High-Intensity Interval Training: competitive and non-competitive effects on physical fitness in school adolescents

Entrenamiento interválico de alta intensidad: efectos competitivos y no competitivos sobre la condición física en adolescentes escolares

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Abstract

Introduction: Adolescents commonly do not reach vigorous-intensity physical activity guidelines, and physical education (PE) classes provide a key opportunity to promote adherence to WHO recommendations.
Objective: The study aimed to examine the effects of a high-intensity interval training (HIIT) program with a competitive component compared with non-competitive HIIT and a control group on adolescents' physical fitness.
Methodology: A total of 199 students (93 females), aged 15–17 years, participated in a 10-week school-based intervention conducted in two public secondary schools in Mallorca, Spain. Physical fitness was assessed through cardiorespiratory fitness, lower- and upper-body strength, jump performance, Body Mass Index and waist circumference.
Results: The competitive HIIT group, implemented through a weekly ranking system, did not show significant pre–post improvements in any physical fitness variables. In contrast, the non-competitive HIIT group demonstrated substantial gains in muscular strength (+2.8, $p < 0.001$) and jump performance (+5.0, $p = 0.011$). The control group showed significant improvements in cardiorespiratory fitness (+1.7, $p < 0.001$), muscular strength (+1.3, $p = 0.035$), and waist circumference (–1.2, $p = 0.006$).
Discussion: These results align with previous studies highlighting the benefits of HIIT in school settings, suggesting that competitive elements may require more engaging motivational strategies than a simple ranking system to enhance adherence
Conclusions: HIIT can effectively improve adolescents' physical fitness in school settings, but competitive dynamics need careful design to maximize motivation and participation. Future research should explore innovative, context-specific strategies incorporating task variety and motivational factors.

Keywords

Adolescents; competitive dynamics; high-intensity interval training; motivation; Physical Education; physical fitness.

Resumen

Introducción: La población adolescente tiene una baja adherencia a las recomendaciones de actividad física vigorosa, y las clases de educación física representan una oportunidad para mejorar la adherencia a las recomendaciones de la OMS.
Objetivo: Este estudio evaluó los efectos de un programa de entrenamiento interválico de alta intensidad (HIIT) con componente competitivo frente a HIIT no competitivo y un grupo control sobre la condición física de adolescentes.
Metodología: Participaron 199 estudiantes (93 chicas), de 15 a 17 años, en una intervención de 10 semanas en dos institutos públicos de Mallorca, España. La condición física se evaluó mediante capacidad cardiorrespiratoria, fuerza de miembros inferiores y superiores, rendimiento en saltos, índice de masa corporal y circunferencia de cintura.
Resultados: El grupo HIIT competitivo, con un sistema de ranking semanal, no mostró mejoras significativas. El grupo HIIT estándar presentó incrementos en fuerza muscular (+2,8, $p < 0,001$) y rendimiento en saltos (+5,0, $p = 0,011$). El grupo control mejoró en capacidad cardiorrespiratoria (+1,7, $p < 0,001$), fuerza muscular (+1,3, $p = 0,035$) y circunferencia de cintura (–1,2, $p = 0,006$).
Discusión: Los resultados coinciden con estudios previos que destacan los beneficios del HIIT en entornos escolares, sugiriendo que los elementos competitivos requieren estrategias motivacionales más atractivas que un simple sistema de ranking para mejorar la adherencia.
Conclusiones: El HIIT puede mejorar la condición física de los adolescentes en la escuela, pero la dinámica competitiva debe diseñarse cuidadosamente para maximizar motivación y participación. Se sugiere explorar estrategias innovadoras y variadas que incorporen factores motivacionales contextuales.

Palabras clave

Adolescentes; dinámica competitiva; Educación Física; entrenamiento interválico de alta intensidad; condición física.

Introduction

Adolescence is a critical period for promoting physical activity (PA), as it is characterised by major physical, psychological, and social changes. This stage is crucial for the development of habits and lifestyles that frequently continue into adulthood (Kumar et al., 2015; van Sluijs et al., 2021). Despite the well-documented benefits of PA, such as the prevention of chronic diseases, improved mental health, brain development, and greater emotional self-regulation (Belcher et al., 2021; Brooks et al., 2021), global data indicate that most adolescents are not sufficiently active, with only 19.7% meeting the PA guidelines, which include both aerobic exercise and muscle-strengthening activities (Garcia-Hermoso et al., 2023). When adherence to all movement behaviour recommendations is considered, that is, meeting the guidelines for PA, limited screen time, and adequate sleep (Carbonell-Escalas et al., 2025), the percentage drops even further, ranging between 9% and 19% in the United States and around 10% in Germany (Hansen et al., 2022; X. Liu et al., 2024).

