



Effectiveness of Integrating Educational Games in Physical Fitness Training to Improve Students Cardiorespiratory Capacity

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Abstract

Background: Cardiorespiratory capacity (CRF) is crucial for physical and cognitive health in children and adolescents. However, declines in CRF due to sedentary lifestyles highlight the need for effective interventions in school-based physical education (PE) programs. Traditional PE methods often fail to engage students sufficiently. Objective: This systematic literature review (SLR) examines the effectiveness of incorporating educational games into physical fitness training and compares these approaches with traditional high-intensity interval training (HIIT) in enhancing students' CRF. Methods: A systematic search of Scopus, Web of Science, and Google Scholar was conducted to identify experimental and quasi-experimental studies published within the past decade. Eligible studies integrated educational games into fitness-related interventions and reported outcomes related to CRF. Results: HIIT consistently improved CRF, particularly VO₂ max and aerobic performance. Game-based interventions showed smaller but significant improvements, primarily through enhanced engagement and motivation. Combining game elements with HIIT enhanced both physiological and behavioral outcomes. Conclusion: HIIT and game-based interventions offer complementary benefits for improving CRF. HIIT provides significant physiological gains, while educational games foster long-term participation. A combined approach could optimize both fitness and engagement in PE programs. Further research is needed to refine intervention parameters and assess long-term outcomes.

How to Cite

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INTRODUCTION

Cardiorespiratory fitness represents a core dimension of physical fitness and serves as an important marker of health status and functional capacity, particularly during the school years. Sufficient levels of cardiorespiratory capacity indicate the effective functioning of the cardiovascular and respiratory systems in sustaining prolonged physical activity and are closely associated with favorable health outcomes across the life course (Satrianingsih & Yulianto, 2025). Among children and adolescents, higher cardiorespiratory fitness has been linked not only to improved physical performance but also to better cognitive functioning, emotional regulation, and reduced risk of chronic disease later in life (Risyanto & Yulianto, 2025).

Despite its well-established importance, a growing body of evidence points to a global decline in cardiorespiratory fitness among students. This trend is largely driven by increasing sedentary lifestyles, prolonged screen exposure, and limited participation in structured physical activity. Within this context, school-based physical education (PE) is expected to play a pivotal role in mitigating these negative trends; however, its potential contribution has not always been fully optimized (Artihung & Yulianto, 2025).

Conventional PE practices frequently rely on traditional training models characterized by repetitive exercises and teacher-centered instruction. Such approaches often fail to align with students' developmental stages and motivational needs, leading to reduced engagement and minimal active involvement during lessons (Mudzakir et al., 2025). As a result, students may not reach the intensity or duration of physical activity necessary to stimulate meaningful improvements in cardiorespiratory fitness (Rusandi et al., 2025).

Low levels of student engagement during fitness-focused PE sessions pose a substantial challenge, as physiological adaptations depend on consistent participation in moderate-to-vigorous physical activity. When fitness activities are perceived as monotonous or excessively demanding, students' motivation tends to decline, thereby diminishing the effectiveness of instructional goals (Hamdan et al., 2025). These conditions underscore the need for innovative pedagogical approaches that address both physiological requirements and motivational characteristics of learners (Yulianto et al., 2024).

In response to this challenge, the integration of educational games into PE instruction has gained increasing scholarly attention. Edu-

cational games incorporate elements of play, challenge, rules, and learning objectives, offering a student-centered pedagogical approach that emphasizes enjoyment and active participation. Within PE settings, game-based activities have the potential to promote sustained movement, social interaction, and intrinsic motivation factors that are critical for effective fitness development (Mandigo et al., 2019).

Previous studies have reported positive effects of game-based approaches on student motivation, engagement, and overall physical activity levels during PE lessons. However, much of the existing research has focused predominantly on behavioral and affective outcomes, such as enjoyment and participation, rather than on objective physiological indicators of fitness. Consequently, empirical evidence regarding the direct effects of integrating educational games on students' cardiorespiratory capacity remains relatively limited (Aske et al., 2018).

Moreover, only a small number of studies have systematically compared game-based fitness training with traditional training methods within formal school environments. Many investigations have been conducted in extracurricular or non-formal contexts, which restricts the applicability of findings to standard PE curricula. In addition, the differential impacts of various game formats such as competitive, cooperative, or technology-supported games on cardiorespiratory fitness outcomes have not been sufficiently examined (Komaludin et al., 2025).

These gaps in the literature point to a clear need for further investigation into the effectiveness of integrating educational games into structured fitness training within school-based PE programs. Addressing this issue is essential to determine whether game-oriented pedagogical strategies can function as effective alternatives to conventional fitness training approaches (Garcia-Puchades & Chiva-Bartoll, 2020).

