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Role of Physical Education in the Cognitive Development of Children at the Secondary Level

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Abstract

This study examined the role of physical education in the cognitive development of secondary-school children. A quantitative, descriptive-correlational design was employed, and data was collected from 489 Grade 9 and Grade 10 students selected through multistage stratified random sampling from public and private schools. A self-developed 50-item questionnaire measured physical education participation, attention, working memory, inhibitory control, cognitive flexibility, decision-making, and problem-solving. Data were analyzed using frequencies, percentages, means, standard deviations, independent-samples t tests, one-way ANOVA, Pearson correlation, and regression analysis. The findings showed high levels of physical education participation and cognitive development. Physical education was significantly and positively related to all cognitive dimensions and explained 39.7% of the variance in cognitive development. Regular attendance, greater weekly frequency, longer lesson duration, and participation in structured sports were associated with higher cognitive scores. The study concluded that quality physical education supports students' cognitive development and should be strengthened in secondary schools.

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Introduction

Physical education plays an indispensable role in secondary education as it is a subject that does more than only contribute towards the physical fitness of students; it also contributes towards their intellectual, emotional and social development. Secondary level cognitive development includes attention, working memory, inhibitory control, cognitive flexibility, decision making, problem solving and information processing and retention. Emerging data suggest that the structured physical activity can have a positive effect on these cognitive functions through increased cerebral blood flow, enhanced neural connections, facilitation of neuroplasticity and enhanced concentration and readiness to learn in students. Recent meta-analysis has revealed that physical exercise interventions significantly benefited the executive function, attention, working memory, cognitive flexibility, and inhibitory control in adolescents, and there is recent evidence that physical exercise interventions modestly improved mathematics and reading performance and overall academic outcomes (Feng et al., 2026; Liu et al., 2025). Thus, physical education must be seen as a pedagogical tool that complements the various areas of education that are crucial to the cognitive, emotional, and physical development of secondary school students, not as simply a sport or fitness class.

Adolescent development is a critical period in which important changes take place in the regions of the brain

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that mediate learning, memory, behavioural control and executive functioning. Regular opportunities are provided for students to engage in aerobic activities, team games, coordination exercises, dance, sports and cognitively demanding tasks of movement in structured physical education. These activities can facilitate cognitive functions by stimulating cerebral circulation, increasing levels of neurotrophic factors, improving mood, repeated experiences of strategic thinking, movement planning, co-operation and speedy decision making. Findings indicated that the intensity, duration, regularity and cognitive demands of physical activity may be responsible for the cognitive consequences. Ball games, dancing, and cognitively demanding physical activities have been found specifically to provide updates, inhibitory control, working memory and task shifting benefits (Mello et al., 2025; Wang et al., 2024). Children and adolescents aged 5–17 years should engage in at least 60 minutes of moderate to vigorous physical activity per day, but physical activity levels for this age group are well short of this recommendation among many children and adolescents globally (Chaput et al., 2020).

While there is an emerging body of international evidence that links physical activity to cognitive functioning, the evidence is methodologically diverse and, in some areas, inconsistent. Previous reviews found positive, neutral, and negative results, low to moderate effect sizes, high heterogeneity, inconsistent levels of intervention quality, and the limited control of other factors like sex and socio-economic status, baseline fitness, exercise intensity, and intervention duration (Wassenaar et al., 2020). For instance, a study using the games approach to physical education identified that a 60-minute lesson did not automatically result in improvements in all cognitive domains, with improvements in working memory being mainly found in students who engaged with more moderate-to-vigorous activity (MTA) during their lesson with physical education (Gilbert et al., 2023). Other meta-analyses have been conducted recently, which showed different effects depending on academic field and intervention characteristics, and some results were found in small numbers of studies (Feng et al., 2026; He et al., 2025). What is most significant is that there is limited research that has measured attention, working memory, inhibitory control, cognitive flexibility and problem solving directly among secondary school children in Pakistan. Research studies conducted at local level have focused mainly on general physical activity, on motor ability or on academic performance, or on attitudes towards physical education. Therefore, a context-specific investigation using clearly defined cognitive indicators is needed.

Physical inactivity among children and youth in school is a growing educational and public health problem globally. About 81% of adolescents aged 11-17 years are not achieving the recommended physical activity levels, and more sedentary time spent on screens may limit opportunities for physical activity and/or negatively impact executive functioning and attention (Chaput et al., 2020; Dergaa et al., 2026; Li et al., 2022). There has been a recent wave of systematic reviews and meta-analyses in various countries, confirming that there is small but robust evidence that school-based physical activity has benefit on cognitive flexibility, working memory, mathematics, reading and general academic outcomes. Ball games, dance, cognitively demanding activities, and aerobic activities seem to be particularly beneficial for attention and executive functioning, while a combination of movement and strategy, coordination, decision-making, and social interaction may be beneficial in cognitive activities (Liu et al., 2025; Mello et al., 2025; Wang et al., 2024). A 2026 meta-analysis of randomized controlled trials yielded statistically significant improvements in mathematics, reading, and academic performance overall, but with varying results across age groups, intervention designs and academic domain (Feng et al., 2026). The results have inspired physical education departments and schools around the world to incorporate high-quality physical education, movement in the classroom, active recess, and organized physical activity throughout the school day.

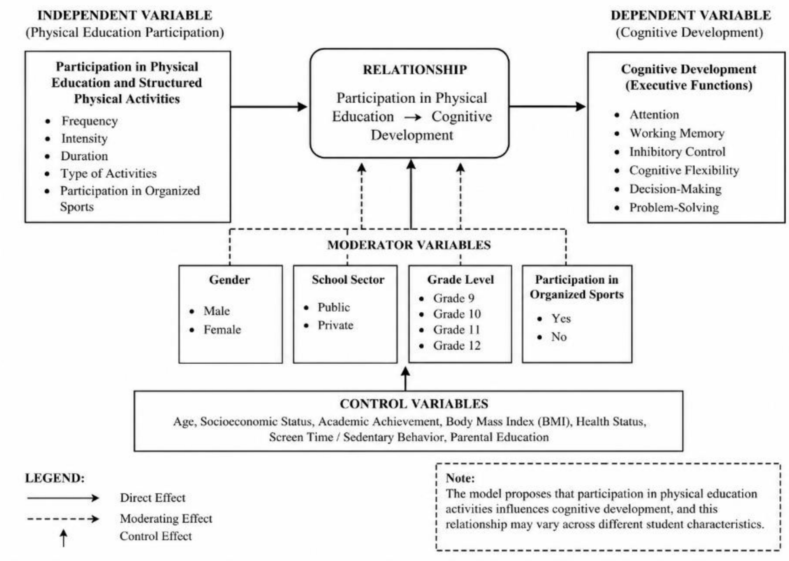
Health and physical education is part of the educational system in Pakistan and is seldom prioritized as much as subjects that focus on examinations. The factors that have been recognized by Pakistani literature as hindering in the effective implementation of physical education are lack of awareness, limited infrastructure, lack of sports materials, financial constraints, lack of trained physical education teachers, and physical education being seen as an optional or co-curricular activity (Iqbal et al., 2021). A Pakistani study of high and higher secondary students found a correlation between participation in physical activity and academic achievement, but the results for the students were limited in their ability to draw causal conclusions due to the convenience sampling and general measures of participation in physical activity (Ijaz & Shaha, 2023). A recent study conducted on 349 public and private school students in Grade 9 and 10 in Hayatabad, Peshawar, revealed that there was a statistically significant relationship between physical activity and academic performance.

