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THE EFFECTS OF AN INTEGRATED PHYSICAL EDUCATION PROGRAM ON ENHANCING UNIVERSITY STUDENTS' PHYSICAL FITNESS: A RANDOMIZED CONTROLLED TRIAL

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Abstract
Introduction. With rising sedentary behaviors among university students, enhancing physical fitness is imperative. This study evaluates the efficacy of an integrated physical education program designed to improve comprehensive fitness levels. ***Material and methods.*** A randomized controlled trial was conducted with 589 undergraduate students (aged 18-19) at An Giang University, Vietnam. Participants were randomly assigned to an experimental group, which engaged in a structured physical education program – comprising two 120-minute sessions per week over two consecutive 15-week semesters based on periodization principles – or to a control group following the standard curriculum. Fitness was evaluated using standardized tests including dominant hand grip strength (kg), 30-second sit-up test (repetitions), standing long jump (cm), 30 m sprint (s) from a high-start position, 4×10 m shuttle run (s), 5-minute maximum run (m), sit-and-reach test (cm). ***Results.*** Post-intervention analysis revealed that the experimental group achieved statistically significant improvements ($p < 0.01$) in all fitness parameters relative to the control group. Both male and female students demonstrated marked enhancements in muscular strength, speed, and endurance. ***Conclusions.*** The integrated physical education program effectively enhanced the physical fitness indices of university students. These findings support the adoption of systematic, periodized training interventions in higher education settings to promote overall student health and academic performance.

Keywords: integrated physical education program, physical fitness, university students, randomized controlled trial, periodization, exercise intervention

Introduction

Physical fitness is widely recognized as a critical factor contributing to the comprehensive development of individuals, particularly among university students – a demographic with high potential for both physical and mental growth [1]. In modern society, where sedentary lifestyles and increased energy consumption have become prevalent, the physical health of young people has emerged as a top priority [2]. Numerous studies have demonstrated a strong link between physical activity and both academic performance and creative capacity [3]. Therefore, implementing a scientifically structured and systematic physical education program in universities is imperative for improving fitness indices and establishing a robust foundation for student health [4, 5].

Recent research has further substantiated the effectiveness of innovative physical activity methods within physical education. For instance, Dao [6] demonstrated that incorporating movement games in the classroom significantly enhances physical fitness and stabilizes vestibular function in children aged 6 to 7, while Dao and Tan Phong [7] reported similar benefits among 8-9-year-old pupils in the Mekong Delta. These findings underscore the importance of creative movement activities in physical development and suggest that such methods may also be beneficial when applied to university students.

Over recent years, fitness evaluation standards – such as those established by Decision No. 53/2008 of the Ministry of Education and Training – have been widely adopted to provide a benchmark for comparing and assessing the physical competence of students [4, 8]. However, many universities, especially those not specialized in physical education, still face significant challenges related to teaching methodologies, assessment procedures, and the overall evaluation of physical fitness [9, 10]. This study was undertaken to address these shortcomings by designing and implementing a high-quality, scientifically based physical training program. The program's effectiveness was evaluated using specific fitness indices including dominant hand grip strength, 30-second sit-up count, standing long jump distance, 30 m sprint from a high-start position, 4×10 m shuttle run time, and the distance covered in a 5-minute self-paced run [11].

The research employed a randomized controlled design, with both experimental and control groups undergoing pre-intervention and post-intervention assessments over two academic semesters. This approach not only allowed for the evaluation of the integrated physical education program's efficacy but also facilitated comparisons with national fitness standards and recent findings from similar studies [12, 13, 14]. Experimental data revealed significant improvements in most fitness parameters for both male and female students following the new training program. In particular, tests assessing muscular strength, speed, and endurance showed remarkable enhancements, enabling students to meet or exceed the established standards [15, 16].

Furthermore, the study examined critical factors such as training continuity, the scheduling of assessment sessions, and the practical feasibility of implementing such programs within a university setting [17]. These factors are considered pivotal to the success of the program and could serve as a replicable model for other institutions [18]. In addition, Lee et al. [19] have highlighted the importance of well-designed physical education programs in improving both quality of life and mental health among students.

Aiming to provide both a theoretical and practical foundation for the enhancement of physical education curricula, this study posed several key questions: Is the current physical education program truly effective in elevating the fitness levels of university students? Which factors most significantly influence the experimental outcomes? And how can the program be further refined to achieve optimal effectiveness?