Accordingly, the present study aims to evaluate the effectiveness of incorporating educational games into fitness training to enhance students' cardiorespiratory capacity. The novelty of this study lies in its explicit focus on physiological outcomes, rather than solely on motivational variables, and in its empirical comparison of game-based fitness training with traditional methods in a formal school setting. The findings are expected to contribute to the development of evidence-based PE pedagogy and to offer practical guidance for teachers in designing engaging and effective fitness-oriented learning experiences.

METHODS

This study employed a Systematic Literature Review (SLR) to critically evaluate the effectiveness of integrating educational games into physical fitness training for improving students' cardiorespiratory capacity. The SLR methodology was chosen due to its rigor, transparency, and replicability, allowing a comprehensive synthesis of evidence from multiple studies while minimizing bias (Page et al., 2021).

A systematic search was conducted in Scopus, Web of Science and Google Scholar using the following combination of keywords: "educational games" AND "physical fitness training" AND "cardiorespiratory capacity" AND "students". Searches were limited to studies published within the last 10 years. Reference lists of included studies were also screened to identify additional relevant publications.

Data collection is part of this research by collecting the data obtained from articles used as research. following inclusion withdrawal as well as the exclusion criteria in the assessment according to the following criteria.

Inclusion Criteria :

Population: Students in primary or secondary education participating in physical fitness programs.

Intervention: Integration of educational games or game-based learning into structured physical fitness training.

Outcome: Measurement of cardiorespiratory capacity using validated instruments (e.g., VO_2 max, heart rate, shuttle run, or standardized fitness tests).

Study Design: Experimental or quasi-experimental studies capable of demonstrating causal effects.

Exclusion Criteria :

Studies examining educational games without physical fitness components.

Studies lacking valid or reliable cardiorespiratory outcome measures.

Non-English publications or inaccessible full-text articles.

Analysis techniques used in this research using bibliographic annotations. Bibliographic annotation analysis, namely drawing simple conclusions based on source identity, qualifications, objectives, conclusions, and sources used answer the problem formulation

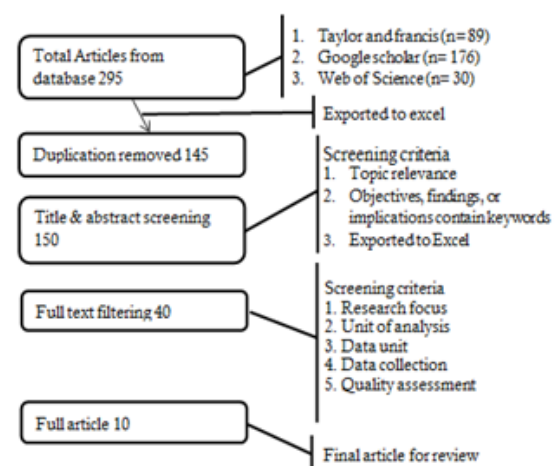


Figure 1. PRISMA Flow Diagram

RESULTS AND DISCUSSION

Name & Title	Year	Journal	Results
Delgado-Floody, Pedro, et al. "Feasibility of incorporating high-intensity interval training into physical education programs to improve body composition and cardiorespiratory capacity of overweight and obese children: A systematic review."	2019	Journal of Exercise Science & Fitness	The HIIT protocols consisted of 2–3 sessions per week, with intervals of 15 s and passive or active rests of 15 s, totaling up to 6 min of work with 4 min of rest. The duration of HIIT programs was 6–24 weeks. Significant changes were reported in body composition, body mass index, body fat (%), waist circumference, and sum of skinfolds; and increases in muscle mass were observed. The inclusion of HIIT programmes improved maximal oxygen uptake ($\text{VO}_{2\text{max}}$), performance in the intermittent Yo-Yo test and maximal aerobic speed.
Martin-Smith, Rhona, et al. "High intensity interval training (HIIT) improves cardiorespiratory fitness (CRF) in healthy, overweight and obese adolescents: a systematic review and meta-analysis of controlled studies."	2020	International journal of environmental research and public health	HIIT displays a moderate effect to improve CRF ($g = 0.86$, 95% CI 0.518–1.106, $p < 0.001$). Neither study duration (weeks), nor total or weekly accumulated HIIT volume (min) displayed any significant moderation effect on pooled improvement on CRF ($p > 0.05$).

