom behavior and engagement; mixed effects on test scores
Norris et al. (2020)	International	Systematic Review	Primary school children	Physically active learning	Integrated into lessons	PA levels, cognition, academic engagement	Increased physical activity and improved attention and engagement
Daly-Smith et al. (2020)	UK/International	Conceptual & Empirical Review	School-aged children	Physically active learning strategies	Ongoing integration	Engagement, learning outcomes	Enhanced motivation, engagement, and learning readiness
Love et al. (2022)	International	Systematic Review & Meta-analysis	Children & adolescents	School-based PA programmes	Moderate-to-vigorous PA, sustained	Physical fitness, academic outcomes	Strong improvements in fitness; moderate academic benefits
Páez-Maldonado et al. (2020)	Spain	Cross-sectional /Empirical	School children	General PA participation	Regular PA	Physical fitness, BMI, academic performance	Improved fitness and reduced BMI; positive association with academic

Table 1 summarizes the characteristics of the studies included in the review, highlighting variations in intervention design, duration, and reported outcomes.

4. Discussion of Results

The findings of this systematic review provide compelling evidence that school-based physical activity interventions represent effective and multifaceted strategies for improving both health and academic outcomes among school-aged children and adolescents. Drawing on a synthesis of recent empirical studies, the results demonstrate that structured physical activity programmes implemented within school environments contribute to measurable improvements in physical fitness, psychological wellbeing, cognitive functioning, and, to a moderate extent, academic performance. However, the magnitude and consistency of these outcomes are influenced by variations in intervention design, implementation quality, and contextual factors within educational settings.

One of the most robust findings emerging from this review is the consistent positive impact of school-based physical activity interventions on physical health outcomes. Across the reviewed studies, improvements in cardiovascular fitness, physical endurance, and body composition were widely reported, reinforcing the well-established role of physical activity in promoting child health. These findings are consistent with prior meta-analytic evidence indicating that regular participation in moderate-to-vigorous physical activity significantly enhances cardiorespiratory fitness and reduces body mass index among children and adolescents (Álvarez-Bueno *et al*., 2022; Love *et al*., 2022 [8]). Importantly, the present review extends this evidence by demonstrating that school-based interventions when systematically implemented, can serve as practical and scalable mechanisms for addressing declining physical activity levels within youth populations. These moderating influences and their relationship to student outcomes are illustrated in Fig 5.



Source: Author's conceptualization based on Daly-Smith *et al*. (2020) [3], Love *et al*. (2022) [8], Watson *et al*. (2021) [19], and Donnelly *et al*. (2022) [4].

Fig 5: Intervention Effectiveness Model for School-Based Physical Activity Programmes

This figure illustrates the key factors influencing the effectiveness of school-based physical activity interventions in improving student outcomes. The model depicts school-based physical activity interventions as the core input, encompassing strategies such as enhanced physical education, physically active learning, classroom movement breaks, and extracurricular activities. It highlights moderating factors—including intervention duration and frequency, activity intensity, school support and resources, and teacher training—that shape the quality and impact of implementation. The model demonstrates that when these factors are optimally aligned, interventions lead to improved student outcomes across three domains: health, cognitive functioning, and academic performance. The framework emphasizes that effectiveness is not solely determined by the presence of interventions but by the conditions under which they are delivered.

In addition to physical health benefits, the findings highlight the significant psychological and emotional advantages associated with participation in school-based physical activity programmes. Improvements in mood, reductions in anxiety, and enhanced emotional regulation were frequently reported across studies, aligning with existing research on the mental health benefits of physical activity (Biddle *et al*., 2021) [2]. These outcomes are particularly relevant in the current educational context, where concerns about student mental wellbeing have intensified. The integration of physical activity into school routines therefore offers a dual benefit: improving both physical health and psychological resilience among students.

Beyond health outcomes, this review provides substantial evidence supporting the role of physical activity in enhancing cognitive functioning. Improvements in executive functions—including attention, working memory, and cognitive flexibility—were consistently observed among students participating in structured physical activity interventions. These findings are supported by neurocognitive research demonstrating that physical activity stimulates brain processes associated with learning, including increased cerebral blood flow and enhanced neural connectivity (Hillman *et al*., 2021; Donnelly *et al*., 2022) [7, 4]. From a theoretical perspective, these results align closely with Cognitive Load Theory, suggesting that physical activity enhances cognitive capacity and reduces mental fatigue, thereby enabling more efficient information processing during academic tasks.