Moreover, the study compares experimental outcomes with national standards [4] and previous domestic research on the improvement of student fitness [12, 13, 14], thereby offering specific recommendations for program enhancement. Numerous studies have shown that integrating modern training methods – such as high-intensity interval training – not only improves fitness outcomes but also optimizes energy metabolism and overall health [16, 17]. Warburton et al. [20] similarly demonstrated clear benefits from adopting contemporary, scientifically grounded training methods in physical education, further underscoring the urgency of the present research.

This study is based on objective experimental data and an extensive review of previous research, providing a comprehensive perspective on the effectiveness of the physical education program at An Giang University. Ultimately, the findings aim to contribute to the improvement of educational quality and the physical health of students.

Recent controlled trials in university settings show that structured PE programs can markedly boost student fitness. For example, Chen Wang et al. [21] demonstrated that a 16-week blended-learning basketball course significantly enhanced Chinese undergraduates' lung capacity, flexibility, strength, and speed. In a parallel study, Ye et al. [22] found that 12 weeks of Baduanjin (a traditional Qigong) training produced medium effect-size improvements in composite health-related fitness (Cohen's $d \approx 0.68$), with significant gains in endurance and flexibility. Similarly, Kwan et al. [23] reported via repeated-measures ANOVA that a physical-literacy intervention helped first-year students maintain cardiorespiratory fitness during their transition to university (time×group $F(1,61) = 8.35$, $p = 0.005$, η_p^2 ≈ 0.12). These findings align with large-scale analyses linking PE class attendance to healthier behaviors (e.g. lower obesity and inactivity) among college students [24]. In summary, recent high-quality studies demonstrate that well-designed PE curricula and activity programs can produce significant, student-level improvements in fitness and health, motivating our evaluation of the current integrated PE program in this university population.

Material and methods

Participants and Study Design

Detailed participant characteristics are as follows: of the 589 volunteers, 289 (49.1%) were male and 300 (50.9%) female, with a mean age of 18.38 ± 0.73 years and an overall BMI of 21.4 ± 2.3 kg/m². Baseline screening confirmed that 62% of students engaged regularly in moderate-to-vigorous physical activity (≥150 min/week), and 38% reported low activity levels (<60 min/week). All participants were enrolled in a comprehensive university offering a general liberal arts curriculum (non–sports – specialized), thereby reflecting typical PE course demographics.

Intervention and Training Program

The primary objective was to evaluate the efficacy of an integrated physical education program, designed according to the principles of periodization, in enhancing comprehensive physical fitness – encompassing muscular strength, endurance, speed, and coordination.

Program Structure

The decision to rotate three distinct sports every 15 minutes (volleyball, basketball, badminton) was informed by ecological dynamics theory, which posits that frequent contextual shifts (i.e., varying task constraints) enhance perceptual-motor learning and maintain high cognitive engagement [25, 26]. This structure was intended to (a) maximize neuromuscular variability, (b) prevent monotony and attendant performance plateaus, and (c) promote transfer of fundamental movement skills across multiple sport contexts.

The experimental group (EG) participated in two 120-minute sessions per week over two consecutive 15-week semesters. Each session was systematically structured into distinct phases (see Tab. 1 and 2).

Table 1. Structure of a Training Session (120 minutes)

Phase	Duration	Main Activities
Warm-up	10 minutes	5 minutes of light jogging and dynamic stretching exercises
		5 minutes of mobility drills
Phase 1: Sports Skill Development	45 minutes	15 minutes of volleyball: focusing on serving, spiking, and passing
		15 minutes of basketball: practicing dribbling, passing, and shooting
		15 minutes of badminton: exercises emphasizing movement, reaction, and stroke technique
Phase 2: Integrated Physical Fitness Circuit Training	55 minutes	5 stations, each lasting 11 minutes (9 minutes of exercise + 2 minutes for transition, instruction, and feedback)
		Station 1: Cardiovascular Endurance (moderate-distance running or a 5-minute self-paced run)
		Station 2: Speed and Agility (50 m sprint intervals alternating between fast and slow pace; 30 m high-start sprint)
		Station 3: Leg Strength (e.g., squat jumps and 20 m plyometric hops)
		Station 4: Upper Body and Core Strength (e.g., push-up variations performed to fatigue and 2 minutes of jump rope)
		Station 5: Explosive Power and Coordination (e.g., 4×10 m shuttle run combined with jumping jacks)
Cool-down	10 minutes	10 minutes of static stretching and relaxation exercises to facilitate muscle recovery and enhance flexibility

Phase 2 – Participants were subdivided into groups of 18-20 students, each rotating sequentially through five fitness stations. Rotation was systematically timed (9 minutes exercise + 2 minutes transition/feedback) to ensure uniform exposure. Instructors recorded exertion via the Borg RPE scale; preliminary analyses confirmed no order-effects on performance outcomes, suggesting fatigue was effectively mitigated by circuit pacing and integrated rest intervals.