Secondary-school students are expected to demonstrate sustained attention, effective memory, problem-solving, cognitive flexibility, self-regulation, and rapid information processing to meet increasing academic demands. However, highly examination-oriented school routines, prolonged sedentary classroom instruction, increasing screen exposure, insufficient physical activity, and limited implementation of quality physical education may restrict opportunities for the development of these cognitive abilities. Although international evidence suggests that regular and appropriately designed physical education can support cognition and academic learning, the effects vary according to activity type, intensity, duration, frequency, student fitness, and instructional quality. Furthermore, Pakistani studies have largely focused on physical fitness, motor abilities, academic grades, or general participation rather than direct indicators of cognitive development. Therefore, the problem addressed by the present study is the insufficient empirical understanding of how participation in physical education contributes to the attention, memory, executive functioning, decision-making, and problem-solving abilities of children at the secondary level.

1. To determine the level of participation of secondary-school students in physical education and structured physical activities and to assess their cognitive development in terms of attention, working memory, inhibitory control, cognitive flexibility, decision-making, and problem-solving.
2. To examine the relationship between participation in physical education and the cognitive development of secondary-school students and to determine the predictive effects of activity frequency, intensity, duration, and type.
3. To investigate differences in the role of physical education in cognitive development according to students' gender, school sector, grade level, and participation in organized sports.

The study was conducted cross-sectionally, geographically, and did not directly assess specific cognitive functions like working memory, attention, or inhibitory control (Ali et al., 2025). The study results suggest that physical activity in Pakistan might have an impact on students' learning performance, however, there is scanty evidence on the impact of physical activity on cognitive development at secondary level. The study will contribute to educational research by offering context specific evidence of the cognitive value of physical education with secondary school students. The results of its research could also be of interest to the policy makers, curriculum developers, school administrators and teachers as they seek to understand that physical education can have an impact beyond physical health on attention, memory, executive functioning, classroom engagement, and academic learning. The outcomes could help education authorities to plan for suitable physical education learning time, ensure suitably competent teachers are in place, upgrade sport facilities and create activities that integrate learning through physical activity with strategy, coordination, decision-making and problem-solving. The study also can help parents and students understand the need for regular exercise for well-rounded development. In terms of academic work, it will fill the gap in the literature on the cognitive outcomes of the Pakistani context and will serve as a basis for future experimental, longitudinal and interventional studies.

Conceptual Framework



Review of Related Literature

Physical education is a planned and structured component of the school curriculum through which students acquire physical fitness, movement competence, sports skills, teamwork, self-discipline, and knowledge about active lifestyles. Unlike unstructured play, physical education is delivered through specific learning objectives, organized activities, teacher guidance, assessment, and progressive skill development. At the secondary level, physical education commonly includes aerobic exercises, athletics, team sports, individual sports, rhythmic activities, fitness training, movement-based games, and health-related education. Its purpose is not restricted to developing muscular strength or physical endurance; it also provides learning situations requiring observation, planning, decision-making, problem-solving, cooperation, and behavioural control. Recent research has therefore conceptualized physical education as an educational environment capable of supporting students' physical, cognitive, psychological, and social development. Improving the quality and quantity of physical education may enhance cognitive functioning and selected areas of academic performance, particularly when lessons are developmentally appropriate, sufficiently intense, and cognitively engaging (García-Hermoso et al., 2021; González-del-Castillo & Barbero-Alcocer, 2025).

Cognitive development refers to the progressive improvement of mental processes used to understand information, regulate behaviour, solve problems, remember experiences, and adapt to changing situations. During secondary education, cognitive development involves attention, perception, processing speed, memory, reasoning, creativity, decision-making, inhibitory control, cognitive flexibility, and planning. These abilities are especially important for adolescents because secondary-school curricula require them to manage complex information, complete multiple academic tasks, control distractions, apply previously learned concepts, and make independent decisions. Executive functions are particularly significant because they allow students to hold information in working memory, resist inappropriate responses, shift between tasks, and organize goal-directed behaviour. The development of these abilities is closely associated with classroom engagement, academic learning, emotional adjustment, and social adaptation. Physical education can create opportunities to exercise these cognitive abilities through movement sequences, changing game situations, tactical decisions, rules, competition, and cooperation (Shi et al., 2022; Wang et al., 2024).

Physical Activity Requirements of Secondary-School Students

Physical activity is regarded as a critical part of children and youth development and health. Current international recommendations are for children and youth aged 5-17 years to build up at least 60 minutes of moderate-vigorous physical activity on average over the week. Most activities should be aerobic; vigorous aerobic activities and activities that strengthen muscles and bones should be done at least 3 days a week. However, it was reported that about 81% of adolescents (aged 11-17 years) in the world were not active enough. This is a critical time in education as during adolescence, physical exercise may be reduced and the school workload, screen time, home-school workload, and examination pressure are likely higher. Physical education can be the most frequent and fair place for many students to engage in organized physical activity, even for those without access to sports clubs, safe spaces in their neighborhoods, or private fitness centers (Chaput et al., 2020). It is not appropriate to think of physical activity and cognition as a dichotomy between active and inactive students. The cognitive value of an activity may be affected by the frequency, intensity, duration, complexity, instructional quality, and the level of participation of the students. A PE class that includes significant time sitting and awaiting directions may not be the same as a class where students are active, engaged in coordinated tasks, are making decisions and involve moderate to vigorous activity. Likewise, over-ambitious or improperly conducted physical activity can lead to short-term fatigue and decrease students' ability to do their schoolwork. Recent literature thus suggests that physical education be studied in terms of frequency, intensity, time and type. Moderate to vigorous activity, participation for about 30-60 minutes, and consistency over several weeks is typically linked to greater cognitive and academic benefits than occasionally or low-intensity activity, according to reviews (James et al., 2023; Shi et al., 2022).

Neurobiological Relationship Between Physical Education and Cognition

The relationship between physical education and cognition is neurobiological. A possible link between physical education and cognition is from the neurobiological impact of exercise. Exercise raises heart rate and blood flow to the brain, potentially enhancing oxygen and nutrient supply to regions of the brain related to learning and behaviour control. Exercise could also have a beneficial effect on synaptic plasticity, the way that different neuronal networks communicate with each other, and structural and functional brain maturation in areas involved in memory and executive functioning. Brain-derived neurotrophic factors are often mentioned as a biological mechanism because it plays a role in the survival of neurons, in development of synapses, learning and memory. Exercise can also affect neurotransmitters that are implicated in attention and motivation, decrease inflammation, psychological stress and physiological processes that may impact cognition. The mechanisms proposed indicate that physical education can, to certain extent, provide students with biological conditions that make them more focused, process information, and retain learning, though the extent of each mechanism differs among populations and research designs (Dergaa et al., 2026; Shi et al., 2022).