The implications of improved cognitive functioning are further reflected in the observed effects on academic outcomes. The review indicates that school-based physical activity interventions are associated with moderate but meaningful improvements in academic performance, particularly in areas related to concentration, classroom engagement, and problem-solving ability. These findings support the growing body of evidence suggesting that physical activity does not detract from academic learning but rather enhances it by improving students' readiness to learn (Singh *et al*., 2021; Watson *et al*., 2021) [16, 19]. Notably, interventions that integrate movement directly into instructional activities—such as physically active learning—appear to produce particularly strong effects on classroom engagement and attentional control.

However, while the overall direction of evidence is positive, the findings also reveal important inconsistencies, particularly with respect to standardized academic achievement measures. Some studies report significant improvements in test scores, while others find minimal or statistically insignificant effects. This variability may be attributed to several factors. First, differences in intervention duration and intensity play a critical role; longer-term and more intensive programmes tend to produce stronger outcomes compared to short-term or low-intensity interventions. Second, methodological differences in outcome measurement contribute to variation, as studies relying on objective standardized tests often report smaller effect sizes than those using observational or teacher-reported measures (Watson *et al*., 2021) [19]. These findings underscore the need for caution in interpreting academic

outcomes and highlight the importance of methodological consistency in future research.

The review also emphasizes the importance of intervention characteristics in determining effectiveness. Programmes that incorporate regular, sustained, and moderate-to-vigorous physical activity within daily school routines consistently demonstrate stronger outcomes across both health and academic domains. This finding aligns with previous research indicating that frequency, intensity, and integration are key determinants of intervention success (Love *et al*., 2022) [8]. In particular, physically active learning approaches and structured physical education programmes that ensure meaningful levels of physical exertion appear to be among the most effective models. These approaches are especially valuable in educational systems where time constraints limit opportunities for additional physical activity, as they allow schools to achieve multiple objectives simultaneously.

Contextual and institutional factors further shape the effectiveness of school-based physical activity interventions. The findings indicate that successful implementation is strongly influenced by factors such as teacher training, school leadership support, infrastructure availability, and alignment with school policies. Schools with supportive environments and adequate resources are more likely to implement interventions effectively and sustain them over time. Conversely, schools facing resource constraints or high academic pressure may encounter challenges in integrating physical activity into daily routines (Daly-Smith *et al*., 2020) [3]. These observations are consistent with Social Ecological Theory, which emphasizes the role of environmental and institutional contexts in shaping behavioral outcomes.

Importantly, the findings of this review contribute to ongoing debates regarding the trade-off between academic instruction and physical activity in schools. The evidence suggests that increasing physical activity does not compromise academic performance; rather, it enhances the cognitive and behavioral conditions necessary for effective learning. This challenges traditional assumptions that allocating time to physical activity detracts from academic achievement and instead supports the argument for integrating physical activity as a core component of educational practice.

Despite these strengths, the review also highlights several limitations within the existing body of empirical research. The heterogeneity of intervention designs, variations in outcome measurement, and differences in study quality limit the comparability of findings across studies. In addition, many studies rely on short-term interventions, making it difficult to assess the long-term impact of physical activity on academic trajectories. There is also a need for more rigorous experimental designs and standardized measurement frameworks to strengthen causal inference and improve the reliability of findings.