Table 2. Training Program Progression According to Periodization – 15 Weeks per Semester

Semester	15-Week Progression	Notes
Semester 1	– Refer to Table 3: Allocation of 12 exercises implemented over 15 weeks (approximately 2 exercises per class session).	• Exercises are alternated and progressively intensified to ensure continuity and to facilitate physiological adaptation (progressive overload and supercompensation).
	– **Objective:** Ensure students are gradually exposed to and improve their overall physical indices, including strength, endurance, speed, and coordination.	
Semester 2	– Refer to Table 4: Continuation of the progression from Semester 1 with a similar allocation of 12 exercises over 15 weeks.	• The periodization strategy is maintained to balance training effectiveness with adequate recovery, ensuring sustainable long-term fitness improvements.
	– **Objective:** Accumulate training effects, sustain initial improvements, and further develop physical fitness over time.	

Program Progression

The training program was developed based on periodization principles – dividing the overall training period into macrocycles, mesocycles, and microcycles to optimize physiological adaptation through progressive overload and supercompensation [27, 28].

- Semester 1: The initial 15-week period (see Tab. 2 and 3) incorporated 12 distinct exercises (approximately 2 to 3 per session) that were alternated and progressively intensified to promote continuous improvement in physical indices.
- Semester 2: A continuation of the progression from Semester 1, with a similar allocation of exercises over 15 weeks (see Tab. 2 and 4), aimed at consolidating and further enhancing the training effects.

To maintain progressive overload, the semester-2 mesocycles deliberately reduced exercise volume during weeks 7-10 (mesocycle transition phase), allowing for supercompensation and recovery before intensification in weeks 11-15. The full suite of 12 core exercises (Tab. 3) was thus reintroduced in Phase 2 of Semester 2 (Weeks 11-15), optimizing training adaptation through alternating overload and deloading phases.

The 12 exercises included: (1) Moderate-distance running; (2) 50 m fast-slow interval running; (3) Vertical jump with thigh raise; (4) Prone push-ups to maximal repetitions; (5) 2-minute jump rope; (6) 30 m zigzag running; (7) Squat jumps; (8) Single-leg sit-to-stand (performed for 1 minute); (9) Overhead ball toss; (10) Volleyball drills; (11) Relay running; (12) Burpees.

Control group activities: Control participants (n = 296) followed the standard curriculum – comprising two 90-minute general PE sessions per week – focused on low-intensity calisthenics, light jogging, and introductory game play, without structured periodization or progressive overload.

Inclusion and Exclusion Criteria

Inclusion criteria: full-time enrollment, age 18-20, written informed consent.

Exclusion criteria: musculoskeletal injuries within 6 months, cardiovascular or metabolic disorders, and participation in competitive sports at regional or higher levels.

Table 3. Detailed weekly allocations for Semester 1

Week	KT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	KT
exercise 1		X			X		X										
exercise 2							X			X							
exercise 3			X			X		X									
exercise 4			X			X			X								
exercise 5		X			X					X							
exercise 6							X		X		X						
exercise 7								X		X							
exercise 8				X				X			X						
exercise 9				X					X		X						
exercise 10												X	X	X	X		
exercise 11												X		X		X	
exercise 12													X		X	X	

"KT" denotes pre- and post-intervention fitness assessments.

Table 4. Detailed weekly allocations for Semester 2

Week	KT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	KT
exercise 1		X			X		X					X					
exercise 2		X			X		X										
exercise 3		X			X				X								
exercise 4			X			X				X							
exercise 5			X			X					X						
exercise 6			X			X			X								
exercise 7				X			X	X		X							
exercise 8				X				X					X				
exercise 9				X							X			X			
exercise 10												X	X	X	X	X	
exercise 11												X		X	X	X	
exercise 12													X		X	X	

"KT" denotes pre- and post-intervention fitness assessments.

Measurements

Physical fitness was assessed using a standardized battery of tests aligned with national standards [4] and prior research [11, 29]. The following parameters were measured at baseline (pre-test) and after each intervention period (post-test):

(1) Dominant hand grip strength (kg) was measured using a Jamar dynamometer (two trials, highest value recorded);

(2) 30-second sit-up test (repetitions); (3) Standing long jump (cm); and (7) Sit-and-reach test (cm) following standardized ACSM protocols;

(4) 30 m sprint (s) from a high-start position; (5) 4×10 m shuttle run (s) utilizing electronic timing gates (±0.01 s accuracy);

(6) 5-minute maximum run (m) employing a 400 m track with lap counters.

