

# Effects of Physical Education Frequency, Activity Intensity and Activity Type on Middle School Students' Cognitive Performance

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## Abstract

*This study aimed to examine how the frequency of physical education (PE) classes, the intensity of physical activity, and different types of exercises influence middle school students' cognitive performance. Understanding these relationships can help optimize PE programs to enhance students' attention, memory, and executive function. A quasi-experimental design was employed, involving 300 middle school students aged 11 to 14 years, who were divided into groups based on PE class frequency (one, two, or three sessions per week), activity intensity (low, moderate, high), and activity type (aerobic, skill-based, mind-body). Cognitive performance was assessed using the standardized test after a 12-week intervention. Physical activity intensity was measured using wearable fitness trackers, and engagement levels were monitored through teacher observations and student self-reports. The findings revealed that students attending PE classes more frequently and engaging in moderate to high-intensity activities showed significantly improved cognitive performance. Aerobic exercises were linked to enhanced attention and memory, while skill-based activities improved executive function. Mind-body exercises provided moderate benefits, particularly in stress reduction and focus. The study highlights the positive impact of structured and frequent PE sessions on cognitive development. Schools should incorporate various physical activities with sufficient intensity to maximize students' cognitive and academic performance.*

**Keywords:** *physical education, cognitive performance, physical activity intensity, middle school students, academic achievement*

## 1. Introduction

Recent attention has focused on physical education (PE) for improving physical health and enhancing cognitive functions and academic achievement in middle school students (1). Traditionally, PE emphasized fitness; however, emerging evidence indicates that regular participation can boost memory, attention, and executive functions (2). This cognitive benefit is attributed to increased neurogenesis, enhanced cerebral blood flow, and the release of mood-enhancing neurotransmitters, with moderate-to-vigorous activities offering greater gains (3). Additionally, the type of physical activity—whether aerobic, team sports, or individual exercises—plays a distinct role in cognitive development. For example, team sports promote strategic thinking and cognitive flexibility, while aerobic exercises are linked to improved memory and learning (4). These cognitive improvements positively affect academic performance and help alleviate anxiety and depression (5). Despite the robust evidence supporting the benefits of PE, many schools are curtailing these programs, potentially undermining students'

cognitive and academic development during this critical stage (6). Therefore, this study investigates how the frequency, intensity, and type of physical activity in PE classes impact memory learning, using the PE-CAP cognitive assessment to inform policy and optimize the integration of PE with academic curricula.

1. What is the effect of the physical education frequency classes on middle school students' cognitive performance?
2. What is the impact of the intensity of physical activity during physical education classes on middle school students' cognitive performance?
3. How do different physical activity types influence middle school students' cognitive performance?

## 2. Literature Review

### *Theoretical Framework: Cognitive Load Theory*

Cognitive Load Theory (CLT), developed by John Sweller, posits that working memory has a limited capacity for processing information. This theory can be applied to physical education by examining how the frequency, intensity, and type of physical activities affect cognitive load and, consequently, cognitive function (7). For instance, regular PE classes with moderate challenges can enhance working memory and attention without overwhelming the brain (8). While moderate exercise optimally boosts cognitive functions by triggering beneficial neurochemicals (e.g., endorphins, dopamine, serotonin), too much intensity may lead to cognitive overload, fatigue, and decreased performance (9).

Additionally, the type of physical activity matters. Activities requiring complex motor skills and strategic thinking, such as team sports, can improve executive functions like planning and problem-solving. At the same time, aerobic exercises enhance overall brain health through increased blood flow and neurogenesis (10). By adjusting the frequency, intensity, and type of activities, PE programs can be designed to manage cognitive load effectively and meet psychological needs such as autonomy, competence, and relatedness (11). This balanced approach is crucial to fostering cognitive and academic development in middle school students, especially given the limited school hours and rising academic pressures (12).

### *Research on Physical Education and Cognitive Development*

Recent research has increasingly explored the cognitive benefits of physical education (PE) on students, demonstrating that regular physical activity enhances brain health through mechanisms such as increased blood flow, neurogenesis, and the release of neurotrophic factors, thereby improving memory, attention, and executive functions (13). Studies indicate that the frequency of PE classes is linked to improved focus, working memory, and processing speed, which are especially important during the middle school years (14). Moreover, the intensity of physical activity plays a crucial role; while moderate-to-vigorous exercises—particularly high-intensity aerobic activities—boost mood and cognitive performance via endorphin and neurotransmitter release, maintaining an optimal balance is essential to avoid cognitive overload (15).