Adolescence is a sensitive period of neurological development that involves the prefrontal cortex and neural systems involved in self-regulation, planning and decision-making. These systems are continually shaped and developed during the secondary education process and are shaped by biological maturation, learning experiences, sleep, nutrition, stress and physical activity. The physical education class may facilitate neurological development because many of the tasks of sport and movement combine physical and cognitive demands. A football player, for instance, should keep track of the whereabouts of others on the field, anticipate how players move, regulate impulsive reactions, select an appropriate response, and adjust the response when the situation changes. Dance and coordinated movement places demands on students to memorize sequences, keep beat, combine visual and auditory cues, and correct errors. They demand both motor and cognitive systems and can therefore have more beneficial impacts on development than repetitive motions with minimal mental engagement (Mao et al., 2024; Wang et al., 2024).

Physical Education and Executive Functions

Executive functions are one of the most widely studied cognitive outcomes to be observed from physical activity. There are three core executive functions: inhibitory control, working memory and cognitive flexibility. Inhibitory control is the ability of a student to inhibit an automatic or distracting response, and to focus on what he or she is supposed to do. Working memory is the component that allows information to be held and manipulated temporarily, e.g., for recalling instructions during problem-solving. Cognitive flexibility is the ability to change attention, rules, and think of alternative solutions. These skills are essential in the learning process and in physical education. Students are expected to abide by the rules, memorize the movements, regulate their actions, adapt to the variations of the game, and plan. Thus, in physical education, the executive functions can be practiced repeatedly in an interesting, participatory and behaviorally relevant context (González-del-Castillo & Barbero-Alcocer, 2025; Shi et al., 2022).

Systematically collected evidence in recent years has shown that physically active interventions can have a beneficial effect on children's and adolescents' executive functioning; however these effects vary by domain of executive function and by intervention characteristics. A systematic review of physical activity in real world contexts found that acute and chronic exercise both might have a positive effect on executive functioning. Generally, the acute moderate-intensity activities, around 30–50 minutes in total, were effective, while the sustained intervention of moderate intensity activity (at least three sessions per week for 30–50 minutes and for a longer period) showed more consistent effects. The review also highlighted the potential of open-skill tasks, in which movements need to be modified in response to an unpredictable environment, for cognition and working memory. Some closed-skill activities may be different, such as the potential benefits of those that contribute to inhibitory control (Shi et al., 2022).

A systematic review and meta-analysis of cognitively engaging physical activity across 23 studies with 2,857 children and adolescents was conducted in 2024. An overall statistically significant improvement in executive functioning was reported with significant improvement observed across inhibitory control and working memory. There were important characteristics of interventions: programmes running for more than 6 weeks, sessions longer than 20 minutes and frequency of more than 2 sessions per week were all associated with better outcomes. Despite this, the review also found significant variation, with the length of intervention, the assessment tools, and the assessment activities and methodological quality varying widely between studies. It seems that just asking students to get up isn't enough. Physical education is seen as more likely to facilitate cognition when the rules are to be followed in response, patterns are to be recalled, strategies are selected, movement problems are to be solved, and the actions are to be adapted to changing circumstances (Mao et al., 2024).

Attention, Concentration, and Classroom Readiness

Concentration and attention are essential for cognitive and academic growth, as students cannot be effective learners without being able to focus on relevant information or without the ability to concentrate. Physical education can lead to better attention by increasing physiological arousal, transient alleviation of restlessness, better mood, and greater activation of cognitive-control systems. After a suitable period of physical activity, students can show increased readiness to learn, better on-task behaviour and better management of competing distractions. At secondary level, these impacts are particularly significant because students often are required to attend extended periods of lessons and focus on more complex or abstract material. But the effect of exercise on cognition can be influenced by the dose and timing of exercise. Too light an activity could not affect the arousal, and too intense an activity could cause fatigue and temporarily affect performance (Graham et al., 2021; Liu et al., 2025).

Graham et al. investigated the acute effects of classroom-based physical activity breaks among 116 students aged 11–14 years. Participants completed physical activity breaks of 5, 10, or 20 minutes, while comparison participants continued sedentary mathematics work. Students who participated in the activity breaks improved across measures of inhibition, switching, and updating compared with those who remained seated. They also reported more positive mood, motivation, and self-efficacy related to completing the cognitive tasks. Similar benefits were observed across the different activity durations, suggesting that even brief movement opportunities may positively affect executive functioning. Although classroom activity breaks are not identical to formal physical education, the results illustrate that movement during the school day can prepare adolescents cognitively and emotionally for subsequent learning (Graham et al., 2021).

Working Memory, Inhibitory Control, and Cognitive Flexibility

Working memory is closely connected with reading comprehension, mathematical reasoning, problem-solving, and the ability to follow multistep instructions. Physical education activities can stimulate working memory when students are required to remember rules, movement patterns, positions, sequences, tactical instructions, and performance feedback. Team sports are especially demanding because students must retain relevant information while simultaneously monitoring a rapidly changing environment. Inhibitory control is similarly exercised when students wait for an appropriate signal, avoid rule violations, regulate aggression, and suppress ineffective movements. Cognitive flexibility develops when students change strategies, move between defensive and offensive roles, and adjust their behaviour in response to new conditions. These characteristics make well-designed physical education a potentially meaningful context for the practical development of executive functions (Mao et al., 2024; Wang et al., 2024).

A network meta-analysis comparing six forms of physical activity found that the effectiveness of exercise differed according to the type of executive function being assessed. Ball games were ranked highly for improving updating accuracy and reducing inhibition reaction time. Cognitively engaging physical activity was effective for inhibition accuracy, while dance showed favourable effects on updating and shifting reaction time. These findings are important for secondary-school physical education because they indicate that a diverse curriculum may be cognitively more beneficial than a programme based only on repetitive fitness drills. Ball games require perception, tactical selection, response inhibition, cooperation, and rapid adaptation, while dance combines movement memory, rhythm, coordination, and attentional shifting. Therefore, physical education teachers should not assume that every activity will produce identical cognitive outcomes; instead, activities should be deliberately selected according to the cognitive and physical abilities to be developed (Wang et al., 2024).

Acute and Long-Term Effects of Physical Education

Literature separates effects of physical activity into acute and chronic effects. The acute effects are temporary changes resulting from a single exercise session while the chronic effects result from repeated exercise sessions over weeks or months. A single PE lesson can have immediate short-term positive effects on alertness, attention, mood or inhibitory control which could help to prepare students for the next lesson in the academic programme. Long-term involvement can help to create lasting gains in fitness, executive functioning, self-regulation, physical competence and learning related behavior. The acute effects can be informative for planning lessons and the chronic for general cognition. Schools should thus ensure that physical education is not a rare recreational activity, or scheduled only during sports competitions (Graham et al., 2021; Mello et al., 2025; Shi et al., 2022).

