Full research paper

ENHANCING COGNITIVE FUNCTION THROUGH PHYSICAL EDUCATION: THE IMPACT OF PHYSICAL EDUCATION ACTIVITY ON ATTENTION AND FOCUS

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ABSTRACT

Aim: This study investigates the impact of an enhanced physical education (PE) program on attentional functions in middle school students. The aim is to evaluate whether increasing physical education hours, emphasizing cognitive tasks and team-based activities, could positively influence students' executive functions.

Methods: The study involved four middle school classes in Italy. Two classes participated in the standard PE curriculum lessons for two hours per week, while the other two classes engaged in an intensified program for four hours weekly, focusing more on team-play and activities that develop cognitive skills.

Results: Findings indicate that students in the intensified program demonstrated faster and more accurate attention responses than those in the control group. This suggests that a more holistic physical education approach incorporating cognitive challenges and strategic team exercises may enhance students' executive functioning.

Conclusion: These findings are relevant for designing educational programs that leverage physical activity to boost academic performance. They also underscore the value of integrating physical activity into the broader educational curriculum, positioning it as a core component that contributes to students' cognitive growth and overall learning experience rather than merely a means for physical education.

KEYWORDS

Attention, physical education, anticipation, preadolescents, executive function, cognitive performance

HOW TO CITE

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Highlights

- *The intervention improved students' ability to focus and complete tasks efficiently, as shown by the increased number of bells in the experimental groups.*
- *Results suggest incorporating targeted activities can enhance executive function, aiding attention and problem-solving in class.*
- *Control groups showed no significant changes, highlighting the importance of structured interventions in physical education.*

INTRODUCTION

Cognitive function, particularly attention, is critical to academic success and overall youth development. Attention allows students to focus on relevant stimuli, ignore distractions, and efficiently process information (Miyake et al., 2000). Research indicates that attentional control is closely linked to executive functions, including inhibitory control and working memory, which play a pivotal role in academic performance across subjects such as mathematics and reading (Diamond, 2020). Deficits in attentional function have been associated with lower academic achievement, increased risk of disengagement from school, and difficulties in social interactions (Ahmed et al., 2019). Enhancing attention in school settings is a priority for educators and policymakers due to its impact on educational outcomes. For example, the rising diagnoses of ADHD highlight the need for cognitive interventions, as recent studies estimate its prevalence at 5–7% among children and adolescents (Polanczyk et al., 2015). Physical activity (PA) has been identified as a potential factor for improving attention and executive functions (Hillman, Erickson, and Kramer, 2008). Both acute and chronic aerobic exercise have shown positive effects on cognitive performance, including attention span and working memory (Pesce et al., 2019).

Among the various ways to incorporate PA into daily routines, school-based physical education (PE) stands out as a structured and inclusive setting where movement can be intentionally linked to cognitive engagement. Unlike unstructured PA, PE ensures accessibility for all students while integrating pedagogical strategies to maximize cognitive benefits. PE offers a structured opportunity to integrate movement-based cognitive engagement, reducing the competitive pressures often found in sports while ensuring broad participation (Bailey, 2006). PA is recognized as a key enhancer of attention and executive functions, with evidence supporting its role in cognitive development (Friedman and Robbins, 2022; Lovecchio, 2022).

PE offers a structured, inclusive space for movement-based cognitive engagement in schools. Ensures participation beyond the subset of students involved in competitive sports (Bidzan-Bluma and Lipowska, 2018). Unlike traditional sports, PE should emphasize cognitively demanding motor activities—such as game-based learning, dual-task exercises, and problem-solving tasks—which have been shown to amplify cognitive gains compared to non-cognitively engaging physical activities (Diamond and Ling, 2020). Webster et al. (2015) suggested different PAs to maximize children's movement in academic classrooms as a key strategy for important educational and public health goals. Further, Robinson et al. (2023) provide a review with preliminary evidence that resistance training may improve cognitive function, academic performance, and on-task behaviors in school-aged youth. Further, due to rising sedentary behavior in youth (Bull et al., 2020), PE is a promising tool for enhancing academic readiness and long-term health.

These findings suggest that an enriched PE curriculum, which integrates cognitive challenges like team-based activities, problem-solving tasks, and coordination exercises, has the potential to offer significant cognitive benefits in addition to physical development. By incorporating these cognitive demands into the PE environment, students may improve their physical skills and enhance key cognitive functions such as attention, memory, and executive control.

