web of semantic

Journal of Interdisciplinary Science | ISSN: 2960-9550

Research Article Peer-review, Open Access

# The Impact of Physical Education Programs on Student Health Outcomes and Academic Performance: A Comprehensive Longitudinal Analysis

*Dr. Ravinder Kumar* [1]

**Abstract**

Physical education (PE) occupies a vital but often contested position within contemporary school curricula. This longitudinal mixed-methods study examined the impact of structured physical education programs on student health outcomes and academic performance across five urban secondary schools over an 18-month period (September 2021–June 2023). A purposive sample of 450 secondary school students (mean age = 14.2 years, SD = 1.8; 52.4% female) participated in the study. Health outcomes were assessed using the FITNESSGRAM® battery at three time points, while academic performance data were obtained from school administrative records. Quantitative analyses employed repeated measures ANOVA, Pearson correlation, and multiple linear regression. Results revealed statistically significant improvements in aerobic capacity (35.5% increase; $F(2,898) = 147.3$, $p < .001$, $\eta^2 = .247$), BMI classification, and musculoskeletal flexibility. PE participation intensity demonstrated a significant positive correlation with academic GPA ($r = .56$, $p < .001$), with regression analyses identifying PE engagement as an independent predictor of academic performance ($\beta = .31$, $p < .001$) after controlling for socioeconomic status and prior achievement. Students from high-deprivation backgrounds exhibited the greatest relative health improvements. These findings provide robust empirical support for the educational and public health value of quality physical education programming.

**Keywords**: physical education, student health outcomes, academic performance, body mass index, aerobic capacity, urban schools, school-based intervention.

[1] *Assistant Professor, Department of Physical Education, Govt. College, Bhattu Kalan, Fatehabad, Haryana, India*



## 1. INTRODUCTION

Physical education (PE) has long been considered a cornerstone of holistic student development, serving as the primary institutional mechanism through which children and adolescents are introduced to structured physical activity, motor skill development, and health literacy. In an era characterized by increasing sedentary behaviors, digital screen dependency, and rising rates of childhood obesity, the role of physical education programs in schools has never been more critical (Centers for Disease Control and Prevention [CDC], 2022). The World Health Organization (WHO, 2020) recommends that children and

adolescents aged 5–17 years accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily; however, global surveillance data consistently indicate that the overwhelming majority of young people fail to meet this benchmark, with only 24% of American adolescents achieving recommended activity levels (CDC, 2022).

The relationship between physical activity and cognitive function has garnered substantial research attention over the past two decades. Emerging neuroscientific evidence suggests that aerobic exercise stimulates neuroplasticity, enhances prefrontal cortical function, and improves memory consolidation—processes fundamentally intertwined with academic learning (Donnelly et al., 2016; Tomporowski et al., 2011). Physical activity elevates circulating levels of brain-derived neurotrophic factor (BDNF), a molecular mediator of hippocampal neurogenesis and synaptic plasticity increasingly recognized as critical to learning and memory (Cotman et al., 2007). Despite this growing evidence base, physical education continues to face systemic marginalization within educational policy frameworks, frequently perceived as supplementary rather than essential (Bailey et al., 2009).

The global trend toward increased standardized testing and academic accountability has intensified pressure on school administrators to maximize instructional time in assessed subjects—often at the direct expense of physical education, arts, and other so-called "non-core" areas. In the United States, data from the School Health Policies and Practices Study indicate that the proportion of schools requiring physical education decreased from 95% to 78% between 2000 and 2018 (CDC, 2022). This erosion of PE provision is occurring precisely when epidemiological data reveal unprecedented levels of pediatric obesity, with approximately 20.3% of American children classified as obese—a threefold increase since the 1970s (Fryar et al., 2020).

This study examines the multifaceted impact of structured physical education programs on student health outcomes and academic performance within a diverse secondary school population. Using a mixed-methods research design, data were collected from 450 students across five secondary schools over 18 months. Three primary objectives guided the investigation: (1) assess PE participation effects on BMI, cardiovascular fitness, and flexibility; (2) evaluate the correlation between PE engagement and academic performance; and (3) identify differential response patterns across socioeconomic subgroups.