Chronic school-based physical activity was associated with positive effects in the areas of cognitive flexibility, inhibitory control, working memory, and attention among children and adolescents, as revealed by a large meta-analysis examining the topic. However, there was a significant variation of the size of effects across the various sub-groups based on the type of intervention. Students' responses to physical activity may also be affected by developmental stage as age was also identified as a predictor of improvement in working memory. The results provide evidence for continued school-based physical activity and highlight the need to avoid a one-size-fits-all approach to physical activity programming. Secondary school interventions should be age appropriate, based on students' fitness, interests, cognition and participation opportunities. The amount of movement (Mello et al., 2025) should be considered, along with the progression, regularity, and complexity of the activities.

Quality and Cognitive Engagement of Physical Education

The effectiveness of physical education does not only rely on the amount of activity that students carry out, but also the nature of the lessons. Quality Physical Education is about maximising participation, building skills up over time, having clear learning objectives, inclusion, constructive feedback and opportunities for independent decision making. Cognitively stimulating activities involve students thinking and reacting to unexpected information, learning new movement patterns, choosing strategies, working collaboratively and solving problems with others. These activities are sometimes referred to as “thinking while moving”. They're not like a task where the students would make the same movement over and over without having any decisions to make. The evidence suggests that cognitively stimulating physical activity may have better effects on executive functions; as it is physiologically stimulating, it simultaneously includes direct cognitive stimulation (García-Hermoso et al., 2021; Mao et al., 2024).

A systematic review and meta-analysis which focused on specific physical education interventions concluded that enhancing the quality of physical education had positive outcomes on cognition and academic outcomes. The researchers found that quality-based teaching methods were more strongly linked to positive outcomes than were those that simply added more of the traditional type lessons. Academic gains were most evident in skills related to mathematics. These findings reflect the argument that it is not the mere presence of physical education periods, but rather curriculum content, teaching approaches, levels of cognitive challenge and actual student engagement that is more significant. For this reason, the amount of time spent waiting, teacher-centeredness, exclusion and excessive time spent in non-active learning should be kept to a minimum in lessons, while active involvement, problem-solving, tactical thinking, cooperative learning and differentiated activities are maximized (García-Hermoso et al., 2021).

Physical Education and Academic Performance

Academic performance is not synonymous with cognitive development; however, it is an important educational outcome that may manifest cognitive benefits. The ability to read, write, think mathematically, perform well in examinations, and participate in class depends on attention, memory, inhibitory control, processing speed, and cognitive flexibility. Physical education has a direct impact on academic success through cognitive functioning, and an indirect impact on academic success through physical fitness, attendance, motivation, mental health, quality of sleep and classroom behaviour. The feedback from reviews suggests that time set aside in school for physical activity has no negative impact on academic performance. Rather, carefully designed physical activity can yield small but educationally significant gains, which varies depending on the academic content, program design, and participant attributes (Feng et al., 2026; James et al., 2023; Latino & Tafuri, 2023).

A recent meta-analysis of 15 randomized controlled trials conducted in children and adolescents ages 8-19 years revealed a small, though statistically significant, positive impact of physical activity on mathematics and reading. The overall academic performance showed a larger pooled effect but was reported from lower number of studies and should be taken with caution. The results showed a range of results depending on the type of activity, length of session, frequency of sessions, length of intervention period, and academic domain. The results are in line with the knowledge that physical activity is not a substitute for classroom-based teaching. Instead, it could enhance the cognitive and behavior contexts in which academic learning takes place. Therefore, physical education should not compete with but be embedded in academic learning (Feng et al., 2026).

The results of a systematic review of school-aged children also confirmed that there was a predominately positive or non-significant association between physical activity and academic outcomes, and limited evidence that physical activity negatively affected academic outcomes. At least about 90 minutes per week, moderate-to-vigorous intensity, and 30–60-minute sessions were often correlated with improvements in performance. However, the researchers couldn’t determine an ideal frequency to use in all populations. Comparisons were not possible because of differences in assessment methods, the type of sport, ages of the students, and programme quality. The results indicate that secondary schools are not doomed to sacrifice academic achievement when ensuring physical education time, and that when, how, and whether the schools achieve these educational outcomes will be dependent on the quality of the implementation (James et al., 2023).

Executive Functions as Mediators of Academic Performance

Recent research has not only examined simple correlations but also explored the role of executive functions in explaining how PA relates to academic achievement. The sample for this study consisted of 172 Spanish secondary school students.The participants in this study were 172 secondary school students attending a Spanish school. The relationship between physical activity and academic performance was mediated, in part, by attention and inhibitory control and was strongly predicted by physical activity, attention, and inhibition. The predictive role for emotional regulation was not present. The results indicate that physical activity could be used as a tool to support achievement, at least in part, by reinforcing students' concentration and inhibiting distractors or inappropriate responses. The evidence is especially pertinent in secondary education, where attention and behavioural inhibition are necessary frequently in exams, self-study, problem-solving and complex tasks in the classroom (Martín-Bozas et al., 2025).

The mediation view offers a more realistic explanation than the automatic increase in examination scores when people exercise. Fitness, mood, attention, working memory, self-control or engagement may be initially influenced by physical education and in turn and indirectly impact on learning behaviour and academic performance. This effect may also be mediated by gender, socioeconomic status, baseline fitness, motor competence, body composition, sleep, school climate, and availability of extra-curricular sports. For instance, an active student might not need an extra class, whereas a previously inactive student might. A student with low self-confidence might not benefit in a competitive or exclusionary class. Correlations have been found between activity and grades in physical education courses, but such relationships should not be the sole basis for investigating the psychological and cognitive paths that link physical education and educational outcomes (González-del-Castillo & Barbero-Alcocer, 2025; Martín-Bozas et al., 2025).

Physically Active Learning and Time-on-Task

Purposeful movement is incorporated into the learning process in the form of physically active learning. While not the same as traditional physical education, it provides evidence of movement being used to enhance cognition in the school context. Pupils can use movement to solve maths problems, act out words or use movement to answer questions. Physical activity can enhance time-on-task through an alternative way to process information, improve motivation and reduce passive sitting. It may be especially useful for secondary school students that sit for long periods of schooling. Yet, the activities should continue to be well planned to ensure that movement does not create greater distraction or additional cognitive load (González-Pérez et al., 2025).

The ACTIVE CLASS study focused on the study of physically active learning in secondary mathematics classes. The intervention was effective in increasing the amount of time students were on task during the active lesson and decreasing the amount of passive off task behaviour. Positive effects also carried over to the subsequent lesson, clearly showing that active learning was not just an exciting pretext to the movement activity. Overall, there was good agreement between teacher observations and quantitative data. The evidence presented here indicates that movement can be integrated into the teaching and learning of secondary school without necessarily affecting discipline or concentration. It also reinforces the argument that physical education and other movement activities available across the school setting can enhance readiness to learn and behavioural engagement in learning, complementing learning in the classroom (González-Pérez et al., 2025).