This study explores whether increasing the number of PE hours, with a particular focus on activities designed to engage and challenge cognitive processes, can lead to measurable improvements in attentional function among middle school students. Through this approach, we seek to determine if a more cognitively demanding PE curriculum can contribute to developing physical and cognitive skills in young learners.

METHODS

Subjects

A total of 75 participants (36 Girls; 48%) from two secondary school classes (classes 6 and 7) were included in the study. Class 6 engaged in four hours of physical education per week; instead, class 7 practiced two hours of physical education. The sample comprised 75 participants and was distributed as follows: 41 in the experimental group and 34 in the control group. Randomization was employed to ensure a balanced distribution across groups. Schools were selected based on willingness to participate in the study; participants were chosen from classes already established in the school system to ensure minimal disruption. No exclusion criteria were applied except for medical conditions preventing physical activity. Descriptive statistics are in Table 1.

		Age (years)	Weight (Kg)	Height (cm)
CLASS 6	*M*	11.59 ± 0.40	44.69 ± 9.04	149.18 ± 7.02
	F	11.66± 0.52	46.93 ± 10.50	149.64 ± 8.27
CLASS 7	*M*	12.32 ± 0.36	49.1 ± 8.14	156.27 ± 7.05
	F	12.67± 0.40	48.7 ± 8.16	153.36 ± 9.22

Table 1: Descriptive statistics about Class 6th and 7th, including mean ± standard deviation

Procedure

The test was administered twice: initially in October and then in December. Between assessments, students followed their assigned PE programs. The curriculum included cognitive-based activities such as agility drills, coordination circuits, and strategic team games like volleyball and badminton, designed to stimulate cognitive engagement (Lovecchio, 2022). Indeed, it is hypothesized that activities with a cognitive load (i.e., those that engage the subject in decision-making with respect to a changing environment) and those that place greater stress on the central nervous system to manage coordination movements can produce a greater improvement in cognitive performance, particularly in individuals of developmental age (Barnett et al., 2022). In this regard, team sports in which one must anticipate the actions of opponents to prevent them from acting are particularly effective because they cognitively engage subjects in analyzing the context (environment) to identify the elements of the space (stimuli) that are (or are not) relevant to take effective actions (decisions to move) with respect to one's goal. Since individual student reassignment was not feasible within the school context, randomization was applied at the class level, meaning that entire classes were assigned to either the experimental or control condition.

Attentional Test

The psychometric assessment used to evaluate cognitive attention was the Bells Test, a validated tool developed by Biancardi and Stoppa (Biancardi and Stoppa, 1997). This test consists of four standardized sheets containing 35 bells randomly interspersed with distractor stimuli, including various inanimate and animate objects (e.g., houses, trees, horses, fish). Participants were instructed to identify and mark as many bells as possible within a predefined time limit, assessing both selective and sustained attention. The test was administered in a controlled, distraction-free environment under standardized lighting conditions. Participants were seated at a fixed distance from the test sheets to ensure uniform visual exposure. Following the official protocol, participants were blinded to the total number of bells, the number of sheets, and the exact task duration to prevent cognitive bias or anticipatory strategies. Each sheet was presented for 120 seconds, with strictly timed intervals for page transitions. Only essential instructions were provided during transitions to maintain cognitive engagement while minimizing disruptions to attentional processing. The Processing Speed Score represents the number of bells correctly identified within the first 30 seconds, measuring initial visual search efficiency. The Total Detection Score refers to the cumulative number of bells identified over the full 120-second period, indicating sustained attention capacity. Lastly, the Error Rate is determined by the number of incorrect markings (i.e., non-bell figures), offering insight into attentional control and response accuracy. A dual-color annotation system was employed to ensure precise data recording: a blue pen for bells identified within the first 30 seconds and a red pen for those marked in the remaining 90 seconds. This method enabled clear differentiation between early-stage visual search efficiency and sustained detection ability. Researchers strictly monitored adherence to time constraints and protocol fidelity to eliminate potential confounds such as premature responses or inattentiveness. All test results were recorded in real-time and subsequently digitized for computational analysis.

