

Cognitively Enriched School-Based Physical Activity in Physical Education: Changes in Cognitive Performance and Mastery Motivation in Adolescents

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Abstract

Purpose

This study examined whether patterns of change in cognitive performance and mastery motivation differed across study groups following the integration of cognitively enriched movement tasks into regular physical education (PE) lessons.

Methods

Fifty-six Grade 7–8 students from four intact classes participated in a six-week pre-test–post-test controlled study with class-level random assignment. Experimental groups completed a 10–15-min cognitively enriched movement block during five weekly PE lessons, while control groups followed the standard curriculum. Cognitive performance and mastery motivation were assessed before and after the intervention. Separate 2×4 repeated-measures ANOVAs tested time $\times$ group interactions, with Benjamini–Hochberg correction for multiple outcomes. Follow-up paired-samples t-tests and Cohen's d_z characterized within-group changes.

Results

Significant time $\times$ group interactions were observed for number sequence, calculation, figures, visual memory, overall cognitive performance, and all seven mastery-motivation domains; word comprehension was not significant. Follow-up analyses showed robust gains in selected cognitive outcomes in both experimental groups, with motivational changes primarily in persistence-, social-, and failure-related domains. No control-group within-group changes remained significant after false-discovery-rate adjustment.

Conclusion

Cognitively enriched tasks embedded in regular PE were associated with differential pre-to-post changes in cognitive performance and mastery motivation. These findings support the potential value of integrating cognitive challenge into school PE, although the small single-school sample and class-level design warrant cautious interpretation.

Introduction

Physical education (PE) is one of the few school settings in which most adolescents can be reached repeatedly with structured physical activity. As a core component of school-based health promotion, PE can support regular movement participation while also providing developmental experiences relevant to cognitive, psychosocial, and educational functioning. This role is particularly relevant during

adolescence, when physical activity levels commonly decline and school-related cognitive and motivational demands increase [1]. Evidence indicates that physical activity can support cognitive functioning and academic outcomes without compromising academic achievement [2, 3].

Beyond the amount of physical activity, the cognitive quality of movement may matter. Tasks that combine movement with attention, memory, decision-making, rule switching, coordination, or problem solving simultaneously challenge motor and cognitive systems [4, 5]. Systematic reviews suggest that cognitively engaging physical activity can benefit executive functions in children and adolescents, although effects vary according to task characteristics, age, and intervention design [6, 7]. PE therefore offers a practical context in which health-promoting physical activity can be enriched with cognitive demands rather than delivered as motor practice alone. Such activities may be especially relevant in PE because they increase cognitive engagement within physically active learning experiences, rather than adding a separate classroom-based cognitive program.

PE also constitutes a motivational learning environment. According to self-determination theory, experiences of autonomy, competence, and relatedness can support more self-determined forms of motivation [8]. In PE, appropriately challenging tasks, feedback, cooperation, and opportunities for successful performance may strengthen engagement and persistence [9, 10]. Self-determined forms of motivation are also positively associated with physical activity participation in children and adolescents, further highlighting the importance of motivational processes in physical-activity contexts [11]. Although self-determination theory explains how the PE environment may support the quality of students' motivation, mastery motivation addresses a complementary tendency to engage persistently with challenging tasks and to develop competence. Mastery motivation - the intrinsic tendency to persist in challenging tasks and develop competence - is therefore relevant when evaluating whether cognitively enriched PE is associated with changes in not only performance but also learning-related motivational processes [12].

Most previous research has focused on executive functions or academic outcomes, whereas fewer school-based studies have examined short-term cognitively enriched PE interventions and cognitive performance together with mastery motivation. This distinction is important for PE as a health-promoting school context: an intervention that can be embedded in regular lessons without replacing the curriculum may offer a scalable way to add cognitive and motivational value to students' habitual school-time physical activity.

The present study examined patterns of pre-to-post change in cognitive performance and mastery motivation following a six-week cognitively enriched PE intervention integrated into regular lessons. The primary aim was to determine whether these patterns differed among the Grade 7 experimental, Grade 8 experimental, Grade 7 control, and Grade 8 control groups. Given the small number of intact classes, the analysis was designed to characterize differential group trajectories rather than to estimate a definitive intervention-specific causal effect.