Sedentary Behaviour, Screen Time, and Cognitive Function

Sedentary behaviour needs to be considered in relation to the cognitive role of PE. The average time that secondary-school students sit during lessons, homework, school transport, watching TV, games and use of a smartphone is significant. Sedentary behaviour is not just lack of moderate to vigorous physical activity, a student can conduct an exercise session but spend most of the day sitting. Sitting for extended periods can limit opportunities for movement, social interaction, exploring the environment, and experiencing a range of sensations. Passive media use, such as screen time, can also bring to student’s constant notifications, information changes, difficulty falling asleep and difficulty focusing. The PE class can break up sedentary school time and offer a protected time for physical activity (Chaput et al., 2020; Li et al., 2022).

Overall, findings from 16 studies in a systematic review indicated that there was inconclusive evidence about how overall sedentary time relates to EF in children and adolescents. The seven studies reported negative associations; the two studies reported positive relationships and the studies using accelerometers yielded mixed results. Five of nine studies, however, reported negative associations between SF and EF, more consistently than was the case with other screen types, suggesting a negative pattern. All of the included studies were observational and had a variety of measures, which prevented the drawing of causal conclusions. However, the results suggest that the nature of the sedentary activity is more important than the amount of sitting time. It is therefore important that physical education is integrated into a greater school-wide approach, including active breaks, limited recreational screen time, quality and consistent sleep and school-wide movement throughout the day (Li et al., 2022).

Psychological and Social Pathways

There can also be psychological and social pathways by which physical education can affect cognitive development. Participation can improve mood and self-efficacy, enjoyment, perceived competence, school connectedness and decrease stress and restlessness. Positive emotions can enhance attention, memory encoding, memory persistence and the willingness to do tasks that seem difficult. Communication, leadership, empathy, conflict resolution, and problem solving are experienced in cooperative activities and team sports. These experiences can reinforce behaviour control and social cognition. But these benefits aren't guaranteed. Physical education in which pupils experience humiliation, high levels of competition, gender stereotyping, exclusion or repeated failure can decrease motivation and increase anxiety. The instructional climate thus needs to be inclusive, mastery-based, safe and supportive of students of varying abilities (Graham et al., 2021; González-del-Castillo & Barbero-Alcocer, 2025).

Student motivation is particularly important in the adolescent years because from that age onwards, participation tends to drop as the students become more self-aware in terms of body image, competence, what others think of them, and gender expectations. Activities should be meaningful, achievable, cooperative, and opportunities for improvement. Students are more likely to be active and develop long-term physical activity habits if they view physical activity as fun and meaningful. Increased participation can then lead to fitness, cognitive engagement and school adjustment. On the other hand, students who are present but not engaged in the classroom are not likely to get very much out of it. Assessing researchers' proposed indicators of physical education effectiveness, such as movement intensity, participation, motivation, lesson climate, and cognitive challenge, should be undertaken rather than just using the number of PE lessons per week (García-Hermoso et al., 2021; Liu et al., 2025).

Evidence From Pakistan

Research conducted in Pakistan remains limited compared with the international evidence base. A 2025 study examined the relationship among physical activity, motor skills, and academic performance in 349 Grade 9 and Grade 10 students from public and private schools in Hayatabad, Peshawar. Physical activity was measured using the short form of the International Physical Activity Questionnaire, while academic performance was obtained from recent examination grades. The study found a statistically significant association between physical activity and academic performance. Vertical-jump performance and handgrip strength were also significantly associated with academic outcomes, whereas flexibility and push-up performance were not. The study supports a possible educational role of physical activity among Pakistani secondary-school students, but its cross-sectional design prevents causal conclusions (Ali et al., 2025).

The Pakistani study was geographically restricted to one area and assessed academic grades rather than directly measuring attention, memory, inhibitory control, cognitive flexibility, reasoning, or problem-solving. Self-reported physical activity may also be affected by recall and social-desirability bias. Furthermore, physical activity outside school was not clearly separated from structured physical education, making it difficult to identify the specific contribution of the physical education curriculum. These limitations illustrate the need for studies involving larger samples from different provinces, urban and rural schools, public and private institutions, and male and female students. Future Pakistani research should employ validated cognitive measures and examine the quality, frequency, intensity, and content of physical education lessons (Ali et al., 2025).

Research Methodology

Research Design

The study employed a quantitative, descriptive-correlational research design. The design was used to collect numerical data and examine the relationship between students' participation in physical education and their cognitive development at the secondary level (Creswell & Creswell, 2023).

Population of the Study

The population of the study consisted of all Grade 9 and Grade 10 students enrolled in selected public and private secondary schools in Lahore District, Punjab. Both male and female students who regularly attended physical education classes were included in the target population (Creswell & Creswell, 2023).

Sample and Sampling of the Study

A sample of 489 secondary-school students was selected from public and private schools. A multistage stratified random sampling technique was used; schools were first divided according to school sector and gender, after which schools and students were randomly selected from each category to ensure appropriate representation (Creswell & Creswell, 2023).

Instrument Development

A self-developed questionnaire was used for data collection. The questionnaire consisted of demographic information, participation in physical education, and cognitive-development dimensions, including attention, working memory, inhibitory control, cognitive flexibility, decision-making, and problem-solving. Items were developed after reviewing recent studies on physical education, exercise, executive functioning, and adolescent cognitive development. Responses were obtained on a five-point Likert scale ranging from strongly disagree to strongly agree (DeVellis & Thorpe, 2022; Liu et al., 2025; Mao et al., 2024).

Validity of the Research Instrument

The initial questionnaire was presented to seven experts in physical education, educational psychology, special education, and educational research. The experts evaluated the relevance, clarity, language, content coverage, and suitability of each item. The questionnaire was revised according to their recommendations, and unclear, repetitive, and irrelevant items were removed before final data collection (DeVellis & Thorpe, 2022).

Reliability of the Research Instrument

The revised questionnaire was pilot-tested on 50 secondary-school students who were not included in the final sample. Cronbach's alpha was used to determine the internal consistency of the instrument, and a coefficient of .70 or above was considered acceptable for the study (DeVellis & Thorpe, 2022).

Data Collection Procedure

Permission was obtained from the relevant school authorities before collecting the data. The purpose of the study was explained to the students, and confidentiality, voluntary participation, and anonymity were ensured. The questionnaires were personally distributed to the selected students during school hours and were collected after completion.

Data Analysis Procedure

The collected data were coded and analysed through IBM SPSS. Frequencies, percentages, means, and standard deviations were calculated to describe demographic characteristics, physical education participation, and cognitive-development levels. Pearson correlation was used to examine the relationship between physical education and cognitive development, while multiple regression was applied to determine the predictive effect of physical education. Independent-samples *t* tests and one-way ANOVA were used to examine differences according to gender, school sector, grade level, and sports participation. Statistical significance was determined at level .05 (Pallant, 2020).