Moreover, moderate levels of PA during adolescence have been shown to provide important benefits, including better self-rated health, greater emotional well-being, and reduced depressive symptoms (Isaksson et al., 2020; Joensuu et al., 2024; Yan et al., 2024). These alarming figures highlight a global public health concern and emphasise the need for targeted interventions during adolescence, a stage in which active and sustainable behaviours are more likely to be established (Messing et al., 2019; Telford et al., 2023).

Physical fitness (PF) refers to the capacity to perform PA effectively and is commonly used as an indicator of overall health and functional ability (Mendonça et al., 2022). PF includes health-related components (cardiorespiratory capacity, muscular strength and endurance, flexibility, and body composition) as well as motor skills such as agility, speed, balance, coordination, and power (Bouamra et al., 2022; Welsner et al., 2024). Good PF is an independent predictor of future health, and it is associated with lower cardiovascular and metabolic risk, better mental health, and higher academic performance (Cadenas-Sanchez et al., 2021; Mintjens et al., 2018; Xiang et al., 2017). Conversely, low fitness levels have been linked to greater physical and mental vulnerability, including a higher risk of chronic diseases, infections, premature mortality, and clinical complications. Despite this evidence, fitness remains an undervalued indicator among health professionals and the general population (Franklin et al., 2023). In adolescents, current fitness levels are concerning, reflecting sedentary lifestyle patterns that demand preventive interventions starting in childhood (Bouamra et al., 2022). In adolescents, PF can be assessed through standardised batteries such as Alpha-Fitness (Ruiz et al., 2011)

One of the most studied approaches in recent years to improve PF levels is HIIT, which involves repeated short bouts of intense effort interspersed with brief recovery periods (Costigan et al., 2015). Its main advantage is efficiency: in as little as 10 to 15 minutes, relevant improvements can be achieved in cardiovascular health, strength, and body composition (Bauer et al., 2022; Duncombe et al., 2022).

In addition to the general evidence on its effectiveness, school-based studies have shown that HIIT can be realistically implemented in physical education (PE) classes (Duncombe et al., 2024; Jovanović et al., 2024). These interventions demonstrate that they can be integrated within the limited time of school sessions and still produce relevant improvements in students' fitness (Bauer et al., 2022; Duncombe et al., 2022). Moreover, its flexible format allows teachers to adapt the activities, whether through circuits, group tasks, or competitive elements, so that they are more engaging for adolescents (Bento et al., 2022; Duncombe et al., 2024).

In adolescents, HIIT has also been shown to improve mood, increase motivation, and benefit psychological well-being, including self-esteem and the reduction of depressive symptoms (Li & Zhou, 2025; Mitić et al., 2025). The short duration of HIIT makes it feasible to implement in PE classes through bodyweight circuits or station-based exercises, without requiring additional equipment (A. F. P. da S. Bento et al., 2022). Existing studies consistently report high acceptance from both students and teachers, with strong participation rates and positive perceptions (Costigan et al., 2015; Sharp et al., 2020).

One of the primary challenges in implementing HIIT in school settings is maintaining high levels of student engagement in terms of exercise intensity. Several studies have identified low motivation as one of the most common reasons for dropout or poor adherence to PA programs (Paulino da Silva Bento et al., 2021). A potential strategy to counteract this lack of motivation is the introduction of competitive elements within training sessions. These components, acting as extrinsic reinforcers, have been shown to increase effort and commitment to PA effectively (Guo et al., 2022). On this point, evidence from a school-based HIIT programme incorporating competitive team challenges, over half of the adolescents reported that the competitive dynamics, such as group-based tasks, performance comparisons and rewards, increased their motivation and willingness to continue with the sessions. Participants described the competitive element as enjoyable and stimulating, although some explained that excessive difficulty could reduce engagement (Sharp et al., 2020). However, the comparative effectiveness of competitive versus non-competitive HIIT formats, as well as the mechanisms underlying their impact on adolescents' physical fitness, remains poorly understood.

This study aims to examine the effect of a HIIT program with a competitive component compared with non-competitive HIIT and a control group on adolescents' PF. It is hypothesised that the inclusion of a ranking system as a motivational element will lead to significant improvements in physical capacities compared with the other groups.

Method

A quasi-experimental cluster study with a parallel-group, pre-post intervention design was conducted, complemented by a qualitative focus group to explore participants' experiences. The research was part of the Burn2Learn Mallorca project (ClinicalTrials.gov identifier: NCT06699862), carried out in two public secondary schools in Mallorca.

Participants

The sample consisted of 199 students (46.7% females) aged 15 to 17 years from two public secondary schools in Mallorca, Spain. The schools were purposively selected to represent both urban and rural contexts. The intervention lasted 10 weeks.