Cao, Meng, Yucheng Tang, and Yu Zou. "Integrating high-intensity interval training into a school setting improve body composition, cardiorespiratory fitness and physical activity in children with obesity: A randomized controlled trial."	2022	Journal of Clinical Medicine	<p>In conclusion, our findings indicated that integrating regular school-based HIIT sessions improved body composition and cardiorespiratory fitness in school children with obesity. Furthermore, the findings supported the implementation of HIIT as innovative PA programs in school settings, helping obese children develop a healthy and active lifestyle. More studies employing similar rigorous designs are needed to explore what modifications might be made to school-based HIIT programs to assist in weight management among children with obesity.</p> <p>two 45 min sessions per week, regardless of their fun- or training-specific focus, seem to be insufficient to contribute significantly on cardiorespiratory fitness, especially if we take into account that PA intensity was never higher than moderate. This should be addressed through an increase in frequency and duration of PE classes, or through more comprehensive in-school PA programs involving not only PE, but also taking advantage of recess and breaks. Finally, game-based activities appear to have similar impact as traditional approaches in our sample. Therefore, they may be used together or in place of more strict exercise routines for the improvement of physical fitness.</p> <p>It was discovered that the indicators of physical mobility of schoolchildren significantly improved: the number of students with a low level of physical mobility (PM) decreased from 50% to 13%, and the average level of PM in schoolchildren increased from 31% to 62%. Due to the developments of this study, it is possible to continue work on the implementation of PFGs in the educational process, since this process is accessible. Physical folk games do not require complex equipment, expensive buildings, and special conditions.</p> <p>The findings of the present study suggest that a gamification-based teaching program designed to increase PA levels in college students has a significant effect on their CRF in comparison with peers of a CG. Furthermore, significant differences were found between groups attending the gamification-based lectures of the subject and groups meeting PA recommendations in college students of IG. There were also significant differences between the group meeting PA recommendations 100% of weeks and the group that did not meet them for CRF improvements.</p> <p>58 students participated in the Escape-Cardio. We observed better performance in the intervention group, improving their average mark and number of correct answers in the exam, with a statistically significant difference compared to the control group (p-value<0.05). In the qualitative assessment, students answered the survey, and all of them scored unanimously each item with the maximum score, aiming for 100% satisfaction.</p> <p>These results add to the paucity of literature investigating the long-term effects of a school-based exergaming program on children's PA and fitness. However, the potential negative effects of exergaming interfering with unstructured outdoor activity should also be kept in mind when seeking to implement a school-based exergaming program in underserved schools. Finally, more studies employing similar rigorous designs are needed to explore what modifications might be made to school-based exergaming programs to assist in promoting CRF among children</p>
Cocca, Armando, et al. "Effect of a game-based physical education program on physical fitness and mental health in elementary school children."	2020	International Journal of Environmental Research and Public Health	
Ermenova, Batilya O., et al. "A Health-improving and educational effect of gamified physical activities (Efecto educativo y de mejora de la salud de la actividad física del juego)."	2021	Retos 39	
Mora-Gonzalez, Jose, et al. "A gamification-based intervention program that encourages physical activity improves cardiorespiratory fitness of college students: 'The Matrix Revolution Program'."	2020	International journal of environmental research and public health	
Ferrer-Sargues, Francisco José, et al. "Escape-cardio: Gamification in cardiovascular physiotherapy. An observational study."	2021	Nurse Education Today	
Ye, Sunyue, et al. "Effects of school-based exergaming on urban children's physical activity and cardiorespiratory fitness: A quasi-experimental study."	2019	International journal of environmental research and public health	

Radhakrishnan, Kavita, et al. "Role of digital games in self-management of cardiovascular diseases: a scoping review."	2019	Games for health journal	Digital games significantly improved exercise capacity and energy expenditure but did not affect quality of life, self-efficacy, anxiety, or depression. Digital games were found enjoyable by 79%–93% of participants, including those with lower education or age; however, barriers to game use included being tired or bored, lack of interest in digital games, poor perception of fitness through games, sensor limitations, conflicts with daily life routine, and preferences for group exercise.
Pozuelo-Carrascosa, Diana P., et al. "Effectiveness of school-based physical activity programmes on cardiorespiratory fitness in children: a meta-analysis of randomised controlled trials."	2018	British journal of sports medicine	Twenty trials with 7287 healthy children aged 3–12 years were included in the meta-analysis. School-based physical activity interventions with aerobic games and activities were associated with a significant small increase in CRF (Hedges' $g=0.22$; 95% CI 0.14 to 0.30; $p<0.001$). Based on subgroup analysis, the increase in CRF was significant in girls (Hedges' $g=0.25$; 95% CI 0.13 to 0.37; $p<0.001$), but not in boys (Hedges' $g=0.02$; 95% CI -0.10 to 0.14; $p=0.731$).