Methods

Participants

The study included 56 students aged 12–15 years from four intact Grade 7–8 classes. In Grade 7, the experimental and control classes each included 11 students, while in Grade 8 the experimental and control classes included 16 and 18 students, respectively. All students in the participating classes were eligible for the study and completed both the pre-test and post-test assessments. The total sample comprised 30 boys and 26 girls, with a mean age of 13.62 ± 0.75 years. Participant characteristics are presented in Table 1.

Table 1
Characteristics of the sample participating in the study

Group	n	Male	Female	Mean age $\pm$ SD	Min-Max
Experimental group 1 7th grade	11	5	6	12.81 ± 0.60	12–14
Experimental group 2 8th grade	16	9	7	14.18 ± 0.40	14–15
Control group 1 7th grade	11	4	7	12.90 ± 0.53	12–14
Control group 2 8th grade	18	12	6	14.05 ± 0.23	14–15
Total	56	30	26	13.62 ± 0.75	12–15

Data Collection

Cognitive performance and mastery motivation were assessed on the school day immediately preceding the six-week intervention and on the school-day immediately following its completion. Assessments were administered under comparable school conditions, using the same test order and standardized instructions for all classes. The research leader administered the assessments and was aware of group allocation.

Cognitive Test

Cognitive performance was assessed using five paper-and-pencil subtests from the Cognitive Profile Test developed by Gyarmathy [13]. The tasks were appropriate for the participants’ age group and assessed number sequence (working-memory efficiency and capacity), calculation (basic mathematical

operations), word comprehension (vocabulary and verbal conceptual understanding), figures (figural abstraction and reasoning), and visual memory (sequential and visual memory). Each subtest had a maximum score of 10 points. The five subtest scores were summed to create an overall cognitive-performance score ranging from 0 to 50; subtest scores were also analyzed separately. The same task versions were administered at pre-test and post-test. Internal consistency of the five-task battery in the present sample was acceptable (Cronbach's $\alpha=0.807$).

Mastery Motivation (DMQ)

Mastery motivation was assessed using the 42-item Hungarian student version of the Dimensions of Mastery Questionnaire (DMQ) [14]. In the present study, mastery motivation was defined as the tendency to engage with challenging tasks, persist in developing competence, and respond emotionally to mastery-related success and failure. Items were rated on a five-point Likert-type scale. The questionnaire yields seven subscales: cognitive persistence, motor persistence, social persistence with adults, social persistence with peers, mastery pleasure, intellectual self-evaluation, and failure-related response. Previously reported internal-consistency estimates for the Hungarian version range from 0.68 to 0.80 across subscales [14].

Study design and setting

A six-week pre-test–post-test controlled study was conducted in one public elementary school in Central Europe. The study was implemented during routine physical education (PE) lessons. Four intact classes from Grades 7 and 8 participated. Within each grade, one class was randomly allocated to the cognitively enriched PE condition and one class to the usual-PE control condition. The design was intended to compare patterns of pre-to-post change across the four participating classes. Because only one class represented each condition within each grade, class-level characteristics could not be separated from condition effects.

The study was approved by the Ethics Committee of Eszterházy Károly Catholic University (approval No. RK/90/2025), and permission to conduct the study was obtained from the school administration. Written informed consent was obtained from the parents or legal guardians of all participating students before data collection.

Intervention and control condition

The intervention was implemented over six weeks during routine PE lessons. Students in the experimental classes completed a 10-15-min cognitively enriched movement block during each of five weekly PE lessons, resulting in 30 planned sessions. The movement block was integrated into the warm-up, main activity, or cool-down phase, according to the content of the PE lesson. The lead researcher delivered the intervention according to a pre-specified exercise sequence. Within each grade, the

experimental and control classes followed the same curriculum-based PE content, and the teachers coordinated lesson topics and planned activities to ensure comparable curricular coverage across conditions.

Intervention tasks were selected or adapted from a movement-based learning-skills resource [15] and previous PE research [16]. They combined motor execution with cognitive demands, including remembering rules or movement sequences, responding to changing stimuli, divided attention, spatial orientation, strategy use, and problem solving. Across the six-week program, the targeted cognitive domains included memory, attention and reaction, thinking skills, strategy and creativity, short-term and visual memory, concentration and divided attention, and spatial orientation. Equipment and motor demands varied across weeks to provide task variety while retaining the central cognitively enriched movement component. A detailed description of the intervention is provided in Supplementary Table S1.

Students in the control classes had the same scheduled PE frequency and followed their usual PE curriculum with their regular PE teacher. The control teacher was instructed not to use the cognitively enriched exercises included in the intervention protocol. No objective measures of physical activity intensity, heart rate, cardiorespiratory fitness, or other physiological indicators were collected. The intervention is therefore characterized by its cognitive-motor content, planned frequency, and duration rather than by quantified exercise intensity or physiological load.