Demographic Analysis

Table 1

Demographic Characteristics of the Respondents

Demographic variable	**Category**	***f***	**%**
Gender	Male	259	53.0
	Female	230	47.0
Age	13 years	42	8.6
	14 years	118	24.1
	15 years	172	35.2
	16 years	119	24.3
	17 years or above	38	7.8
Grade level	Grade 9	254	51.9
	Grade 10	235	48.1
School sector	Public	294	60.1
	Private	195	39.9
School location	Urban	318	65.0
	Rural	171	35.0
Total		**489**	**100.0**

Table 1 shows that the sample comprised 259 male students and 230 female students, showing reasonably balanced gender representation. Most respondents were 15 years old, while Grade 9 and Grade 10 students represented 51.9% and 48.1% of the sample, respectively. Public-school and urban students formed the majority, accounting for 60.1% and 65.0% of the sample.

Physical Education Participation Profile

Table 2

Frequency and Percentage Distribution of Physical Education Participation

Variable	Category	*f*	%
Regular attendance in physical education classes	Yes	422	86.3
	No	67	13.7
Physical education classes per week	None	31	6.3
	One class	116	23.7
	Two classes	187	38.2
	Three classes	104	21.3
	More than three classes	51	10.4
Duration of each class	Less than 30 minutes	46	9.4
	30–40 minutes	137	28.0
	41–50 minutes	161	32.9
	51–60 minutes	105	21.5
	More than 60 minutes	40	8.2
Participation outside school	Yes	308	63.0

	No	181	37.0
Most frequent activity	Team sports	188	38.4
	Individual sports	71	14.5
	Exercise or fitness activities	79	16.2
	Walking or running	102	20.9
	Other activities	49	10.0
Total		**489**	**100.0**

Table 2 mentions that a large majority of students regularly attended physical education classes, while two classes per week was the most frequently reported arrangement. The most common lesson duration was 41–50 minutes, reported by 32.9% of the respondents. Almost two-thirds participated in physical activities outside school, with team sports being the most common activity.

Descriptive Analysis of Study Variables

Table 3

Descriptive Statistics for Physical Education and Cognitive Development

Study variable	Number of items	*M*	*SD*	Minimum	Maximum	Level
Physical education participation and environment	20	3.71	0.59	1.45	5.00	High
Attention and concentration	6	3.76	0.63	1.33	5.00	High
Working memory	6	3.69	0.65	1.17	5.00	High
Inhibitory control and self-regulation	6	3.62	0.67	1.17	5.00	Moderate
Cognitive flexibility	6	3.68	0.64	1.33	5.00	High
Decision-making and problem-solving	6	3.74	0.62	1.50	5.00	High
Overall cognitive development	30	3.70	0.56	1.57	4.97	High

Table 3 describes Students reported a high level of participation in physical education and a high overall level of cognitive development. Attention and concentration produced the highest mean score, whereas inhibitory control and self-regulation had the lowest mean and remained at a moderate level. The findings indicated that physical education was particularly associated with attention, decision-making, working memory, and cognitive flexibility.

Frequency and Percentage Levels

Table 4

Frequency and Percentage Distribution of the Study Variables by Level

Variable	Low *f* (%)	Moderate *f* (%)	High *f* (%)
Physical education participation	46 (9.4)	175 (35.8)	268 (54.8)
Attention and concentration	45 (9.2)	175 (35.8)	269 (55.0)
Working memory	52 (10.6)	197 (40.3)	240 (49.1)
Inhibitory control and self-regulation	59 (12.1)	211 (43.1)	219 (44.8)
Cognitive flexibility	54 (11.0)	201 (41.1)	234 (47.9)
Decision-making and problem-solving	42 (8.6)	185 (37.8)	262 (53.6)
Overall cognitive development	48 (9.8)	190 (38.9)	251 (51.3)

Table 4 elaborates that more than half of the respondents demonstrated high physical education participation, attention, decision-making, and overall cognitive development. Inhibitory control showed the largest moderate-level group, indicating that self-regulation remained comparatively less developed. Only a small proportion of students fell within the low category across the study variables.

Reliability Analysis

Table 5

Internal Consistency Reliability of the Research Instrument

Scale or dimension	Items	Corrected item-total correlation range	Cronbach's α
Physical education participation and environment	20	.42–.71	.91
Attention and concentration	6	.48–.69	.84
Working memory	6	.45–.67	.82
Inhibitory control and self-regulation	6	.41–.64	.80
Cognitive flexibility	6	.44–.68	.83
Decision-making and problem-solving	6	.50–.72	.86
Overall cognitive-development scale	30	.43–.74	.93
Complete questionnaire	50	.41–.74	.95

Table 5 shows that Cronbach's alpha coefficients ranged from .80 to .95, exceeding the commonly accepted minimum value of .70. The complete 50-item questionnaire demonstrated excellent internal consistency with an alpha coefficient of .95. The findings confirmed that all dimensions of the instrument were sufficiently reliable for further statistical analysis.

Assessment of Normality

Table 6

Skewness and Kurtosis of the Study Variables

Variable	Skewness	Standard error	Kurtosis	Standard error
Physical education participation	−0.41	0.11	−0.12	0.22
Attention and concentration	−0.46	0.11	0.18	0.22
Working memory	−0.37	0.11	−0.09	0.22
Inhibitory control and self-regulation	−0.29	0.11	−0.22	0.22
Cognitive flexibility	−0.35	0.11	0.05	0.22
Decision-making and problem-solving	−0.43	0.11	0.11	0.22
Overall cognitive development	−0.39	0.11	0.07	0.22

Table 6 represents that the skewness values ranged from −0.46 to −0.29, while kurtosis values ranged from −0.22 to 0.18. All values remained within the acceptable range of −1.00 to +1.00, indicating approximately normal distributions. Therefore, the assumptions for applying parametric statistical tests were adequately satisfied.

Correlation Analysis

Table 7

Pearson Correlations Between Physical Education and Cognitive-Development Dimensions

Variable	1	2	3	4	5	6
1. Physical education participation	—					
2. Attention and concentration	.56***	—				
3. Working memory	.52***	.62***	—			
4. Inhibitory control	.47***	.55***	.58***	—		
5. Cognitive flexibility	.50***	.57***	.61***	.56***	—	
6. Decision-making and problem-solving	.58***	.60***	.59***	.54***	.63***	—

Table 7 describes that physical education participation had significant positive correlations with all dimensions of cognitive development. Its strongest relationship was with decision-making and problem-solving, followed by attention and concentration. These moderate positive correlations indicated that greater participation in quality physical education was associated with stronger cognitive abilities.