Inclusion criteria were being 15–17 years old at the start of the intervention, having informed consent signed by both the participant and their legal guardian, no medical contraindications preventing participation in high-intensity exercise, regular attendance at intervention sessions (at least 80% of scheduled sessions), and presence during the weeks designated for pre- and post-intervention data collection. To ensure full participation, data collection was conducted over two weeks in both the pre- and post-intervention phases.

Exclusion criteria included absence during either evaluation phase (pre- or post-intervention) and the presence of injuries or health issues that would prevent safe completion of the physical tests.

Procedure

The study was approved by the Research Ethics Committee of the University of the Balearic Islands (Ref. 385CER23) and the Ethics Committee for Clinical Research with Medicines of the Balearic Islands (Ref. IB5511/24PI). Throughout the entire process, data confidentiality was ensured, and the ethical principles for research with human participants were strictly followed. Data collection took place between May 2024 and January 2025.

PF assessments were conducted by qualified personnel who had been previously trained in the standardised protocols to ensure the reliability and validity of the measurements. To minimise fatigue and enhance accuracy, the different tests were scheduled on non-consecutive days. All sessions were carried out under controlled conditions and supervised by the research team.

The intervention took place over 10 weeks, involving two sessions of high-intensity interval training (HIIT) per week, delivered during regular PE classes in the school setting. Each session lasted between 8 and 12 minutes, structured as two short segments of approximately 4 to 6 minutes, separated by brief pauses to reset exercises and instructions. Students independently performed a warm-up based on previously learned content in the curriculum, while no specific cool-down was conducted, as lessons continued immediately afterwards.

To improve reproducibility, further details of the exercise structure are provided. In running-based sessions, a fixed 1:1 work-to-rest ratio was used (e.g., 1 minute of fast running followed by 1 minute at a light pace). In circuit-based sessions, students repeatedly performed short bouts of bodyweight exercises such as burpees, jump squats, push-ups, forward lunges, jumping jacks, and 20-m shuttle sprints for the full duration of each mini-session.

Typically, sessions were conducted in the schoolyard or similar open spaces, using mainly bodyweight exercises arranged in stations to facilitate movement and reduce setup complexity. The exercise design involved alternating brief periods of intense effort with low-intensity or complete rest intervals. Students wore heart rate monitors that provided continuous, real-time feedback, aiming to maintain at least 85% of their predicted maximum heart rate during effort phases to achieve physiological benefits consistent with HIIT. No exercise-related injuries occurred during the intervention. Session attendance exceeded 80% for all included participants.

To enhance motivation and participation, students contributed ideas for exercises and tasks to include during sessions through brainstorming, which the instructor then adapted to ensure safety and feasibility while maintaining the objective of vigorous intensity. In the competitive condition, the physical structure remained the same but was framed as a team-oriented competition between classes, encouraging participants to exert maximal effort.

Points were calculated for each participant based on the proportion of time spent above the vigorous intensity threshold during sessions. For example, if a student spent 10 minutes above 85% of their predicted maximum heart rate during a 50-minute PE class, this would represent 20% of the total class time, corresponding to 20 points. These scores were averaged at the class level to create a leaderboard, helping to motivate classes. An example leaderboard from session 7 is shown in Figure 1. To protect privacy, participant names have been replaced with anonymized initials.

Figure 1. An example leaderboard used during the intervention to communicate student rankings and points. Participant names are anonymized to ensure confidentiality.

Teachers supervised sessions, offering encouragement and attending to issues. Occasional sensor malfunctions (e.g., loss of signal or strap loosening) were resolved immediately, ensuring that all students received valid intensity feedback during the sessions. Data on attendance, device usage, and intensity levels were regularly recorded to monitor adherence and exposure. Results were communicated on a group basis to preserve individual confidentiality while maintaining motivation through public recognition of collective progress.

Instruments

Cardiorespiratory fitness was estimated using the 20-meter shuttle run test (Course Navette), a progressive and incremental protocol that allows the assessment of maximal oxygen consumption

(VO_2max). The test involves running back and forth in intervals synchronised with auditory signals, adjusted for participants' age and sex. This method has shown high validity and reliability and is widely used to assess PF in youth populations (García & Secchi, 2014).

Lower limb muscular power was assessed using the standing long jump. Participants performed two attempts from a static position with both feet, and the distance from the take-off line to the rearmost heel upon landing was measured. The best performance was used for analysis (Castro-Piñero et al., 2010).

Upper body muscular strength was evaluated with an adjustable handgrip dynamometer. Participants performed two attempts with each hand, and the maximum value from each hand was recorded. The average of both maxima was calculated as a representative measure of overall muscular strength (Hamilton et al., 1992).