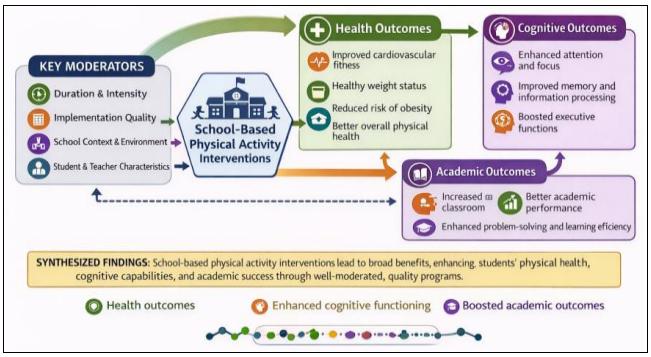


Fig 6: Evidence Synthesis of Outcomes from School-Based Physical Activity Interventions

This figure presents a synthesized overview of the key findings from the reviewed empirical studies, illustrating the multidimensional effects of school-based physical activity interventions on student outcomes. The diagram categorizes outcomes into three interconnected domains: health outcomes (e.g., improved cardiovascular fitness, body composition, and overall physical wellbeing), cognitive outcomes (e.g., enhanced attention, memory, and executive functioning), and academic outcomes (e.g., improved classroom engagement, problem-solving ability, and academic performance). It also highlights moderating factors—such as intervention duration, intensity, implementation quality, and school context—that influence the effectiveness of these interventions.

The discussion underscores that school-based physical activity interventions are not merely health promotion strategies but are integral components of holistic educational development. By simultaneously influencing physical health, psychological wellbeing, cognitive functioning, and academic performance, these interventions offer a comprehensive approach to improving student outcomes. The findings therefore support the integration of structured physical activity programmes within school systems as evidence-based strategies for enhancing both educational and public health outcomes.

5. Conclusion

This systematic review provides robust and up-to-date evidence that school-based physical activity interventions are effective strategies for promoting both physical health and academic development among school-aged children and adolescents. Synthesizing findings from recent empirical studies (2020–2026), the review demonstrates that structured physical activity programmes implemented within school environments contribute to significant improvements in cardiovascular fitness, body composition, psychological wellbeing, and cognitive functioning. These outcomes collectively reinforce the critical role of physical activity as a foundational component of holistic child development.

Importantly, the findings extend beyond traditional health benefits to highlight the educational value of physical

activity. The evidence indicates that school-based physical activity interventions are associated with moderate but meaningful improvements in cognitive processes such as attention, executive functioning, and classroom engagement, which are essential for effective learning. While the effects on standardized academic achievement remain somewhat variable, the overall pattern of findings suggests that physical activity either enhances or, at minimum, does not hinder academic performance. This challenges persistent assumptions that time allocated to physical activity detracts from academic instruction and instead supports its integration as a complementary educational strategy.

The review further identifies key characteristics of effective interventions. Programmes that incorporate regular, sustained, and moderate-to-vigorous physical activity within daily school routines consistently demonstrate the strongest outcomes across both health and academic domains. In particular, integrated approaches—such as physically active learning and high-quality physical education—offer practical and efficient models for embedding physical activity into educational systems without compromising instructional time. These findings underscore the importance of moving beyond isolated or short-term initiatives toward comprehensive, whole-school approaches that prioritize both student wellbeing and learning outcomes.

From a theoretical perspective, the findings support the combined explanatory power of Social Ecological Theory and Cognitive Load Theory. School environments that provide supportive structures, resources, and social reinforcement enable sustained engagement in physical activity, while the physiological and cognitive effects of such activity enhance learning capacity and academic performance. This integrated understanding highlights that the benefits of physical activity are not limited to individual behavior change but are shaped by broader institutional and cognitive processes.

Despite these contributions, the review also identifies important limitations within the existing literature. Variations in intervention design, outcome measurement, and study quality limit the comparability of findings across studies. In addition, the predominance of short-term interventions restricts understanding of the long-term impact of school-based physical activity on academic trajectories and lifelong health outcomes. These gaps highlight the need for future research employing standardized methodologies, longitudinal designs, and rigorous experimental approaches to strengthen causal inference and identify optimal intervention models.

Overall, this study underscores that school-based physical activity interventions represent a critical intersection between public health and educational policy. By simultaneously addressing physical inactivity, mental wellbeing, and academic engagement, these interventions offer a comprehensive and evidence-based approach to improving student outcomes. The findings provide strong justification for policymakers, educators, and school administrators to prioritize the integration of structured physical activity within school curricula. Investing in active school environments is not only a strategy for improving health but also a means of fostering more engaged, cognitively prepared, and academically successful learners.

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