Independent-Samples *t* Tests

Table 8

Independent-Samples t Tests for Differences in Overall Cognitive Development

Demographic variable	Group	*n*	*M*	*SD*	*t*(487)	*p*	Cohen's *d*
Gender	Male	259	3.73	0.55	1.18	.237	0.11
	Female	230	3.67	0.57			
School sector	Public	294	3.64	0.58	−2.92	.004	−0.27
	Private	195	3.79	0.52			
Grade level	Grade 9	254	3.65	0.57	−2.19	.029	−0.20
	Grade 10	235	3.76	0.54			
School location	Urban	318	3.74	0.55	2.08	.038	0.20
	Rural	171	3.63	0.57			
Participation outside school	Yes	308	3.82	0.50	6.39	< .001	0.60
	No	181	3.50	0.59			
Regular attendance in PE classes	Yes	422	3.77	0.51	6.94	< .001	0.91
	No	67	3.29	0.62			

Table 8 shows that no statistically significant difference in cognitive development was found between male and female students. Significant differences were observed according to school sector, grade, location, outside-school participation, and regular attendance in physical education classes. The largest difference occurred for regular physical education attendance, followed by participation in sports or physical activities outside school.

One-Way Analysis of Variance

Table 9

One-Way ANOVA for Overall Cognitive Development Across Demographic Groups

Grouping variable	Between-groups *df*	Within-groups *df*	*F*	*p*	η^2
Age group	4	484	1.81	.125	.015
Number of PE classes per week	4	484	19.97	< .001	.142
Duration of PE class	4	484	9.20	< .001	.071
Type of physical activity	4	484	6.40	< .001	.050

Table 9 elaborates that cognitive-development scores did not differ significantly across age groups. Significant differences were found according to the number, duration, and type of physical education activities. The number of classes per week produced the largest effect, explaining approximately 14.2% of the variance in cognitive-development scores.

Group Means for the ANOVA

Table 10

Means and Standard Deviations of Cognitive Development Across ANOVA Groups

Grouping variable	Category	*n*	*M*	*SD*
Age	13 years	42	3.56	0.58
	14 years	118	3.64	0.56
	15 years	172	3.70	0.55
	16 years	119	3.77	0.53
	17 years or above	38	3.80	0.57

PE classes per week	None	31	3.20	0.60
	One class	116	3.49	0.57
	Two classes	187	3.72	0.51
	Three classes	104	3.89	0.48
	More than three classes	51	4.01	0.46
Duration of PE class	Less than 30 minutes	46	3.42	0.58
	30–40 minutes	137	3.59	0.56
	41–50 minutes	161	3.72	0.52
	51–60 minutes	105	3.86	0.50
	More than 60 minutes	40	3.94	0.47
Activity type	Team sports	188	3.83	0.51
	Individual sports	71	3.75	0.54
	Exercise or fitness	79	3.78	0.52
	Walking or running	102	3.57	0.58
	Other activities	49	3.49	0.61

Table 10 represents that **c**ognitive development means gradually increased with the number and duration of physical education classes. Students attending more than three classes per week and lessons lasting more than 60 minutes reported the highest scores. Team sports and exercise or fitness activities were associated with higher cognitive development means than walking, running, or other activities.

Post Hoc Analysis

Table 11

Selected Significant Tukey HSD Comparisons

Grouping variable	Comparison	Mean difference	*p*
PE classes per week	None vs. two classes	−0.52	< .001
	None vs. three classes	−0.69	< .001
	None vs. more than three classes	−0.81	< .001
	One class vs. two classes	−0.23	.002
	One class vs. three classes	−0.40	< .001
	Two classes vs. more than three classes	−0.29	.004
Duration of PE class	Less than 30 vs. 41–50 minutes	−0.30	.007
	Less than 30 vs. 51–60 minutes	−0.44	< .001
	Less than 30 vs. more than 60 minutes	−0.52	< .001
	30–40 vs. 51–60 minutes	−0.27	.001
Activity type	Team sports vs. walking or running	0.26	.001
	Team sports vs. other activities	0.34	.001
	Exercise or fitness vs. other activities	0.29	.028

Table 11 exhibits that students who attended two or more physical education classes had significantly higher scores than students who attended no class or only one class. Lessons lasting at least 41 minutes generally produced higher scores than lessons lasting less than 30 minutes. Team sports and fitness activities were associated with significantly better cognitive outcomes than walking, running, or less structured activities.

Regression Analysis

Table 12

Model Summary for Physical Education Predicting Cognitive Development

R	R^2	Adjusted R^2	Standard error of estimate	$F(1, 487)$	p
.630	.397	.396	.435	320.60	< .001

Table 12 shows that Physical education participation significantly predicted students' overall cognitive development. The model explained approximately 39.7% of the variance in cognitive-development scores. The statistically significant *F* value demonstrated that the regression model provided a substantially better prediction than a model without physical education participation.

Table 13

Regression Coefficients for the Prediction of Cognitive Development

Predictor	B	$SE\ B$	β	t	p
Constant	1.48	0.12	—	12.33	< .001
Physical education participation	0.60	0.03	.63	17.91	< .001

Note. Dependent variable = overall cognitive development.

Physical education participation had a significant and positive predictive effect on cognitive development. A one-unit increase in physical education participation was associated with an estimated 0.60-unit increase in cognitive-development scores. The standardized coefficient showed that physical education was a strong positive predictor of students' cognitive abilities.

Discussion

The findings showed that secondary-school students demonstrated high levels of physical education participation and cognitive development. The high scores for attention, working memory, cognitive flexibility, decision-making, and problem-solving indicated that physical education was associated with several cognitive abilities required for successful classroom learning. Physical activities may provide students with opportunities to follow instructions, remember rules, select appropriate responses, control distractions, and modify their actions according to changing situations. Recent evidence has similarly shown that physical activity contributes positively to cognitive function, memory, executive functioning, and academic outcomes among children and adolescents (Chaput et al., 2020; Shi et al., 2022).

Attention and concentration emerged as the strongest cognitive dimension in the study. This finding suggested that physical education may help students remain mentally alert, reduce classroom restlessness, and sustain their focus during learning activities. Graham et al. (2021) found that students aged 11–14 years who completed classroom-based physical activity breaks demonstrated improvements in inhibition, cognitive switching, and working-memory updating compared with students who remained engaged in sedentary classroom work. The researchers also reported improvements in students' mood, motivation, and self-efficacy after relatively brief periods of physical activity (Graham et al., 2021).

Physical education participation had significant positive relationships with all five cognitive-development dimensions. Its strongest relationship was with decision-making and problem-solving, followed by attention and concentration. Team games and open-skill activities frequently require students to observe rapidly changing situations, anticipate the actions of other players, evaluate alternative responses, make immediate decisions, and adjust strategies. A systematic review of 49 studies concluded that open and sequential motor skills were particularly beneficial for working memory, cognitive flexibility, and executive functioning because they involved continuous adaptation to environmental and task demands (Shi et al., 2022).

The positive relationship between physical education and working memory was also consistent with recent empirical evidence. During physical education lessons, students must remember instructions, retain rules, recall movement sequences, monitor teammates, and apply feedback while performing physical actions. Mao et al. (2024) synthesized 23 randomized and cluster-randomized studies involving 2,857 children and adolescents and found that cognitively engaging physical activity produced a significant overall improvement in executive functioning. Statistically significant improvements were particularly reported for inhibitory control and working memory, although substantial variation was observed among the included studies (Mao et al., 2024).