The type of physical activity also matters as aerobic exercises, team sports, and activities requiring intricate motor skills contribute uniquely to cognitive development. For instance, team sports enhance strategic thinking and problem-solving, while aerobic activities improve overall memory and learning (16). Furthermore, a strong body of research links regular physical activity to improved academic performance, with benefits extending to reduced anxiety, enhanced self-confidence, and better mental well-being. Social skills developed through PE, such as teamwork and communication, further support academic engagement and reduce absenteeism (17,18,19).

Despite these positive findings, challenges remain. PE often competes with academic demands, leading to reduced class time, and the quality of programs can vary due to differences in resources, teacher expertise, and infrastructure. Researchers call for more longitudinal studies to better understand the long-term effects of PE on cognitive and academic outcomes and to explore how different physical activities influence affective cognitive domains (20).

### 3. Research Method

#### *Research Design*

This study will employ a quasi-experimental design with a sample of middle school students divided into groups based on PE class frequency, activity intensity, and activity type. The first variable, PE class frequency, will be tested by assigning students to groups with varying weekly PE sessions (e.g., 2, 3, or 5 times per week). The second variable, activity intensity, will be controlled by categorizing students into low-, moderate-, and high-intensity exercise groups, monitored using heart rate data. The third variable, activity type, will be examined by assigning students to aerobic exercises, skill-based sports, or mind-body activities. Cognitive performance will be assessed using standardized tests measuring attention, memory, and executive function before and after the intervention. A mixed-methods approach will incorporate quantitative cognitive test scores and qualitative student feedback. Statistical analyses, including ANOVA and regression models, will determine the impact of each factor on cognitive outcomes.

#### *Participants*

The sample for this study consisted of middle school students aged 11 to 14 years from multiple schools, selected using a random stratified sampling method to ensure diversity in gender, academic performance, and physical activity levels. Three hundred students participated, divided into subgroups based on the frequency of physical education (PE) classes, the intensity of physical activity, and the type of activities performed. Students were assigned to low-, moderate, and high-intensity exercise groups and different activity types, including aerobic, skill-based, and mind-body exercises. Cognitive performance was assessed through standardized tests measuring attention, memory retention, processing speed, and executive function. The study controlled for potential confounding variables such as socioeconomic background, prior fitness levels, and baseline cognitive abilities to ensure reliable comparisons across groups.

#### *Research Instrument*

The research utilized a combination of standardized cognitive performance tests, physical activity tracking, and self-reported questionnaires to assess the relationship between physical education (PE) class frequency, activity intensity, and types of physical activities on middle

school students' cognitive performance. Cognitive performance was measured using validated tools such as the Stroop Test for attention, the Digit Span Test for memory retention, and the Trail Making Test for processing speed and executive function. These tests were administered before and after the intervention period to evaluate changes in cognitive performance across different student groups.

To measure physical education frequency and intensity, attendance records were collected from schools, categorizing students into groups based on their weekly PE class participation (e.g., one, two, or three sessions per week). Physical activity intensity was monitored using wearable fitness trackers, which recorded heart rate and step count during PE classes. The intensity levels were classified into low, moderate, and high based on heart rate thresholds and perceived exertion scales. Additionally, teachers maintained activity logs to verify student engagement levels during classes.

For assessing the influence of different types of physical activities, students were grouped into aerobic exercises (e.g., running, cycling), skill-based activities (e.g., basketball, soccer), and mind-body exercises (e.g., yoga, stretching). Observations and student feedback surveys were conducted to document their engagement and enjoyment levels. The collected data were then statistically analyzed to identify the effects of each variable on cognitive performance, ensuring a comprehensive evaluation of how different aspects of PE influence students' cognitive abilities.

### ***Data Collection and Analysis***

Data collection was conducted over 12 weeks, involving pre- and post-intervention assessments. Cognitive performance data were gathered through standardized tests administered at the beginning and end of the study. Physical education frequency was recorded from school attendance logs, while physical activity intensity was measured using wearable fitness trackers that recorded heart rate and step count. Additionally, teacher observations and student self-reports monitored students' engagement in different physical activity types (aerobic, skill-based, or mind-body exercises). To ensure accuracy, trained research assistants supervised the data collection process, and teachers maintained detailed logs of PE sessions.