Data Analysis

The number of bells identified (in the first 30 s and as a total over the 120 s) was stratified according to group (control and experimental) and according to the period (pre and post-experimental). Normality was checked with the Shapiro-Wilk test. A one-way ANOVA was conducted to evaluate the effect of treatments across groups.

The data from the 10–11-year-olds (Class 6) and the 11–12-year-olds (Class 7) were analyzed separately because the test of attention is dependent on cognitive maturation and development, which is also linked to school progression (Schul et al., 2003). No comparisons were made by gender, given that, in contrast to physiological performance, the cognitive outcome is not gender-specific (Biederman et al., 2005). In particular, the cut-offs for normality in bell recognition (speed and accuracy) and by age (11 and 12 years) are reported to be 63.20/130.3 and 63.30/1128.4, respectively.

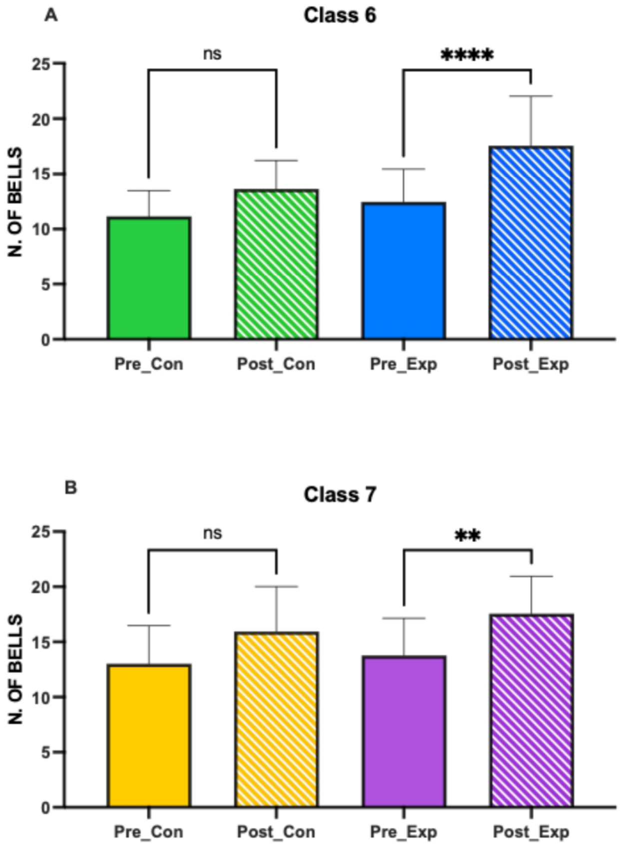
RESULTS

Number of Bells in 30 Seconds

ANOVA analysis showed a significant improvement in attention speed for the experimental group in Class 6 ($p < 0.001$) and Class 7 ($p < 0.001$). In contrast, no significant change was observed in the control groups (Figure 1A, B).

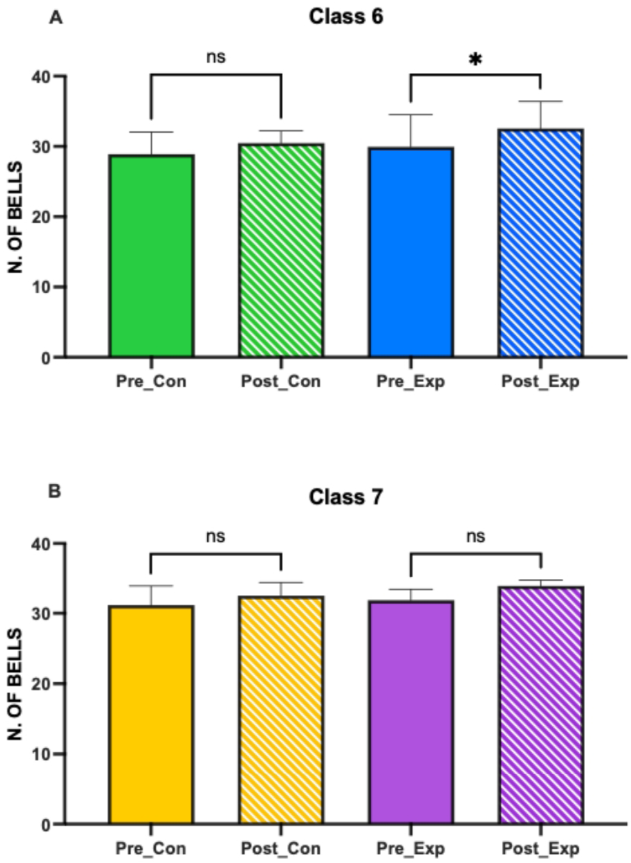
Number of Bells in 120 Seconds

A significant improvement in sustained attention was found in the experimental group of Class 6 ($p = 0.012$), but no notable changes were observed in Class 7. This suggests that increased PE hours have a greater impact on short-term attention than long-term attention (Figure 2A, B).