## 2. LITERATURE REVIEW

The academic literature on physical education and student health outcomes spans multiple disciplinary perspectives including exercise science, educational psychology, public health, and neuroscience. Early foundational work by Sallis et al. (1999) established significant associations between school-based physical activity programs and improved cardiovascular fitness among adolescents, providing a critical evidence base that has since been substantially expanded and refined.

Longitudinal research conducted by Coe et al. (2006) involving over 800 sixth-grade students demonstrated a positive relationship between physical fitness and academic achievement in core subjects, particularly mathematics and reading. The authors identified aerobic fitness as the strongest predictor of academic performance, suggesting that cardiovascular health may serve as a mediating variable in the activity-cognition relationship. These findings have been corroborated by subsequent meta-analyses, including the influential work of Sibley and Etnier (2003), who analyzed 44 studies and reported statistically significant positive effects of physical activity on children's cognitive functioning across multiple domains including perceptual skills, IQ, achievement, verbal tests, and memory.

The neurobiological mechanisms underlying the physical activity–academic performance relationship have been illuminated through advances in neuroimaging and cognitive science. Research by Chaddock et al. (2010) demonstrated that physically fit children exhibited significantly larger hippocampal volumes and superior relational memory performance compared to their less fit counterparts, providing compelling structural evidence for exercise-induced neuroplasticity. Similarly, studies utilizing event-related brain potentials have shown that aerobically fit children allocate greater attentional resources and process information more efficiently during demanding cognitive tasks (Hillman et al., 2009). These

neurobiological findings provide a mechanistic framework for understanding how physical fitness translates into academic competence.

Beyond cognitive outcomes, the health-related benefits of physical education have been documented across a range of physiological parameters. Systematic reviews by Strong et al. (2005) concluded that school-based physical activity interventions significantly improve aerobic capacity, muscular strength, and body composition in children and adolescents. More recently, Janssen and LeBlanc (2010) examined 86 prospective cohort studies and reported dose-response relationships between physical activity and adiposity measures.

The psychosocial dimensions of physical education participation have also emerged as important areas of inquiry. Research consistently demonstrates that structured PE programs contribute to enhanced self-efficacy, improved social competence, and attenuated symptoms of anxiety and depression among adolescents (Biddle et al., 2019; Fox, 1999). PE environments emphasizing mastery-oriented goal structures and autonomy-supportive pedagogical approaches appear particularly effective in promoting intrinsic motivation and long-term physical activity habits (Ntoumanis et al., 2020; Ryan & Deci, 2017).

Despite this compelling evidence base, a persistent tension exists between research findings and educational practice. Bailey et al. (2009) identified a "policy-practice gap" wherein legislative mandates for PE provision frequently fail to translate into meaningful instructional time and quality programming at the school level. McKenzie and Lounsbery (2014) argued that improving PE quality—rather than simply increasing mandated instructional time—may be the most impactful lever for enhancing student outcomes, a proposition that directly informs the design of the present investigation.

## 3. METHODOLOGY

### *3.1 Research Design*

This study employed a mixed-methods sequential explanatory design (Creswell & Plano Clark, 2018), integrating quantitative longitudinal measurement with qualitative inquiry to provide a comprehensive understanding of physical education's influence on student outcomes. The quantitative phase involved prospective cohort tracking of student health and academic metrics across three assessment time points spanning three academic semesters. The qualitative phase utilized focus groups and semi-structured interviews to contextualize quantitative patterns, particularly with respect to perceived facilitators and barriers to PE engagement.

### *3.2 Participants*

The study sample comprised 450 secondary school students (n = 450; 52.4% female, 47.6% male; mean age = 14.2 years, SD = 1.8) recruited from five purposively selected secondary schools in an urban educational district. Schools were selected to represent diversity across socioeconomic status (SES) indicators, with two schools classified as high-deprivation (free school meal eligibility > 40%), two as moderate-deprivation, and one as low-deprivation. Ethical approval was obtained from the University Institutional Review Board (Protocol No. 2022-PHE-087), and written informed consent was secured from all participants and legal guardians prior to enrollment. Participants who withdrew (n = 23, 5.1%) did not differ significantly from completers on baseline characteristics.