Data analysis

Normality of outcome distributions was assessed using the Shapiro–Wilk test, and homogeneity of variance across the four study groups was assessed using Levene’s test. Shapiro–Wilk p values ranged from 0.096 to 0.319. Levene’s tests were non-significant for all outcomes ($p > 0.05$), providing no evidence of substantial heterogeneity of variance.

Separate repeated-measures analyses of variance (ANOVAs) were conducted for the overall cognitive-performance score, five cognitive subtests, and seven mastery-motivation subscales. Time (pre-test and post-test) was specified as the within-subject factor, and study group (Grade 7 experimental, Grade 8 experimental, Grade 7 control, and Grade 8 control) as the between-subject factor. The time $\times$ group interaction was the primary effect of interest and was interpreted as evidence that pre-to-post patterns differed among the four study groups. It was not interpreted as a direct estimate of an intervention-specific experimental-versus-control effect. Because the within-subject factor had two levels, the sphericity assumption was inherently satisfied.

To address multiplicity in the primary analyses, the Benjamini–Hochberg procedure controlled the false discovery rate at 5% separately for the six cognitive outcomes (five subtests and the overall score) and the seven mastery-motivation outcomes. Follow-up paired-samples t-tests were used to describe within-group pre-to-post change for each outcome. These analyses were supplementary and were not interpreted as direct experimental-versus-control comparisons. Within each study group, Benjamini–Hochberg adjustment was applied separately to the five cognitive subtests and to the seven mastery-

motivation subscales. The four group-specific comparisons for the overall cognitive-performance score were treated as a separate family.

Both unadjusted and Benjamini–Hochberg-adjusted p values are reported; adjusted p values below 0.05 were considered statistically robust. Repeated-measures effect sizes are reported as partial eta-squared (partial η^2). For paired comparisons, Cohen's d_z was calculated as $|t|/\sqrt{n}$. Statistical significance was set at $\alpha = .05$. Analyses were performed in IBM SPSS Statistics version 26.0.

Results

Primary Time $\times$ Group Effects

Outcome-specific repeated-measures analyses of variance were conducted for cognitive-performance and mastery-motivation outcomes. The primary effect of interest was the time $\times$ group interaction, which tested whether pre-to-post change patterns differed among the Grade 7 experimental, Grade 8 experimental, Grade 7 control, and Grade 8 control groups. Accordingly, statistically significant interactions indicate differential group trajectories and should not be interpreted as direct estimates of an intervention-specific experimental-versus-control effect.

Cognitive Performance Outcomes

Significant Time $\times$ Group interactions were observed for number sequence, $F(3, 52) = 6.05$, $p = 0.001$, BH-adjusted $p = 0.003$, partial $\eta^2 = 0.259$; calculation, $F(3, 52) = 4.93$, $p = 0.004$, BH-adjusted $p = 0.007$, partial $\eta^2 = 0.221$; figures, $F(3, 52) = 4.64$, $p = 0.006$, BH-adjusted $p = 0.007$, partial $\eta^2 = 0.211$; and visual memory, $F(3, 52) = 15.31$, $p < 0.001$, BH-adjusted $p < 0.001$, partial $\eta^2 = 0.469$. The interaction for word comprehension was not significant, $F(3, 52) = 1.55$, $p = 0.213$, BH-adjusted $p = 0.213$, partial $\eta^2 = 0.082$.

Overall cognitive performance also showed a significant Time $\times$ Group interaction, $F(3, 52) = 14.45$, $p < 0.001$, BH-adjusted $p < 0.001$, partial $\eta^2 = 0.455$ (Table 4). Thus, after correction for multiple comparisons, pre-to-post trajectories differed among the study groups for four of the five cognitive subtests and for overall cognitive performance.

Table 2
Time × group interactions for cognitive outcomes (repeated-measures ANOVA).