Note: A = Class 6, B = Class 7

Figure 1: Comparison between Pre–Post condition in control vs. experimental group in classes 6 and 7 after 30 seconds.



Note: A = Class 6, B = Class 7

Figure 2: Comparison between Pre–Post condition in control vs. experimental group in classes 6 and 7 after 120 seconds.

DISCUSSION

The results of this research show that improvements are observed in the short-term tests (30 seconds), particularly in the experimental group of Class 6 (4 hours of activity per week) compared to Class 7 (2 hours of activity per week). The long-term tests (120 seconds) show limited benefits only for Class 6. No significant changes were found in the control groups.

Numerous studies have demonstrated the positive effect of physical activity on attention (Bidzan-Bluma and Lipowska, 2018; Janssen et al., 2014). In line with this research, the results of the present study suggest that increasing the number of hours of physical education had a greater impact on the speed of attention, particularly in the group that had 4 hours of activity per week. An interesting aspect that emerged was that the most pronounced improvements were in the short-duration test (30 seconds), where the experimental group was in Class 6. In contrast, for the 120-second test, improvements were limited to Class 6 itself, with no significant differences for Class 7, suggesting that the amount of physical activity is crucial in determining the extent of improvement. In line with this, a randomized controlled trial conducted by Hillman et al. (2014) revealed that children who participated in an afterschool exercise program of 150 minutes per week exhibited notable improvements in tasks measuring attention and cognitive flexibility. Considering this study, the amount of time spent in physical activity is more closely aligned with class 6 than class 7, which suggests that 120 minutes per week is insufficient to facilitate improvement.

The data show no significant changes in the control groups, indicating that the observed benefits are directly attributable to the implemented protocol. However, the discussion should be more cautious in generalizing that the intervention improves all dimensions of attention, as the benefits of accuracy and prolonged attention span were less consistent.

Another noteworthy element is the importance attached to the content of motor activities. Although the literature suggests that activities with high cognitive load may further stimulate attention and other cognitive functions (Giuriato et al., 2024; Giuriato et al., 2024; Lovecchio, 2022; Lovecchio et al., 2021), the results do not provide direct evidence on how the benefits are related to the specific type of activity performed. It is plausible that cognitive load contributed, but further research is needed to confirm this. The observation that improvements are more pronounced in tests of short duration indicates a functional adaptation to the stimuli that characterize the contemporary socio-cultural milieu, which is characterized by a prevailing tendency towards shorter attention spans. A decline in sustained attention has been observed across all age groups, with digital media use identified as a significant contributing factor (Nesi, Telzer, and Prinstein, 2022). Tasks requiring prolonged focus often compete with stimuli that encourage frequent, rapid shifts in attention. This socio-cultural shift may make individuals more responsive to cognitive tasks that mirror these patterns, such as brief tests requiring quick decision-making or short bursts of focus (Hillman et al., 2014; Nesi et al., 2022). Nevertheless, to promote more effective development of sustained attention abilities, it would be beneficial to extend the duration of motor activity and implement structured exercises to gradually train students in maintaining attention for extended periods.

This study has some limitations, including the influence of contextual factors such as class schedules, fatigue, and extracurricular activities, which may have affected attention levels. Additionally, the generalizability of the results is limited, as the study focused on a specific age group, and the findings may not apply to younger or older students. Lastly, the specific contribution of different activities (e.g., team sports vs. coordination exercises) requires further investigation.

CONCLUSION

The present study emphasizes how increasing physical education hours, especially when supplemented with strategically designed activities, can significantly improve short-term attention spans. To maximize their benefits, these activities should be preferably placed at the beginning of the school day (Trudeau and Shephard, 2008). However, further studies are needed to explore the long-term effects and content-specific impact of the activities.

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