Body Mass Index was calculated by dividing body weight in kilograms by height in meters squared (kg/m^2). Weight was measured using an electronic scale, with participants barefoot and wearing light clothing, and height was recorded with a stadiometer, ensuring alignment with the Frankfurt plane. Two measurements of each variable were taken, and the mean was used for analysis. Body Mass Index is a general indicator of body size and is associated with cardiovascular health in adolescents (Ruiz et al., 2011).

Central adiposity was assessed by measuring waist circumference with a non-elastic tape placed at the narrowest part of the torso, between the tenth rib and the iliac crest. Measurements were taken at the end of a normal exhalation, without compressing the skin, with the participant standing relaxed and arms at the sides. Two non-consecutive measurements were recorded, and the mean was used for analysis. This measure is a recognised proxy for abdominal fat and has been linked to increased cardiometabolic risk in youth (Ruiz et al., 2011).

Data analysis

Descriptive statistics (mean and standard deviation) were calculated for all main variables, stratified by group (competitive HIIT, non-competitive HIIT, and control) and by sex, to provide an initial characterisation of the sample.

To examine within-group changes from pre- to post-intervention, paired-sample t-tests were conducted, adjusting for sex as a covariate. Effect sizes (Cohen's d) were also calculated to assess the magnitude of changes beyond statistical significance.

Finally, between-group differences in absolute changes (Post – Pre) were analysed using a one-way ANOVA, adjusted for sex. This analysis examined whether any group showed significantly greater improvements than the others. F-statistics, p-values, and mean differences between groups were reported, complemented by a figure illustrating the pre- to post-intervention evolution of the different variables. The level of statistical significance was set at $p < 0.05$.

Qualitative Complementary Analysis

In addition to the quantitative design, a complementary qualitative component was incorporated better to understand students' perceptions of the competitive HIIT intervention. A focus group methodology was used to capture understandings, perspectives, and experiences of participants, providing opportunities for in-depth conversations and interactions among individuals exploring the meaning of a specific set of issues (Barbour, 2005; Morgan, 1996). Eight discussion groups were formed, with 8–10 participants in each group, resulting in a total sample size of n = 49. One researcher facilitated the discussion group while another researcher took notes on the participants' contributions. All data were treated confidentially. This qualitative analysis was conceived as a secondary objective to provide interpretative insights that could contextualise and complement the quantitative findings. The data were analysed using a thematic content approach. First, meaningful units were identified in the transcripts and coded into preliminary categories. Next, a process of refinement was conducted to consolidate themes, which were subsequently quantified by calculating the frequency of responses within each category. This procedure allowed us to identify the most common perspectives expressed by the students.

Results

Baseline descriptive values of PF and body composition variables for the three groups, stratified by sex, are shown in Table 1. Adolescents in the control and non-competitive HIIT groups presented higher VO_2max at baseline (42.9 and 41.6 mL·kg^{-1}·min^{-1}, respectively) compared with the competitive HIIT group (37.6 mL·kg^{-1}·min^{-1}). Similar differences were observed in muscular strength and standing long jump, where participants in the Competitive HIIT group displayed lower baseline values. In contrast, the competitive HIIT group showed higher BMI (23.5 vs. 21.5–21.3 kg/m^2) and waist circumference (75.9 vs. 70.2 cm) relative to the other groups, indicating a less favourable fitness and body composition-profile at study entry.

Table 1. Descriptive characteristics of the sample

Control Group (n=70)							Non-Competitive HIIT (n=70)						Competitive HIIT (n=49)					
Variable	Total		Boys		Girls		Total		Boys		Girls		Total		Boys		Girls	
	x̄	SD	x̄	SD	x̄	SD	x̄	SD	x̄	SD	x̄	SD	x̄	SD	x̄	SD	x̄	SD
VO_2max	42.9	7.53	46.4	6.43	36.4	4.46	41.6	7.28	45.2	6.54	38.2	6.30	37.6	6.45	41.3	6.86	34.9	4.53
Muscular strength	34.0	7.90	37.5	6.39	26.4	4.12	30.9	8.01	35.7	8.24	26.2	4.11	30.1	9.24	37.3	8.00	24.5	5.57
Standing Long Jump	164.9	61.22	187.1	53.59	127.0	55.10	157.0	52.13	172.7	60.73	141.6	36.58	156.4	27.92	175.9	22.95	141.3	21.50
BMI	21.5	3.03	21.0	2.86	22.4	3.18	21.3	2.75	20.8	2.54	22.0	2.87	23.5	4.27	24.1	4.72	23.0	3.91
Waist circumference	70.2	6.68	72.1	6.39	66.6	5.73	70.2	7.68	71.3	6.61	69.1	8.55	75.9	11.48	80.0	10.11	72.8	11.63

Table 1. Descriptive values of PF and body composition variables of the sample, expressed as mean (x̄) and standard deviation (SD), stratified by group (Control, Non-competitive HIIT, and Competitive HIIT) and sex. VO_2max = maximal oxygen uptake; BMI = body mass index.