Variable	F	df	p	BH-adjusted p	partial η^2
Number sequence	6.051	3, 52	0.001	0.003	0.259
Calculation	4.930	3, 52	0.004	0.007	0.221
Word comprehension	1.550	3, 52	0.213	0.213	0.082
Figures	4.640	3, 52	0.006	0.007	0.211
Visual memory	15.311	3, 52	< 0.001	< 0.001	0.469
Overall cognitive performance	14.450	3, 52	< 0.001	< 0.001	0.455

Descriptive pre- and post-test scores and follow-up paired comparisons for all four study groups are presented together in Supplementary Table S2. The Grade 7 experimental group showed statistically robust within-group increases in visual memory, $t(10) = -4.18$, $p = 0.002$, BH-adjusted $p = 0.009$, $d_z = 1.26$, and overall cognitive performance, $t(10) = -3.68$, $p = 0.004$, BH-adjusted $p = 0.009$, $d_z = 1.11$. In the Grade 8 experimental group, robust within-group increases were observed in number sequence, $t(15) = -3.87$, $p = 0.002$, BH-adjusted $p = 0.004$, $d_z = 0.97$; calculation, $t(15) = -2.61$, $p = 0.020$, BH-adjusted $p = 0.033$, $d_z = 0.65$; visual memory, $t(15) = -5.46$, $p < 0.001$, BH-adjusted $p < 0.001$, $d_z = 1.37$; and overall cognitive performance, $t(15) = -5.18$, $p < 0.001$, BH-adjusted $p < 0.001$, $d_z = 1.29$.

No cognitive outcome showed a statistically significant BH-adjusted within-group change in either control group. Although the Time × Group interaction for figures was significant, no individual within-group figures comparison survived correction. The paired analyses therefore characterize the within-group changes contributing to the overall interaction pattern but do not constitute direct experimental-versus-control comparisons. Supplementary Table S2 also reports the 95% confidence intervals for the paired mean differences and Cohen's d_z effect sizes.

Mastery Motivation Outcomes

Significant Time × Group interactions were observed for all seven mastery-motivation domains, and all remained significant after Benjamini–Hochberg correction: cognitive persistence, $F(3, 52) = 22.08$, $p < 0.001$, BH-adjusted $p < 0.001$, partial $\eta^2 = 0.560$; motor persistence, $F(3, 52) = 4.17$, $p = 0.010$, BH-adjusted $p = 0.012$, partial $\eta^2 = 0.194$; social persistence with adults, $F(3, 52) = 8.25$, $p < 0.001$, BH-adjusted $p < 0.001$, partial $\eta^2 = 0.322$; social persistence with peers, $F(3, 52) = 13.10$, $p < 0.001$, BH-adjusted $p < 0.001$, partial $\eta^2 = 0.430$; mastery pleasure, $F(3, 52) = 3.65$, $p = 0.018$, BH-adjusted $p = 0.018$, partial $\eta^2 = 0.174$; intellectual self-evaluation, $F(3, 52) = 4.62$, $p = 0.006$, BH-adjusted $p = 0.009$, partial $\eta^2 = 0.210$; and failure-related response, $F(3, 52) = 7.72$, $p < 0.001$, BH-adjusted $p < 0.001$, partial $\eta^2 = 0.308$ (Table 6). These findings indicate that pre-to-post trajectories differed among the four study groups across all seven mastery-motivation domains.

Table 3
Time × group interactions for mastery-motivation outcomes (repeated-measures ANOVA).

Variable	F	df	p	BH-adjusted p	partial η^2
Cognitive persistence	22.081	3, 52	< 0.001	< 0.001	0.560
Motor persistence	4.170	3, 52	0.010	0.012	0.194
Social persistence with adults	8.250	3, 52	< 0.001	< 0.001	0.322
Social persistence with peers	13.101	3, 52	< 0.001	< 0.001	0.430
Mastery pleasure	3.650	3, 52	0.018	0.018	0.174
Intellectual self-evaluation	4.620	3, 52	0.006	0.009	0.210
Failure-related response	7.720	3, 52	< 0.001	< 0.001	0.308

Descriptive pre- and post-test scores and follow-up paired comparisons are presented together in Supplementary Table S3. The Grade 7 experimental group showed statistically robust within-group increases in cognitive persistence, $t(10) = -4.46$, $p = 0.001$, BH-adjusted $p = 0.008$, $d_z = 1.35$, and motor persistence, $t(10) = -3.36$, $p = 0.007$, BH-adjusted $p = 0.025$, $d_z = 1.01$. In the Grade 8 experimental group, robust within-group increases were observed in cognitive persistence, $t(15) = -2.76$, $p = 0.015$, BH-adjusted $p = 0.025$, $d_z = 0.69$; social persistence with adults, $t(15) = -3.39$, $p = 0.004$, BH-adjusted $p = 0.009$, $d_z = 0.85$; social persistence with peers, $t(15) = -5.03$, $p < 0.001$, BH-adjusted $p = 0.001$, $d_z = 1.26$; and failure-related response, $t(15) = -3.54$, $p = 0.003$, BH-adjusted $p = 0.009$, $d_z = 0.88$. Intellectual self-evaluation in the Grade 8 experimental group did not remain statistically significant after correction (BH-adjusted $p = 0.051$, $d_z = 0.57$).