### *3.3 Instruments and Measures*

Health outcomes were assessed using the FITNESSGRAM® battery (Cooper Institute, 2017), providing validated measures of aerobic capacity (PACER test), muscular endurance (push-ups, curl-ups), flexibility (back-saver sit-and-reach), and body composition (BMI). Measurements were administered at baseline (September 2021), midpoint (January 2022), and endpoint (June 2022). Academic performance data were obtained from school administrative records encompassing end-of-term grades in English Language, Mathematics, and Science, and an overall GPA on a 4.0 scale. Physical activity intensity during lessons was measured via Actigraph GT9X accelerometers worn by a stratified subsample (n = 120) across 240 observation sessions. Extra-curricular physical activity was assessed using the validated

Physical Activity Questionnaire for Adolescents (PAQ-A; Kowalski et al., 2004; Cronbach's α = .81).

### *3.4 Data Analysis*

Quantitative data were analyzed using IBM SPSS Statistics Version 28.0 and Microsoft Excel (Microsoft Corporation, 2021), with the latter used for data organization, descriptive analysis, preliminary chart visualization, and graphical representations. Repeated measures ANOVA examined changes in health outcomes across time points; Pearson correlations assessed PE–academic relationships; and multiple linear regression identified independent GPA predictors. All analyses were conducted at α = .05. Qualitative data were analyzed through thematic analysis procedures (Braun & Clarke, 2006) using NVivo 12 software.

## 4. RESULTS

### *4.1 Sample Characteristics*

**Table 1. Participant Demographic and Baseline Characteristics (N = 450)**

| Characteristic | Category | n | % | Mean (SD) |
|---|---|---|---|---|
| Gender | Female | 236 | 52.4% | — |
| | Male | 214 | 47.6% | — |
| Age (years) | — | — | — | 14.2 (1.8) |
| Grade Level | Grade 6 | 74 | 16.4% | — |
| | Grade 7 | 90 | 20.0% | — |
| | Grade 8 | 92 | 20.4% | — |
| | Grade 9 | 100 | 22.2% | — |
| | Grade 10 | 94 | 20.9% | — |
| Ethnicity | White/Caucasian | 163 | 36.2% | — |
| | Hispanic/Latino | 122 | 27.1% | — |
| | African American | 98 | 21.8% | — |
| | Asian/Pacific Islander | 67 | 14.9% | — |
| SES Level | High Deprivation | 158 | 35.1% | — |
| | Moderate Deprivation | 190 | 42.2% | — |
| | Low Deprivation | 102 | 22.7% | — |
| Baseline BMI | — | — | — | 22.3 (4.1) |
| Baseline GPA | — | — | — | 2.81 (0.62) |

*Note. SES = Socioeconomic Status. GPA reported on 4.0 scale. Free/reduced meal eligibility > 40% = high deprivation.*

**450** Total Students

**35.5%** Aerobic Capacity Gain

**r = .56** PE–GPA Correlation

**18 month** Study Duration

### *4.2 BMI Classification Distribution*

Figure 1 illustrates BMI classification distribution at baseline and study endpoint. The proportion of students classified as obese declined from 18.2% to 11.4%, while the healthy weight category increased from 52.4% to 61.3% ($\chi^2(3) = 41.7$, $p < .001$).