Pre- and post-intervention values are presented in Table 2. In the control group, who continued to conduct the usual PE sessions, significant improvements were found in VO_2max ($t = -3.65$, $p < 0.001$, $d = -0.46$), muscular strength ($t = -2.15$, $p = 0.035$, $d = -0.21$), with and waist circumference ($t = 2.84$, $p = 0.006$, $d = 0.35$). No significant changes were observed in the standing long jump or BMI.

The non-competitive HIIT group showed the most consistent improvements. Significant increases were found in VO_2max ($t = -3.11$, $p = 0.003$, $d = -0.39$), muscular strength ($t = -5.00$, $p < 0.001$, $d = -0.61$), and standing long jump ($t = -2.61$, $p = 0.011$, $d = -0.32$). No significant changes occurred in BMI or waist circumference.

In relation to the competitive HIIT group, although there was a slight improvement in the post-test, no significant changes were found in any outcome variable: VO_2max ($t = -1.68$, $p = 0.100$, $d = -0.24$), muscular strength ($t = 0.09$, $p = 0.927$, $d = 0.01$), standing long jump ($t = -0.42$, $p = 0.677$, $d = -0.06$), BMI ($t = 0.06$, $p = 0.955$, $d = 0.01$), and waist circumference ($t = 1.05$, $p = 0.299$, $d = 0.15$).

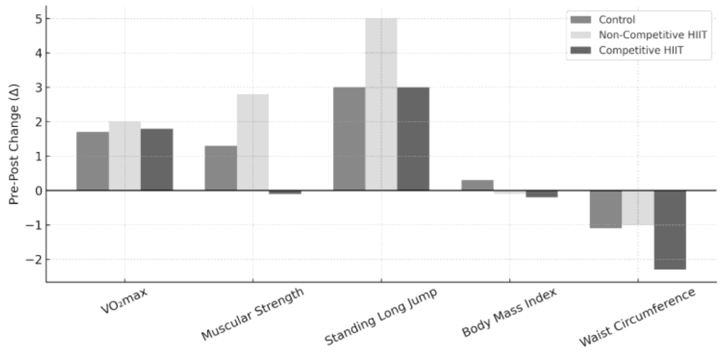
Table 2. Pre- and Post-Intervention Changes in PF and Body Composition Variables within Each Study Group

	Control Group (n=70)				Non-Competitive HIIT (n=70)				Competitive HIIT (n=49)			
	Pre	Post			Pre	Post			Pre	Post		
	X (SD)	X (SD)	Effect Size (d)	Signif	X (SD)	X (SD)	Effect Size (d)	Signif	X (SD)	X (SD)	Effect Size (d)	Signif
VO_2max	43.4 (7.63)	45.1 (8.22)	-0.46	t= -3.65 p= .001*	42.0 (7.01)	44.0 (6.83)	-0.39	t= -3.11 p= .003	37.6 (6.45)	39.4 (6.82)	-0.24	t= -1.68 p=.100
Muscular Strength	31.5 (8.30)	32.8 (8.67)	-0.21	t= -2.15 p= .035	30.5 (8.01)	33.3 (8.92)	-0.61	t= -5.00 p= .001*	30.1 (9.24)	30.0 (8.95)	0.01	t= 0.09 p= .927
Standing Long Jump	180.0 (37.9)	183.0 (39.8)	-0.17	t= -1.38 p= .174	170.0 (29.8)	175.0 (34.2)	-0.32	t= -2.61 p= .011	156.0 (27.92)	159.0 (32.8)	-0.06	t= -0.42 p= .677
BMI	21.5 (3.03)	21.8 (3.59)	-0.15	t= -1.22 p= .226	21.3 (2.75)	21.2 (2.93)	0.17	t= 0.40 p= .116	23.5 (4.27)	23.5 (4.13)	0.01	t= 0.06 p=.955
Waist circumference	70.2 (6.68)	69.0 (7.30)	0.35	t= 2.84 p= .006	70.2 (7.68)	69.2 (9.18)	0.04	t= 0.30 p= .765	75.9 (11.48)	73.6 (10.09)	0.15	t= 1.05 p= .299

Pre- and post-intervention values (mean ± SD) of PF and body composition variables for the Control, Non-competitive HIIT, and Competitive HIIT groups. Effect sizes are reported as Cohen's d. Significance levels (p) and t-statistics correspond to paired-samples t-tests. Analyses were adjusted for sex. VO_2max =maximal oxygen uptake; BMI = Body Mass Index

Mean pre–post changes across groups are displayed in Figure 2. The change between post-intervention and pre-intervention assessments (post–pre change) is indicated for each variable. Between-group analyses showed no significant differences in VO_2max (Control: +1.7; Non-competitive HIIT: +2.0; Competitive HIIT: +1.8; F = 0.113, p = .893), muscular strength (Control: +1.3; Non-competitive HIIT: +2.8; Competitive HIIT: –0.1; F = 1.71, p = .187), or standing long jump (Control: +3.0; Non-competitive HIIT: +5.0; Competitive HIIT: +3.0; F = 0.275, p = .760). A significant group effect was observed for BMI (Control: +0.3; Non-competitive HIIT: –0.1; Competitive HIIT: 0.0; F = 5.11, p = .008), favouring the Non-competitive HIIT group. Waist circumference decreased similarly across all groups (F = 0.358, p = 0.70).