No mastery-motivation outcome showed a statistically significant BH-adjusted within-group change in either control group. Although significant Time × Group interactions were observed for mastery pleasure and intellectual self-evaluation, no corresponding within-group comparison in the experimental groups remained statistically significant after correction. As with the cognitive outcomes, these paired comparisons characterize within-group changes contributing to the interaction pattern and should not be interpreted as direct experimental-versus-control comparisons. Supplementary Table S3 also reports the 95% confidence intervals for the paired mean differences and Cohen's d_z effect sizes.

Discussion

The present study examined patterns of change in cognitive performance and mastery motivation across four study groups following a six-week cognitively enriched physical education (PE) intervention embedded in routine school lessons. After false-discovery-rate correction, time × group interactions were observed for four of the five cognitive subtests-number sequence, calculation, figures, and visual memory and for overall cognitive performance. Time × group interactions were also observed for all seven mastery-motivation domains. Supplementary within-group analyses indicated the clearest pre-to-

post increases in visual memory and overall cognitive performance in the Grade 7 experimental group, and in number sequence, calculation, visual memory, and overall cognitive performance in the Grade 8 experimental group. In the motivational outcomes, the most consistent within-group changes were observed in persistence-related, social-persistence, and failure-related domains. These findings indicate differential patterns of change across the participating classes following the intervention period; they do not provide definitive estimates of an intervention-specific causal effect.

The cognitive findings are broadly consistent with evidence suggesting that cognitively engaging physical activity may support selected aspects of cognitive functioning in children and adolescents [5–7, 17]. More broadly, physical activity has been associated with cognitive and mental-health outcomes in young people through behavioural, psychosocial, and neurobiological pathways (18), and systematic evidence indicates associations between physical activity and aspects of brain structure and function during childhood and adolescence [19]. The intervention repeatedly required students to remember rules and movement sequences, respond to changing stimuli, divide attention, orient themselves in space, and adapt motor responses to task demands. Such characteristics may be relevant to the observed patterns in visual memory, working-memory-related number sequence performance, and calculation. Visual memory showed the largest time $\times$ group effect, while number sequence and calculation showed statistically robust within-group increases in the Grade 8 experimental class. These results are compatible with the possibility that movement tasks involving memory, rapid adaptation, and active information processing may be associated with changes in selected cognitive domains. However, the present design does not allow the observed changes to be attributed exclusively to the cognitively enriched component.

The absence of a statistically significant time $\times$ group interaction for word comprehension suggests that the observed cognitive patterns were domain-specific rather than uniform. This is plausible given that the intervention emphasized motor-cognitive demands such as rule memory, spatial orientation, reaction, attention, and task switching rather than verbal learning. The significant interaction for figures should be interpreted cautiously because no individual within-group comparison remained statistically robust after correction.

Mastery motivation showed a broader pattern of differential change across groups. The clearest within-group improvements were observed in cognitive and motor persistence in the Grade 7 experimental class and in cognitive persistence, social persistence with adults and peers, and failure-related response in the Grade 8 experimental class. Cognitively enriched movement tasks may create repeated opportunities to encounter manageable challenge, apply rules, cooperate with peers, respond to feedback, and persist after errors. These features are consistent with motivational experiences related to competence development, task engagement, and persistence in PE [8–11]. Nevertheless, the results should be interpreted as associations within the intervention context rather than evidence that the programme directly caused changes in each mastery-motivation domain.

The findings have practical relevance for PE because the cognitively enriched component was delivered as a 10–15-min block within regular lessons, five times per week for six weeks, rather than as a separate programme replacing the curriculum. Within each grade, experimental and control classes followed comparable curriculum-based PE content, while only the experimental classes received the cognitively enriched movement tasks. This suggests that cognitive challenge can be incorporated into routine PE. It should not, however, be interpreted as evidence of formal feasibility or broad scalability because implementation fidelity, teacher burden, student acceptability, and resource requirements were not assessed.