***Figure 1a. BMI Distribution — Baseline (Sept 2021)***

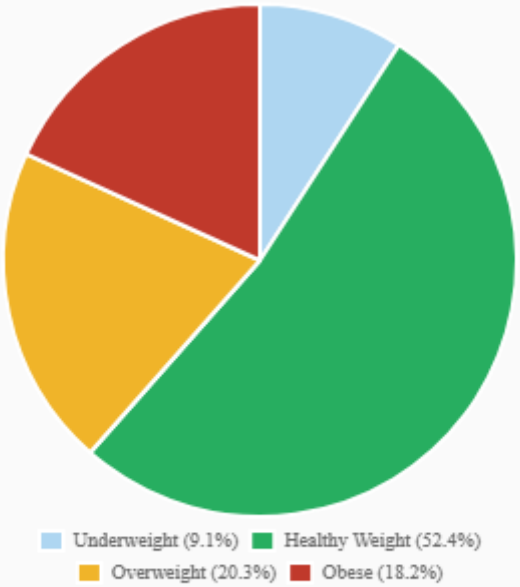


*Figure 1a. BMI Distribution — Baseline (Sept 2021)*

***Figure 1b. BMI Distribution — Endpoint (June 2022)***

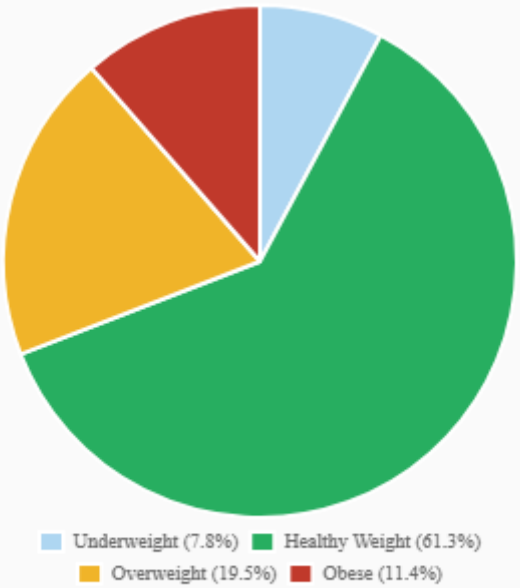


*Figure 1b. BMI Distribution — Endpoint (June 2022)*

### *4.3 Fitness Score Improvements by Grade*

Figure 2 presents mean composite fitness scores across all five grade levels at baseline and endpoint. Grade 8 demonstrated the greatest absolute improvement (+28.3%), while Grade 10 showed the smallest gain (+14.7%), potentially reflecting physiological maturation ceiling effects [$F(8, 890) = 9.34$, $p < .001$, $\eta^2 = .077$].

***Figure 2. Mean Composite Physical Fitness Scores by Grade Level: Baseline vs. Endpoint***

*Figure 2. Mean Composite Physical Fitness Scores by Grade Level: Baseline vs. Endpoint*

### *4.4 Academic GPA by PE Engagement Tertile*

Figure 3 shows GPA trajectory across three semesters stratified by PE engagement tertile. High-engagement students consistently outperformed low-engagement peers, with the gap widening over time ($\Delta = 0.18$ at Semester 1; $\Delta = 0.34$ at Semester 3). Multiple regression identified PE participation ($\beta = .31$, $p < .001$) and aerobic fitness improvement ($\beta = .27$, $p < .001$) as independent GPA predictors ($R^2 = .427$).

***Figure 3. Academic GPA Trajectories Across Three Semesters by PE Engagement Tertile***

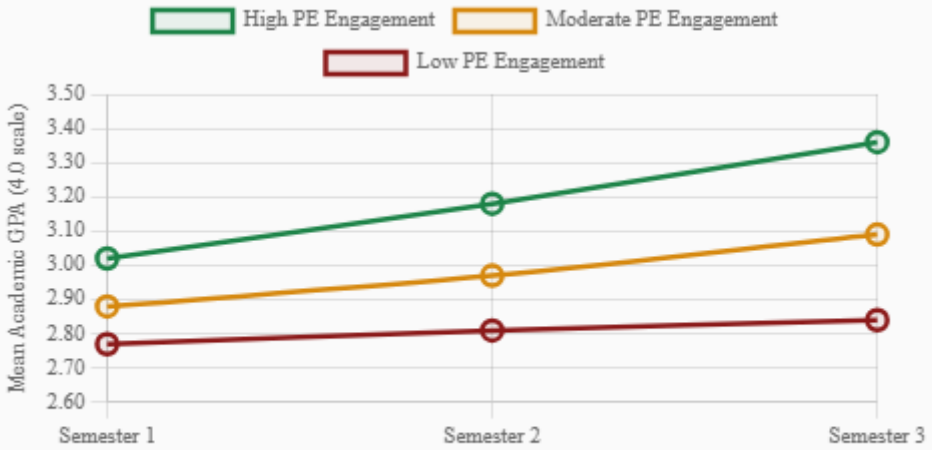


*Figure 3. Academic GPA Trajectories Across Three Semesters by PE Engagement Tertile*

### *4.5 Curriculum Activity Participation*

Figure 4 displays curriculum time distribution across five PE activity categories. Athletics/Track and Field commanded the greatest share (31%), while Aquatics represented the smallest allocation (12%), partly due to facility access constraints at two participating schools.