Figure 2. Pre–post intervention changes across groups in physical fitness and body composition variables



Qualitative Findings on Motivation and Perceptions of Competitive HIIT

Figure 3 displays the distribution of motivation types reported in the focus groups, with extrinsic motivation predominating (62.5%), amotivation present to a lesser extent (25%), and a smaller subgroup of intrinsic motivation (12.5%). This pattern highlights the salience of scores, ranking, and inter-class comparison, while self-improvement goals were less frequent, and some students expressed indifference toward the activity.

Illustrative quotations include: "I loved competing with the heart rate monitor." (FGx_P07, translated), "The ranking mattered to me; I wanted to win." (FGx_P12, translated), "I wanted to outdo myself." (FGx_P03, translated), and "It was indifferent to me." (FGx_P15, translated).

Figure 3. Distribution of Students' Prioritised Motivation Types

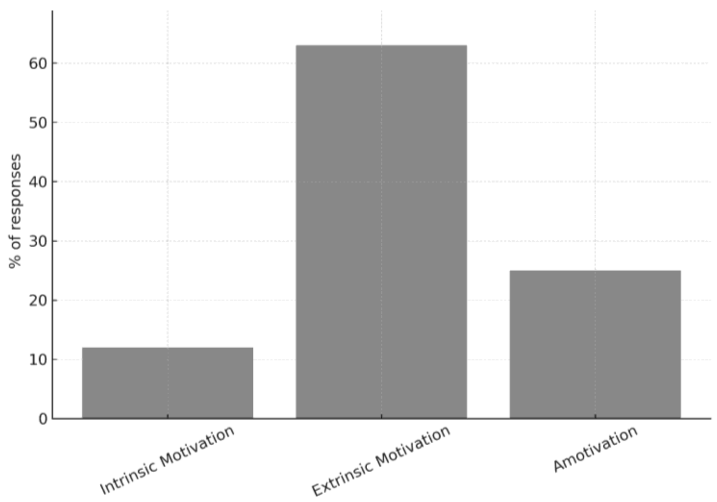


Figure 4 displays how students prioritised competition, with high importance predominating (53.3%), low importance forming a secondary group (26.7%), and smaller segments reporting decreases (16.7%) or increases (3.3%) in importance over time. Representative comments underscoring high importance included "I loved competing with the heart rate monitor." (FGx_P07, translated), "Seeing the score made me want to do better." (FGx_P13, translated), "Competing with a classmate made me push a lot and I loved it." (FGx_P18, translated), "The ranking mattered to me; I wanted to win." (FGx_P12, translated), and "We sometimes had friendly duels to see who had more points." (FGx_P16, translated). Change over time was captured by statements such as "At first I didn't care, but later I started checking it." (FGx_P02, translated) and "At first I got really into it and checked the score, but later I got bored." (FGx_P11, translated). Low-importance perspectives were also present, for example, "We didn't give it much importance." (FGx_P06, translated) and "It felt like it wasn't even there." (FGx_P04, translated). Together, these quotations corroborate the distribution in Figure 3 by linking high salience to rankings, inter-class rivalry, and wearable-driven feedback, while acknowledging small groups with fluctuating or minimal salience.