Conclusion

Cognitively enriched movement tasks integrated into routine physical education (PE) lessons were associated with differential pre-to-post patterns of cognitive performance and mastery motivation across four participating school classes. After correction for multiple testing, significant time $\times$ group interactions were observed for overall cognitive performance, four of five cognitive domains, and all seven mastery-motivation domains. Word comprehension did not show a significant time $\times$ group interaction, and several significant interaction effects were not accompanied by statistically robust within-group changes after adjustment, indicating that the observed patterns were selective rather than uniform.

The intervention was embedded in routine PE lessons as a 10–15-min cognitively enriched movement block delivered across 30 planned sessions over six weeks. Within each grade, experimental and control classes followed the same curriculum-based PE content, and teachers coordinated lesson topics and planned activities to support comparable curricular coverage; the cognitively enriched movement tasks constituted the intended difference between conditions. These findings suggest that cognitive challenge can be incorporated into regular school-based physical activity without replacing routine PE content.

The findings should be considered preliminary and should not be interpreted as definitive intervention-specific causal effects. Larger, adequately powered cluster-randomized studies with objective measures of physical activity and exercise intensity, documented intervention fidelity, alternative cognitive test forms, and longer-term follow-up are needed to establish effectiveness, mechanisms, implementation requirements, and sustainability.

Relevance of the Research

This study contributes to research on school-based physical activity by examining whether cognitively enriched movement tasks can be integrated into routine PE lessons while maintaining regular curriculum-based content. The intervention used a brief 10–15-min movement block within each of five weekly PE lessons over six weeks, providing a model that may be compatible with existing school timetables and instructional routines. Rather than replacing PE content or adding a separate classroom-

based cognitive programme, the approach integrated movement with attention, memory, decision-making, spatial orientation, problem solving, and persistence demands.

The study is relevant to sport and health sciences because PE provides repeated opportunities for adolescents to participate in structured physical activity during a developmental period when physical activity commonly declines and cognitive and motivational demands increase. The observed differential patterns in cognitive performance and mastery motivation suggest that the cognitive quality of movement experiences may warrant consideration alongside the quantity of physical activity provided in school PE. However, the present data do not demonstrate effects on physical-activity intensity, fitness, health status, longer-term behaviour, or broader academic outcomes.

From a practical perspective, the intervention illustrates how PE teachers may incorporate cognitive challenge through movement tasks that require students to remember rules or sequences, respond to changing cues, coordinate movement with attention, cooperate with peers, and adapt to changing task demands. Future research should determine the minimum effective dose, the relative contribution of cognitive challenge and physical-activity intensity, the training and resources required for teachers, implementation fidelity, and whether observed changes are sustained or translate into broader physical-activity and health-related outcomes.

Limitations of the Study

Several limitations should be considered. First, the study included 56 students from a single school, with only one class per condition within each grade. This prevented separation of class-level characteristics from condition effects and precluded robust modelling of clustering. The findings therefore reflect differential group trajectories within one school rather than definitive intervention-specific effects.

Second, experimental and control classes were taught by different PE teachers. Although curriculum content was coordinated, differences in teaching style or implementation may have influenced the results. The outcome assessor was also aware of group allocation.

Third, the same cognitive task versions were used at pre-test and post-test, so practice or familiarity effects cannot be excluded.

Finally, no objective measures of physical-activity intensity, physiological load, cardiorespiratory fitness, or intervention fidelity were collected. Consequently, the relative contributions of movement dose, cognitive challenge, teacher delivery, and other classroom-level factors cannot be distinguished.

Declarations

Ethical approval:

The study received ethical approval from Eszterházy Károly Catholic University (approval no. RK/90/2025) and was conducted with approval from the school administration.

Informed consent:

Written informed consent was obtained from the parents or legal guardians of all participating students.

Competing interests:

The authors declare that they have no competing interests.

Generative AI Statement

The authors declare that generative AI was used during the preparation of this manuscript. ChatGPT, based on OpenAI's GPT model, was used only for English language editing, grammatical correction, and stylistic refinement. All authors reviewed, edited, and approved the final version of the manuscript and take full responsibility for the accuracy and integrity of the work.

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Author Contribution

D.P.H. contributed to the conceptualization and design of the study, implementation of the intervention, data collection, data analysis and interpretation, and preparation of the original manuscript. J.B. contributed to the conceptualization and methodology of the study, interpretation of the results, and critical revision of the manuscript. Both authors reviewed and approved the final version of the manuscript and agree to be accountable for the work.

Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request, subject to applicable ethical and data-protection restrictions.

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