The collected data were analyzed using descriptive and inferential statistical methods. Descriptive statistics, including means and standard deviations, were used to summarize cognitive performance scores across PE frequencies, activity intensities, and activity types. A one-way ANOVA was conducted to determine significant differences between groups, while paired t-tests compared pre- and post-intervention scores to assess changes in cognitive performance over time. Additionally, regression analysis was applied to examine the strength and direction of relationships between PE class frequency, activity intensity, and cognitive outcomes. The statistical significance level was set at  $p < 0.05$ , ensuring that only meaningful differences were considered in interpreting results.

## **4. Results**

### ***Research Question (RQ) 1: What is the effect of the physical education frequency classes on middle school students' cognitive performance***

The results indicate a statistically significant effect of PE frequency on cognitive performance, with students attending more sessions per week achieving higher cognitive test scores. The following table indicates the results of the ANOVA test.

**Table 1.** The results of statistical analysis

Group (PE Sessions/Week)	Mean Cognitive Score	Standard Deviation (SD)	Post-hoc Tukey Comparison
2 sessions	75.2	8.4	Lower than 5 sessions ( $p < 0.01$ )
3 sessions	78.5	7.9	Lower than 5 sessions ( $p < 0.05$ )
5 sessions	83.6	7.2	Higher than 2 and 3 sessions

**Table 2.** The results of the Anova Test

Statistics	Value
	6.85
$\beta$ (Regression Coefficient)	0.42

The statistical analysis using a one-way ANOVA revealed a significant effect of PE class frequency on middle school students' cognitive performance ( $F(2,147) = 6.85$ ,  $p < 0.01$ ). Post-hoc Tukey tests indicated that students attending PE classes five times per week scored significantly higher on cognitive performance tests compared to those attending twice per week ( $p < 0.01$ ) and three times per week ( $p < 0.05$ ). The mean cognitive test scores increased progressively with higher PE frequency, suggesting a positive correlation. Additionally, regression analysis showed a moderate positive relationship between PE class frequency and cognitive scores ( $\beta = 0.42$ ,  $p < 0.001$ ), with PE frequency explaining approximately 18% of the variance in cognitive performance ( $R^2 = 0.18$ ).

***Research Question (RQ) 2: How does physical activity intensity (PAI) impact middle school students' cognitive performance during physical education classes?***

The following table shows that students who engaged in higher-intensity physical activity had significantly better cognitive performance across various measures. The effect sizes suggest a moderate to enormous impact of physical activity intensity on cognitive performance.

**Table 3.** The effect of PAI on Cognitive performance

Variable	Low-Intensity PA (Mean $\pm$ SD)	Moderate-Intensity PA (Mean $\pm$ SD)	High-Intensity PA (Mean $\pm$ SD)	F / t Value	p-Value	Effect Size (Cohen's d / $\eta^2$ )
Attention Score	72.4 $\pm$ 8.5	78.9 $\pm$ 7.2	85.1 $\pm$ 6.8	6.23	0.002**	0.28 ( $\eta^2$ )
Memory Retention	68.2 $\pm$ 9.1	75.3 $\pm$ 8.4	82.7 $\pm$ 7.9	7.01	0.001**	0.31 ( $\eta^2$ )
Processing Speed	54.7 $\pm$ 6.3	61.5 $\pm$ 5.9	69.2 $\pm$ 5.7	8.14	<0.001**	0.35 ( $\eta^2$ )
Executive Function	63.5 $\pm$ 7.8	71.6 $\pm$ 7.1	79.8 $\pm$ 6.5	7.89	<0.001**	0.33 ( $\eta^2$ )

The findings indicate that higher-intensity physical activity during physical education classes positively influences middle school students' cognitive performance. Students who engaged in moderate to vigorous physical activity showed improved attention, memory retention, and processing speed compared to those who participated in low-intensity exercises. The cognitive benefits were particularly evident in tasks requiring executive function, such as problem-solving and decision-making. These results suggest that structured, high-intensity

physical activities in PE classes can enhance students' academic performance and overall cognitive development.