Figure 4. Importance Assigned to Competition

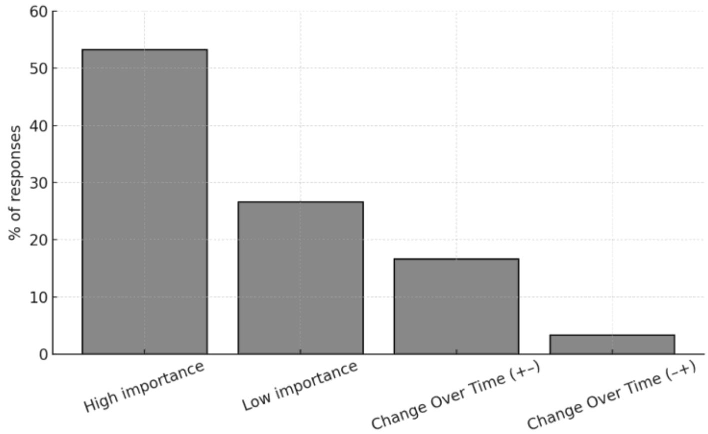
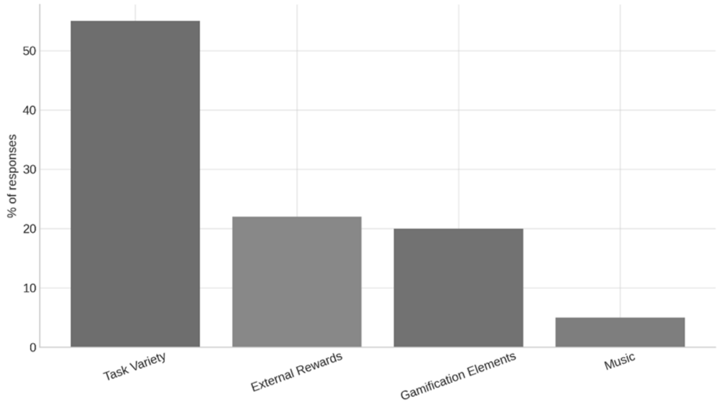


Figure 5 summarises students' preferred strategies to increase motivation (52.6%), led by session dynamics and variety (change exercises, avoid repetition, group by level), followed by external rewards (21.1%) and playful/game-based formats (21.0%), with background music as an in-session booster (5.2%). This emphasis on variety was voiced as "Something more dynamic, more different; it got repetitive" and "More variety; it was very repetitive." (FGx_P01; FGx_P12, translated) Requests for playful formats included "Make the high-intensity part through a sport—turn it into a game" and "I'd like to play a game during HIIT, like dodgeball." (FGx_P05; FGx_P09, translated) Students also proposed extrinsic incentives: "Include a prize for the winner like a sandwich, a field trip, a free day, etc," and "With a prize, I would have tried harder; any reward would do." (FGx_P10; FGx_P14, translated) As a situational enhancer, "Background music would help" captured the role of in-session stimulation. (FGx_P02, translated) A practical note also emerged: "Some heart rate monitors were very big and slipped; we had to tie them", suggesting small equipment adjustments alongside format changes. (FGx_P08, translated).

Figure 5. Preferred Strategies to Increase Motivation in Competitive HIIT



Discussion

This study aimed to examine the effect of a HIIT program with a competitive component compared with non-competitive HIIT and a control group on adolescents' PF. It was hypothesised that the inclusion of a ranking system as a motivational element would lead to significant improvements in physical capacities, particularly cardiorespiratory fitness and strength, compared with the other groups.

These results contradict the initial hypothesis, as the expected significant improvements in physical capacities were not observed in the competitive HIIT group relative to the other groups. Therefore, in this study, competitive HIIT was not an effective strategy for improving PF in any of the variables analysed. Previous studies implementing similar competitive HIIT formats in school contexts have reported benefits primarily in motivation and engagement: team-based challenges, performance comparisons, and reward systems were described as enjoyable and stimulating by adolescents, encouraging greater effort and sustained participation. However, these interventions generally did not result in measurable improvements in physical fitness (Sharp et al., 2020; Weston et al., 2021).

The lack of effectiveness of competitive HIIT in PE classes may be attributed to multiple factors. One of them could be the lack of motivation among students in the competitive group with the ranking system. Following a focus group conducted after the intervention, students reported that they needed additional stimuli beyond the ranking, such as tangible rewards, extra credit toward their course grade, external motivators like music to enhance the sessions, or more variety in the session tasks. Previous studies indicate that when student motivation in PE classes is low, improvements in PF are compromised due to reduced adherence to PA (Liu et al., 2023; Paulino da Silva Bento et al., 2021). Although the ranking system did not prove to be an effective strategy for improving PF, participants reported that they tend to prioritise competitive activities over collaborative ones and extrinsic motivation over intrinsic motivation in PE classes. This distinction between motivational orientations is consistent with the Self-Determination Theory, which conceptualises motivation along a continuum from intrinsic to extrinsic regulation and amotivation (Deci & Ryan, 1985; Ryan & Deci, 2000). These findings underscore the importance of continuing to explore and refine competitive HIIT strategies that are both engaging and motivating for adolescents. The results obtained highlight the need to continue exploring and redesigning competitive HIIT strategies that are engaging and motivating for adolescents.

Moreover, non-competitive HIIT did produce additional improvements in strength and jump performance compared with the control group. Thus, it can be revealed that HIIT remains an effective and highly applicable method in PE classes. Existing literature supports this view, suggesting that the positive effects of non-competitive HIIT can be explained by the physiological mechanisms inherent to this type of training, which promote rapid improvements in cardiorespiratory fitness and muscular strength through alternating periods of intense effort and brief recovery. These adaptations, widely documented in adolescents, support the effectiveness of HIIT as a brief, efficient, and feasible method in the school setting (Duncombe et al., 2022; Kable et al., 2022).