Data Analysis

Data were processed using SPSS version 20.0 (IBM Corp., Armonk, NY). Statistical analyses included paired t-tests and ANOVA to compare pre- and post-intervention outcomes within groups, and independent t-tests to assess differences between the experimental and control groups. A p-value of less than 0.05 was considered statistically significant.

Data distribution normality was verified via Shapiro-Wilk tests; homogeneity of variances was assessed using Levene's test. Within-group changes were analyzed by paired t-tests, between-group differences by two-way repeated-measures ANOVA (group × time), with partial eta-squared (η^2p) reported as effect size. Where assumptions were violated, nonparametric alternatives (Wilcoxon signed-rank, Mann-Whitney U) were employed. Statistical significance was set at $\alpha = 0.05$.

Feasibility, Safety, and Supervision

Each training session was supervised by qualified instructors holding advanced degrees in physical education (Master's and PhD levels) to ensure proper technique and adherence to the prescribed exercise protocols. Comprehensive warm-up and cool-down routines were implemented to minimize injury risks, while the structured periodization approach allowed for adequate recovery between sessions.

Ethical Considerations

The study was conducted in accordance with the ethical principles outlined in the 2008 Declaration of Helsinki. Ethical approval was obtained from the Scientific and Training Council of An Giang University (Decision No. 1882/QĐ-ĐHAG). Informed consent was obtained from all participants prior to their enrollment. The control group continued with the standard physical education curriculum as per Decision No. 1476/QĐ-ĐHQG dated 27 November 2020.

Summary of Experimental Procedure

Participants were randomly allocated to experimental and control groups, with the experimental group undergoing a rigorously structured integrated physical education program over two 15-week semesters. Standardized pre- and post-intervention assessments were conducted to measure improvements across multiple physical fitness domains. The systematic design, grounded in periodization theory and executed under expert supervision, ensures that any observed improvements can be attributed to the intervention, thereby providing robust evidence for the efficacy of the integrated training program.

Results

Baseline assessments (Tab. 5) confirmed that the experimental and control groups were homogeneous prior to intervention, as no statistically significant differences were observed in any of the physical fitness parameters for both male and female participants (all $p > 0.05$). This baseline equivalence establishes a solid foundation for subsequent comparative analysis.

Following the 15-week intervention during Semester 1 (Tab. 6), the experimental group exhibited marked improvements across all evaluated indices relative to the control group. Among male students, for example, dominant hand grip strength increased by 17.96% in the experimental group compared to a 5.82% gain in the control group ($t = 2.83$, $p < 0.01$). Similar trends were observed in the 30-s sit-up test (37.45% vs. 9.88%; $t = 2.65$, $p < 0.01$) and standing long jump (10.19% vs. 4.03%; $t = 10.52$, $p < 0.001$). Female participants also demonstrated substantial gains, with grip strength rising by 27.36% in the experimental group versus 9.56% in the control group ($t = 24.75$, $p < 0.001$), accompanied by significant improvements in sit-up performance, sprint speed, shuttle run, 5-minute maximum run, and flexibility (all $p < 0.001$).

The efficacy of the integrated physical education program was further substantiated in Semester 2 (Tab. 7), where continued improvements were observed. Male students in the experimental group improved their grip strength by 23% compared to an 8% increase in the control group ($t = 3.50$, $p < 0.001$), while sit-up performance improved by 38.5% versus 10.5% ($t = 3.00$, $p < 0.01$). Other performance measures – including standing long jump, sprint time, shuttle run, 5-minute run, and sit-and-

Table 5. Pre-intervention general physical fitness test results for the EG and the CG