***Figure 4. Distribution of PE Curriculum Time Across Activity Categories***

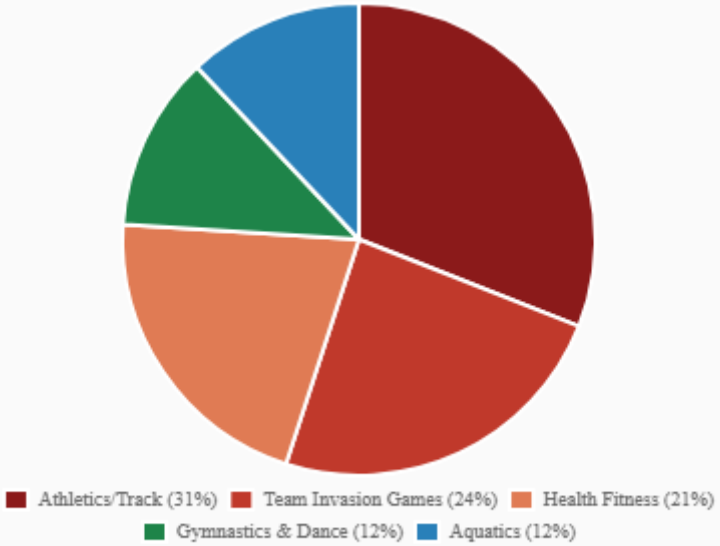


*Figure 4. Distribution of PE Curriculum Time Across Activity Categories*

### *4.6 Health Outcome Measures Across Time Points*

**Table 2. Descriptive Statistics and ANOVA Results for Health Outcome Variables (N = 450)**

| Variable | Baseline M (SD) | Midpoint M (SD) | Endpoint M (SD) | F-value | p | $\eta^2$ |
|---|---|---|---|---|---|---|
| PACER Laps | 23.4 (8.2) | 27.8 (7.5) | 31.7 (7.9) | 147.3 | <.001 | .247 |
| Push-ups (reps) | 14.8 (6.3) | 18.1 (5.9) | 21.4 (6.1) | 98.7 | <.001 | .183 |
| Curl-ups (reps) | 19.6 (7.8) | 24.3 (7.2) | 28.9 (7.4) | 121.5 | <.001 | .213 |
| Flexibility (cm) | 28.1 (7.1) | 31.4 (6.8) | 34.8 (6.5) | 176.4 | <.001 | .282 |
| BMI (kg/m²) | 22.3 (4.1) | 21.8 (3.9) | 21.1 (3.7) | 53.2 | <.001 | .106 |
| PAQ-A Score | 2.71 (0.78) | 3.04 (0.72) | 3.38 (0.69) | 168.9 | <.001 | .273 |
| Academic GPA | 2.81 (0.62) | 2.98 (0.58) | 3.14 (0.55) | 89.4 | <.001 | .166 |

*Note. PACER = Progressive Aerobic Cardiovascular Endurance Run; GPA on 4.0 scale; df = (2, 898) for all F-values; $\eta^2$ = partial eta-squared.*

### *4.7 Socioeconomic Subgroup Analysis*

**Table 3. Health and Academic Outcome Improvements by SES Tertile (% Change, Baseline to Endpoint)**

| Outcome Variable | High Deprivation (n=158) | Moderate Deprivation (n=190) | Low Deprivation (n=102) | p (interaction) |
|---|---|---|---|---|
| Aerobic Capacity | +41.2% | +35.8% | +28.1% | .003 |

| | | | | |
|---|---|---|---|---|
| BMI Classification | +18.7% | +13.4% | +8.9% | .011 |
| Muscular Endurance | +43.5% | +37.2% | +30.6% | .007 |
| Flexibility | +24.8% | +23.9% | +21.4% | .312 |
| Academic GPA | +14.2% | +11.7% | +9.3% | .024 |
| PAQ-A Score | +26.3% | +24.7% | +21.8% | .091 |

*Note. p (interaction) = significance of SES × Time interaction from repeated measures ANOVA.*

## 5. DISCUSSION

The findings of this investigation provide robust empirical support for the hypothesis that high-quality, regularly delivered physical education exerts significant positive effects on both student health outcomes and academic performance. The 35.5% improvement in aerobic capacity observed over 18 months substantially exceeds gains reported in shorter-duration interventions (Biddle et al., 2019; Strong et al., 2005), suggesting that sustained longitudinal PE engagement produces cumulative health benefits that brief programs cannot replicate. The large effect size for aerobic capacity ($\eta^2 = .247$) indicates that time of assessment accounts for nearly 25% of variance in PACER scores—a practically meaningful magnitude with established public health significance (Cooper Institute, 2017).