It is also important to highlight the value of school-based PE. The control group, which participated in conventional PE classes, improved in all measured indicators. In some cases, their improvements were greater than those of the HIIT group, although differences between groups were not statistically significant. These results support the idea that PE classes are, by themselves, an effective approach to enhance PF and BMI in adolescents (Peralta et al., 2020; Ramires et al., 2023). This effect may be explained by the fact that regular PA, even in formats less intensive than HIIT, is sufficient to induce positive adaptations in adolescent fitness. The repetition of motor tasks, the improvement of motor competence, and the increase in moderate-to-vigorous PA time during PE classes are key mechanisms for promoting improvements in both cardiorespiratory fitness and muscular strength (Zhong et al., 2024). Moreover, a potential learning effect should be considered, as students might have improved their performance in the post-tests simply due to greater familiarity with the testing procedures rather than actual physiological changes. In addition to a potential learning effect, the improvements observed in the control group may also be explained by the regular content of the PE curriculum. During the intervention period, students continued participating in standard lessons that typically include running-based activities, jumping tasks, and general locomotor skills, all of which are closely related to the components assessed in the fitness tests. Therefore, exposure to these routine PE activities could have contributed to the significant gains observed in the control group, even in the absence of a structured HIIT programme.

Regarding the strengths of the study, the simultaneous comparison of three distinct groups (control, non-competitive HIIT, and competitive HIIT) provides a more comprehensive view of the relative effectiveness of each modality, an aspect that has been underexplored in previous literature. Additionally, data were collected using standardised and validated measures, ensuring methodological consistency. Another strength of this study is its strong ecological validity. The intervention was carried out entirely within real school settings, using the resources available in each centre. All necessary materials were provided to the teachers, who implemented the intervention themselves after receiving specific training. This allowed them to make small adaptations to fit the characteristics and needs of their students, while maintaining the overall structure of the program. Such an approach reinforces the practical applicability and replicability of the findings in authentic educational contexts.

The main limitations of the study were the unequal group sizes, with the competitive HIIT group being the smallest, which may have affected the generalizability of the results. Second, no socioeconomic data were collected from the adolescents' families, which would have provided important context for interpreting the results. Another point to note is that the competitive intervention was relatively short, lasting only 10 weeks, compared with other studies (Bento et al., 2025; Jovanović et al., 2024). Although this may be enough to produce some changes in physical fitness, it might not provide sufficient time for participants to benefit from the learning and motivational aspects of the programme, which often require repeated practice and longer exposure, especially in adolescents. In terms of practical implications, the intervention demonstrated that non-competitive HIIT is a simple and effective tool that works well in the school setting and produces significant improvements in adolescent PF. In contrast, the competitive component, as implemented in this study, did not provide the expected results. The weekly ranking format lacked additional motivational elements, limiting effectiveness. However, qualitative analysis showed that many students expressed a preference for competitive activities and extrinsic motivation over intrinsic motivation. This suggests that the issue does not lie in competition itself, but in how it was designed. Future applications should incorporate more engaging competitive models, integrating gamification elements, tangible or academic rewards, dynamic rankings, music, and greater task variety. In this way, competition could become a more effective tool for increasing adherence and enhancing the benefits of HIIT in school contexts.

Future research should focus on designing more comprehensive and engaging competitive interventions, incorporating gamification, tangible or academic rewards, and greater variability in tasks. Similarly, longer-term studies should be conducted to evaluate not only immediate changes but also the sustainability of effects over the medium and long term. It is also important to consider the context in which programs are implemented, including variables such as rural versus urban settings and socioeconomic factors, which may influence adolescents' responses to these interventions. Finally, differences by sex should be explored, and evaluations should expand to include motivational and psychological indicators to better understand the mechanisms underlying the effectiveness of competitive HIIT in school settings.

Conclusions

The results showed that competitive HIIT, in the ranking format implemented, did not produce significant improvements in PF compared with non-competitive HIIT and traditional PE classes, contradicting the initial hypothesis. In contrast, non-competitive HIIT led to additional improvements in strength and jump performance, confirming its effectiveness and applicability in the school setting. Similarly, traditional PE classes were also effective in enhancing PF, highlighting their value as a setting for promoting health in adolescents.

From an educational perspective, these findings highlight the need to design school-based training experiences that combine physical challenge with engaging motivation. HIIT can be an effective and time-efficient tool for teachers, but competitive elements must be implemented carefully to promote inclusion and engagement. Supporting self-improvement, cooperation, and variety in activities may increase motivation and help consolidate active, lifelong habits through PE.

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