Inhibitory control and self-regulation received the lowest mean score among the cognitive dimensions, although physical education participation remained significantly associated with this variable. Inhibitory control requires students to suppress impulsive actions, follow rules, wait for an appropriate opportunity, control emotional reactions, and remain focused despite distractions. Its comparatively lower score may indicate that self-regulation is a more complex developmental outcome that requires sustained practice, clear behavioural expectations, positive teacher modelling, and carefully structured activities. Recent meta-analytic evidence indicates that cognitively engaging physical activity produces small but significant improvements in inhibitory control, particularly when activities combine physical movement with rules, strategic choices, memory demands, and rapid responses (Mao et al., 2024).

The study found no statistically significant gender difference in overall cognitive development. This result indicated that male and female students may receive broadly comparable cognitive benefits from physical education when both groups are provided with meaningful and equitable opportunities to participate. The absence of a gender difference should not be interpreted as evidence that male and female students necessarily have identical activity preferences, fitness levels, or access to sports. Rather, it suggests that the cognitive value of physical education was not restricted to one gender within the present sample. Shi et al. (2022) also noted that the available intervention literature did not establish consistent gender differences in the effects of physical activity on executive functions (Shi et al., 2022).

Private-school and urban students reported significantly higher cognitive-development scores than public-school and rural students. These differences may have reflected variation in access to trained physical education teachers, suitable playgrounds, sports equipment, regular timetables, extracurricular sports, and safe activity spaces. However, these possible explanations were not directly measured and should therefore be interpreted cautiously. International guidelines emphasize the need for equitable investment in physical-activity programmes so that all children, regardless of social or geographical circumstances, receive regular opportunities for physical activity and movement-based development (Chaput et al., 2020).

Grade 10 students reported significantly higher cognitive-development scores than Grade 9 students, although the effect size was small. The difference may have been connected with age-related maturation, greater experience with school routines, longer exposure to physical education, or improved ability to understand and apply game strategies. However, age-group differences were not statistically significant in the one-way ANOVA. This indicated that the positive role of physical education was relatively consistent across the secondary-school age groups included in the study. Previous evidence has similarly suggested that exercise interventions can support executive functioning across childhood and adolescence, although responses may differ according to baseline development and the characteristics of the intervention (Shi et al., 2022).

Students who regularly attended physical education classes obtained substantially higher scores than students who did not attend regularly. Similarly, students who participated in sports or physical activities outside school demonstrated higher scores than students who were inactive outside school. These findings indicated that both school-based physical education and extracurricular activity may contribute to students' cognitive functioning. Current guidelines recommend that children and adolescents accumulate an average of at least 60 minutes of moderate-to-vigorous physical activity per day and limit extended sedentary behaviour, particularly recreational screen time (Chaput et al., 2020).

The number of physical education classes per week had the largest ANOVA effect size. Cognitive-development scores increased progressively from students attending no classes to those attending more than three classes per week. This result suggested that regularity and repeated exposure may be important for cognitive development. Mao et al. (2024) found that interventions conducted more than twice per week produced stronger executive-function outcomes than less frequent interventions. Shi et al. (2022) similarly reported that moderate-intensity activities conducted approximately three times per week were generally effective in supporting executive functioning among children and adolescents (Mao et al., 2024; Shi et al., 2022).

The significant difference according to lesson duration further demonstrated the importance of sufficient instructional time. Students participating in lessons lasting 51–60 minutes or more had higher cognitive-development scores than those attending lessons of less than 30 minutes. Longer lessons may allow sufficient time for warm-up, skill instruction, moderate-to-vigorous activity, strategic games, reflection, and cool-down activities. Recent evidence shows that cognitively engaging interventions lasting more than 20 minutes and extending beyond six weeks generally produce stronger executive-function outcomes than shorter or less sustained programmes (Mao et al., 2024).

Students involved in team sports obtained higher cognitive-development scores than those mainly involved in walking, running, or other activities. Team sports generally require simultaneous physical, perceptual, social, and cognitive engagement. Players must communicate, remember rules, monitor several sources of information, inhibit inappropriate actions, anticipate movement, and change strategies. This finding did not imply that walking or running lacked health value; aerobic activities remain important for physical and cognitive health. However, activities involving complex and unpredictable environments may provide additional practice in executive functioning, strategic thinking, and rapid decision-making (Mao et al., 2024; Shi et al., 2022).

The regression analysis demonstrated that physical education participation explained 39.7% of the variance in cognitive development. This represented a substantial statistical contribution and supported the central proposition of the study that physical education played an important role in students' cognitive development. Nevertheless, the remaining 60.3% of variance indicated that cognition was also influenced by factors not included in the model, such as teaching quality, socioeconomic background, nutrition, family support, academic engagement, mental health, screen exposure, and individual developmental differences. Moreover, because the study used a quantitative descriptive-correlational design, the findings established association and prediction rather than definitive causation.

The findings should also be considered in relation to sedentary behaviour. Secondary-school students spend considerable time sitting during lessons, homework, transportation, and recreational screen use. A systematic review found mixed evidence regarding total sedentary time but reported that screen-based sedentary behaviour was more consistently associated with poorer executive functioning among children and adolescents. Regular physical education may therefore support cognitive development both by providing beneficial activity and by interrupting extended periods of sedentary behaviour (Li et al., 2022).

Conclusion

The study concluded that physical education had a significant positive role in the cognitive development of children at the secondary level. Regular participation was positively associated with attention, working memory, inhibitory control, cognitive flexibility, decision-making, and problem-solving. Students attending physical education classes regularly, participating more frequently, engaging for longer periods, and taking part in structured sports generally demonstrated stronger cognitive-development scores. Physical education should therefore be recognized as an essential educational subject rather than merely a recreational or extracurricular activity. Its value extended beyond physical fitness to include students' readiness to learn, concentration, memory, behavioural regulation, strategic thinking, and ability to solve problems. Recent research similarly supports the integration of sustained, frequent, and cognitively challenging physical activities within school programmes to strengthen executive functioning among children and adolescents. The significant predictive effect of physical education did not establish a causal relationship because the study was descriptive and correlational. Cognitive development is multidimensional and may also be influenced by family, school, health, psychological, and socioeconomic variables. Future experimental and longitudinal research should therefore verify whether improvements in physical education participation directly produce sustained changes in students objectively measured cognitive performance.

Recommendations

1. Secondary schools should provide compulsory physical education classes at least three times per week, with sufficient time for structured and cognitively engaging activities. Physical education periods should remain protected and should not be replaced by other academic subjects.
2. Schools should appoint trained physical education teachers and provide safe playgrounds, suitable equipment, team sports, strategic games, and fitness activities. Equal participation should be ensured for male and female students, students with disabilities, and learners with diverse abilities.
3. Schools and parents should encourage sports clubs, active breaks, outdoor activities, and reduced recreational screen time to support students' cognitive and physical development. Future studies should use experimental designs and objective measures of physical activity, cognition, and academic performance.

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