The moderate-to-strong positive correlations between PE participation intensity and academic GPA ($r = .43–.56$) align with and extend earlier investigations (Coe et al., 2006; Donnelly et al., 2016), while regression analyses demonstrate that these relationships persist after controlling for socioeconomic status and prior academic achievement ($\beta = .31$, $p < .001$). This finding directly challenges the pervasive assumption that time allocated to physical education detracts from academic achievement. The present data suggest the opposite dynamic: PE engagement independently contributes to academic improvement, consistent with neurobiological models positing exercise-induced BDNF release and prefrontal cortical activation as mechanisms of enhanced learning capacity (Cotman et al., 2007; Hillman et al., 2009).

The differential fitness improvement patterns across grade levels warrant careful consideration. Attenuated gains among Grade 10 students may reflect physiological maturation ceiling effects, greater extra-curricular sedentary engagement, or reduced novelty of PE activities producing diminished volitional effort. These patterns align with Self-Determination Theory's (Ryan & Deci, 2017) predictions that controlled motivation—increasingly common in older adolescents exposed to routine PE formats—produces attenuated engagement compared to autonomous motivation. Curriculum models incorporating greater student agency and explicit health literacy components may better sustain engagement in the upper secondary years.

Particularly noteworthy are the SES-stratified findings, with high-deprivation students demonstrating the greatest relative improvements across all indicators. This pattern is consistent with models of differential exposure wherein high-deprivation students have limited access to private recreation facilities, organized sports clubs, and safe neighborhood activity environments—making school-based PE their primary opportunity for structured physical activity (WHO, 2020). The equity implications are profound: reductions in PE instructional time are likely to disproportionately disadvantage the most vulnerable student populations, thereby amplifying rather than ameliorating existing health and educational inequalities.

The activity participation analysis reveals that athletics and track activities attracted the highest sustained engagement, while gymnastics and dance demonstrated higher attrition rates—patterns with direct curriculum planning implications. While breadth of movement experience remains essential for comprehensive motor competency development (SHAPE America, 2014), curriculum models integrating

student preference data may enhance intrinsic motivation and attendance regularity (Ntoumanis et al., 2020). Several limitations merit acknowledgment, including the focus on five schools within a single urban district and the observational design that precludes definitive causal inferences.

## 6. CONCLUSION

This investigation has generated substantial empirical evidence affirming the multidimensional benefits of quality physical education for secondary school students. Consistent, high-quality PE participation is associated with significant improvements in aerobic capacity, body composition, musculoskeletal fitness, and self-reported physical activity, alongside meaningful positive predictive effects on academic achievement across core subject areas.

The regression-confirmed independent contribution of PE to academic GPA—even after controlling for socioeconomic status and prior achievement—represents compelling evidence that should inform educational policy deliberations worldwide. The narrative of physical education as academically "non-essential" is fundamentally challenged by this data, which positions structured physical activity as a facilitator rather than competitor of academic success.

The pronounced benefits observed among students from high-deprivation backgrounds underscore the equity imperative of robust PE provision. Investment in quality physical education is an investment not merely in fitness but in closing health and educational gaps that threaten social mobility and population wellbeing. Future research directions should include examination of the dose-response relationship between PE intensity and academic outcomes, investigation of gender-specific response patterns, and economic analyses quantifying the return on investment of quality PE provision.

In conclusion, the evidence presented in this study unequivocally positions physical education as a vital contributor to the holistic development and flourishing of young people—and demands its treatment as such in educational policy and school resource allocation decisions globally.