***Research Question (RQ) 3: How do different physical activity types influence middle school students' cognitive performance?***

**Table 3.** Analysis of Effect size of PE types and cognitive performance

Variable	Exercises (Mean $\pm$ SD)	Skill-based activities PA (Mean $\pm$ SD)	Mind-Body Exercises PA (Mean $\pm$ SD)	F / t Value	p-Value	Effect Size (Cohen's d / $\eta^2$ )
Attention Score	86.2 $\pm$ 7.4	81.6 $\pm$ 6.9	79.1 $\pm$ 7.8	5.97	0.003**	0.27 ( $\eta^2$ )
Memory Retention	82.7 $\pm$ 8.1	78.6 $\pm$ 7.4	73.1 $\pm$ 6.9	6.49	0.002**	0.29 ( $\eta^2$ )
Processing Speed	70.3 $\pm$ 6.5	69.5 $\pm$ 6.1	62.4 $\pm$ 5.7	7.14	<0.001**	0.33 ( $\eta^2$ )
Executive Function	80.4 $\pm$ 7.3	85.6 $\pm$ 6.9	76.4 $\pm$ 7.5	6.89	<0.001**	0.31 ( $\eta^2$ )

The findings suggest that different types of physical activities affect middle school students' cognitive performance. Aerobic exercises, such as running and cycling, were associated with the greatest improvements in attention, memory, and processing speed, likely due to increased blood flow and oxygen delivery to the brain. Skill-based activities, such as basketball and soccer, enhanced executive function and decision-making abilities, possibly due to these sports' strategic and coordination demands. Meanwhile, mind-body exercises, such as yoga and stretching, showed moderate benefits, particularly in reducing stress and improving concentration. These results highlight the importance of incorporating various physical activities in school curricula to optimize cognitive benefits for students.

## 4. Discussion

**Hypothesis 1: Increased physical education frequency classes lead to improved middle school students' cognitive performance.**

The data supports the hypothesis that an increase in the frequency of physical education (PE) classes correlates with enhanced cognitive performance among middle school students. Regular physical activity through PE classes not only boosts mental alertness and focus but also aids in stress and anxiety reduction, which are significant barriers to cognitive function (21). The discipline learned in PE transfers to academic settings, enhancing students' time management and energy levels. Qualitative feedback from participants corroborates these findings, highlighting that regular physical activity leads to increased academic motivation and better preparation for academic tasks (22). Frequent physical education can contribute to physical health and cognitive development.

**Hypothesis 2: Higher-intensity physical activities enhance middle school students' cognitive performance during physical education classes.**

Evidence strongly supports the link between higher-intensity physical activities in PE and improved cognitive outcomes. These activities stimulate neurogenesis and release endorphins associated with enhanced memory and learning (23). High-intensity exercises also activate brain



regions responsible for decision-making, attention, and reasoning, which are crucial for academic success. Participants noted increased concentration and mental clarity following vigorous exercise, indicating that such activities build physical resilience and enhance cognitive endurance and problem-solving capabilities (24). Including high and low-intensity activities in school programs is vital for maximizing physical and cognitive benefits.

**Hypothesis 3: Engaging in diverse physical activity types, particularly those involving coordination and strategic thinking, positively impacts middle school students' cognitive performance.**

The results affirm that participation in various physical activities, especially those requiring coordination and strategic thinking, positively influences cognitive performance. Such activities stimulate different brain areas, promoting mental agility and adaptability (25). Team sports and strategic games enhance decision-making and critical thinking, paralleling academic problem-solving. This diversity in physical activities also supports social and emotional learning, which is crucial for academic success (26). Students engaging in varied activities, from team sports to individual practices like yoga, reported sustained motivation and improved focus on academics, linking physical activity diversity with cognitive and academic benefits (27).

## 5. Conclusion

This study delved into the cognitive effects of physical education on middle school students by examining how the frequency, intensity, and variety of physical activities influence cognitive outcomes. The research findings underscore that regular, high-intensity, and diverse physical activities positively affect cognitive functions like memory, attention, problem-solving, and overall academic achievement. This highlights the essential role of well-structured physical education programs in fostering cognitive development and academic success among students. A significant positive correlation was observed between the frequency of physical education classes and cognitive performance. Students engaging in more frequent PE sessions exhibited enhanced concentration, increased academic involvement, and improved executive functions. This supports the idea that consistent physical activity within the school setting directly contributes to better academic results. Moreover, qualitative data from interviews with students revealed that regular physical activities helped reduce stress and improve mental clarity, aiding their academic endeavors.

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