This systematic review examined the effectiveness of incorporating educational games and high-intensity interval training (HIIT) within school-based physical education programs to enhance students' cardiorespiratory fitness (CRF). The findings indicate that both HIIT and game-oriented interventions contribute positively to CRF, although they operate through distinct mechanisms and produce varying magnitudes of impact. This section integrates the main results with relevant theoretical perspectives, discusses practical implications for physical education, and highlights directions for future research.

High-intensity interval training (HIIT) has been consistently demonstrated to be an effective strategy for enhancing cardiorespiratory fitness, as reflected in significant improvements in $VO_{2\max}$ and overall aerobic capacity across numerous studies (Delgado-Floody et al., 2019) (Cao et al., 2022) (Martin-Smith et al., 2020). The physiological advantages of HIIT are well established, with underlying mechanisms including increases in cardiac output, mitochondrial biogenesis, and improved efficiency of oxygen utilization (Carrick-Ranson et al., 2020) (Ferrer-Sargues et al., 2021). These adaptations collectively contribute to greater maximal aerobic capacity and endurance, positioning HIIT as a highly time-efficient method for improving cardiovascular fitness in children and adolescents.

The consistency of positive outcomes across the reviewed studies indicates that HIIT interventions implemented within school settings can produce meaningful gains in cardiorespiratory fitness, even when delivered over relatively short durations ranging from 6 to 24 weeks. The intensity and structure of these interventions align with established dose–response principles in exercise physiology, whereby higher training intensities elicit more substantial cardiovascu-

lar adaptations (Holloway et al., 2018). Taken together, these findings underscore the potential of HIIT as an effective pedagogical approach to counteract increasing levels of physical inactivity and declining cardiovascular health among school-aged populations.

While HIIT offers robust physiological adaptations, game-based interventions (including exergaming and gamified PE programs) demonstrated more modest, yet important, improvements in CRF. The primary benefit of game-based interventions lies in their motivation-enhancing and engagement-promoting properties, which can lead to sustained participation in physical activity (Mora-Gonzalez et al., 2020) (Ermenova et al., 2021). These interventions typically encourage intrinsic motivation through fun, competition, and social interaction, which has been shown to foster long-term physical activity adherence (Perrone & D'Angelo, 2025).

A primary limitation of game-based interventions lies in the generally moderate intensity of physical activity they elicit, which may be insufficient to induce substantial cardiovascular adaptations (Ye et al., 2019) (Cocca et al., 2020). Consequently, although such interventions demonstrate clear potential in enhancing student motivation and long-term participation, their impact on improving cardiorespiratory fitness tends to be less robust when compared with intensity-focused approaches such as high-intensity interval training (HIIT) (Radhakrishnan et al., 2019).

An emerging finding from this review is the potential for synergistic benefits when combining HIIT with gamified elements. Integrating game-like elements into HIIT sessions could foster higher levels of engagement, while maintaining the exercise intensity required for significant CRF improvements. This combination aligns with social cognitive theory (Choi & Md-Yunus,

2011), which emphasizes the importance of self-efficacy and goal-setting in motivating sustained physical activity. By combining the intrinsic motivation fostered by games with the physiological benefits of HIIT, such a combined approach could optimize both physiological and behavioral outcomes (Pozuelo-Carrascosa et al., 2018).

This combined intervention model could be especially beneficial in school-based settings, where children may struggle with maintaining engagement in traditional physical education formats. Gamifying HIIT could offer a fun, yet highly effective, strategy for improving both fitness and long-term physical activity habits.

Several limitations must be considered when interpreting the findings of this review. First, study heterogeneity in terms of intervention design, intensity, frequency, and duration limits the ability to draw definitive conclusions about the most effective program characteristics. The inclusion of studies targeting specific populations, such as children with obesity, also affects the generalizability of the results.

Furthermore, long-term follow-up data are sparse, and more research is needed to assess the sustainability of CRF improvements and the impact of these interventions on other health-related outcomes, such as mental well-being and academic performance. Future studies should also aim to establish optimal intensity, frequency, and duration parameters for both HIIT and game-based interventions to maximize their efficacy.

In particular, randomized controlled trials with larger sample sizes, diverse populations, and longer follow-up periods would provide stronger evidence for the effectiveness and sustainability of these interventions.

CONCLUSION

In conclusion, both HIIT and game-based interventions offer distinct but complementary benefits for improving students' cardiorespiratory capacity. HIIT provides clear physiological benefits through intense exercise that induces cardiovascular adaptations, while game-based interventions enhance engagement and adherence to physical activity. Combining the strengths of both approaches may provide a synergistic model that maximizes both fitness improvements and long-term engagement. Schools should consider integrating both HIIT and gamified elements into physical education programs to address the dual goals of improving physical fitness and fostering sustained participation in physical activity. Future research should focus on optimizing the

intensity and structure of these interventions and evaluating their long-term impacts on student health outcomes.

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