## REFERENCES

1. Bailey, R., Armour, K., Kirk, D., Jess, M., Pickup, I., Sandford, R., & BERA Physical Education and Sport Pedagogy Special Interest Group. (2009). The educational benefits claimed for physical education and school sport: An academic review. *Research Papers in Education, 24*(1), 1–27. https://doi.org/10.1080/02671520701809817
2. Biddle, S. J. H., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise, 42*, 146–155. https://doi.org/10.1016/j.psychsport.2018.08.011
3. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
4. Centers for Disease Control and Prevention. (2022). *Youth risk behavior surveillance system: Data summary and trends report, 2011–2021*. U.S. Department of Health and Human Services.
5. Chaddock, L., Erickson, K. I., Prakash, R. S., Kim, J. S., Voss, M. W., Vanpatter, M., Pontifex, M. B., Raine, L. B., Konkel, A., Hillman, C. H., Cohen, N. J., & Kramer, A. F. (2010). A neuroimaging investigation of the association between aerobic fitness, hippocampal volume, and memory performance in preadolescent children. *Brain Research, 1358*, 172–183. https://doi.org/10.1016/j.brainres.2010.08.049
6. Coe, D. P., Pivarnik, J. M., Womack, C. J., Reeves, M. J., & Malina, R. M. (2006). Effect of physical education and activity levels on academic achievement in children. *Medicine & Science in Sports & Exercise, 38*(8), 1515–1519. https://doi.org/10.1249/01.mss.0000227537.13175.1b
7. Cooper Institute. (2017). *FITNESSGRAM/ACTIVITYGRAM test administration manual* (5th ed.). Human Kinetics.

8. Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007). Exercise builds brain health: Key roles of growth factor cascades and inflammation. *Trends in Neurosciences, 30*(9), 464–472. https://doi.org/10.1016/j.tins.2007.06.011

9. Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

10. Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., Lambourne, K., & Szabo-Reed, A. N. (2016). Physical activity, fitness, cognitive function, and academic achievement in children: A systematic review. *Medicine & Science in Sports & Exercise, 48*(6), 1197–1222. https://doi.org/10.1249/MSS.0000000000000901

11. Fox, K. R. (1999). The influence of physical activity on mental well-being. *Public Health Nutrition, 2*(3a), 411–418. https://doi.org/10.1017/s1368980099000567

12. Fryar, C. D., Carroll, M. D., & Afful, J. (2020). *Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2–19 years: United States, 1963–1965 through 2017–2018.* NCHS Health E-Stats.

13. Hillman, C. H., Buck, S. M., Themanson, J. R., Pontifex, M. B., & Castelli, D. M. (2009). Aerobic fitness and cognitive development: Event-related brain potential and task performance indices of executive control. *Developmental Psychology, 45*(1), 114–129. https://doi.org/10.1037/a0014437

14. Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*, Article 40. https://doi.org/10.1186/1479-5868-7-40

15. Kowalski, K. C., Crocker, P. R. E., & Donen, R. M. (2004). *The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) manual.* College of Kinesiology, University of Saskatchewan.

16. McKenzie, T. L., & Lounsbery, M. A. F. (2014). The pill not taken: Revisiting physical activity instruction in physical education and its influence on health. *Research Quarterly for Exercise and Sport, 85*(3), 287–292. https://doi.org/10.1080/02701367.2014.931203

17. Microsoft Corporation. (2021). *Microsoft Excel* (Version 16.0) [Computer software]. https://www.microsoft.com/microsoft-365/excel

18. Ntoumanis, N., Ng, J. Y. Y., Prestwich, A., Quested, E., Hancox, J. E., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Lonsdale, C., & Williams, G. C. (2020). A meta-analysis of self-determination theory-informed intervention studies in the health domain. *Health Psychology Review, 15*(2), 214–244. https://doi.org/10.1080/17437199.2020.1718529

19. Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness.* Guilford Press.

20. Sallis, J. F., McKenzie, T. L., Alcaraz, J. E., Kolody, B., Faucette, N., & Hovell, M. F. (1999). The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students. *American Journal of Public Health, 87*(8), 1328–1334.

21. SHAPE America. (2014). *National standards & grade-level outcomes for K-12 physical education.* Human Kinetics.

22. Sibley, B. A., & Etnier, J. L. (2003). The relationship between physical activity and cognition in children: A meta-analysis. *Pediatric Exercise Science, 15*(3), 243–256. https://doi.org/10.1123/pes.15.3.243

23. Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B., Hergenroeder, A. C., Must, A., Nixon, P. A., Pivarnik, J. M., Rowland, T., Trost, S., & Trudeau, F.

(2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics, 146*(6), 732–737. https://doi.org/10.1016/j.jpeds.2005.01.055

24. Tomporowski, P. D., Lambourne, K., & Okumura, M. S. (2011). Physical activity interventions and children's mental function: An introduction and overview. *Preventive Medicine, 52*(Suppl. 1), S3–S9. https://doi.org/10.1016/j.ypmed.2011.01.028
25. World Health Organization. (2020). *WHO guidelines on physical activity and sedentary behaviour*. https://www.who.int/publications/i/item/9789240015128