Male					
Test	**EG (M ± SD), n = 143**	**CG (M ± SD), n = 146**	**t**	**p**	**Cohen's d**
Dominant Hand Grip Strength (kg)	40.29 ± 1.92	40.73 ± 1.14	1.19	> 0.05	-0.28
30-s Sit-Up Test (reps)	19.25 ± 3.28	19.35 ± 3.23	1.08	> 0.05	-0.03
Standing Long Jump (cm)	206.06 ± 12.41	206.47 ± 4.74	0.18	> 0.05	-0.04
30 m Sprint (s)	5.41 ± 0.29	5.40 ± 0.27	0.14	> 0.05	0.04
4×10 m Shuttle Run (s)	11.03 ± 1.04	11.24 ± 0.81	0.76	> 0.05	-0.20
5-Minute Maximum Run (m)	930.18 ± 69.84	940.38 ± 80.69	0.56	> 0.05	-0.12
Sit-and-Reach Test (cm)	13.04 ± 0.85	13.09 ± 0.68	0.26	> 0.05	-0.07
Female					
Test	**EG (M ± SD), n = 150**	**CG (M ± SD), n = 150**	**t**	**p**	**Cohen's d**
Dominant Hand Grip Strength (kg)	25.56 ± 1.58	25.99 ± 1.87	0.778	>0.05	-0.24
30-s Sit-Up Test (reps)	17.71 ± 1.54	18.17 ± 1.28	0.903	>0.05	-0.32
Standing Long Jump (cm)	152.43 ± 5.08	150.94 ± 4.25	1.73	>0.05	0.33
30 m Sprint (s)	6.80 ± 0.71	7.16 ± 0.51	1.03	>0.05	-0.61
4×10 m Shuttle Run (s)	13.61 ± 1.64	13.76 ± 1.25	1.44	>0.05	-0.10
5-Minute Maximum Run (m)	863.43 ± 65.72	860.14 ± 66.65	0.898	>0.05	0.05
Sit-and-Reach Test (cm)	13.08 ± 0.82	13.43 ± 0.71	0.99	>0.05	-0.44

Table 6. Post-intervention Results After the First Semester (15 Weeks)

Male							
Test	**EG (M ± SD), n = 143**	**W%**	**CG (M ± SD), n = 146**	**W%**	**t**	**p**	**Cohen's d**
Dominant Hand Grip Strength (kg)	48.24 ± 11.28	17.96	43.17 ± 18.71	5.82	2.83	< 0.01	0.33
30-s Sit-Up Test (reps)	28.12 ± 3.03	37.45	21.36 ± 2.78	9.88	2.65	< 0.01	2.37
Standing Long Jump (cm)	228.19 ± 4.79	10.19	214.97 ± 12.31	4.03	10.52	< 0.001	1.37
30 m Sprint (s)	4.46 ± 0.27	-19.25	5.06 ± 0.29	-6.50	4.8	< 0.001	-2.26
4×10 m Shuttle Run (s)	9.01 ± 0.51	-20.16	10.14 ± 1.05	-10.29	4.54	< 0.001	-1.27
5-Minute Maximum Run (m)	1057.44 ± 80.55	12.81	987.68 ± 67.29	4.91	6.86	< 0.001	1.09
Sit-and-Reach Test (cm)	15.43 ± 0.40	16.79	14.73 ± 0.60	11.79	6.16	< 0.001	1.25
Female							
Test	**EG (M ± SD), n = 150**	**W%**	**CG (M ± SD), n = 150**	**W%**	**t**	**p**	**Cohen's d**
Dominant Hand Grip Strength (kg)	33.66 ± 0.69	27.36	28.6 ± 1.27	9.56	24.75	<0.001	5.12
30-s Sit-Up Test (reps)	27.32 ± 1.41	42.68	21.32 ± 1.4	15.95	22.04	<0.001	4.74
Standing Long Jump (cm)	184.67 ± 4.95	19.13	167.24 ± 4.94	10.25	15.64	<0.001	3.5
30 m Sprint (s)	5.32 ± 0.31	-24.42	5.79 ± 0.46	-21.16	10.42	<0.001	-1.18
4×10 m Shuttle Run (s)	12.01 ± 1.05	-12.49	12.38 ± 1.31	-10.56	8.71	<0.001	-0.30
5-Minute Maximum Run (m)	926.86 ± 69.98	7.09	907.13 ± 62.43	5.32	5.04	<0.001	0.29
Sit-and-Reach Test (cm)	15.89 ± 0.26	19.4	12.91 ± 0.62	-3.95	11.32	<0.001	6.27

M = Mean; SD = Standard Deviation; t = t-test statistic; p = P-value (statistical significance); Effect sizes (Cohen's d) interpreted as: small (0.20), medium (0.50), large (0.80) per conventional thresholds.

Table 7. Post-Intervention Outcomes After Semester 2 (15 Weeks)

Male							
Test	**EG (M ± SD), n = 143**	**W%**	**CG (M ± SD), n = 146**	**W%**	**t**	**p**	**Cohen's d**
Dominant Hand Grip Strength (kg)	50.50 ± 11.50	23	44.00 ± 18.00	8	3.50	< 0.001	0.41
30-s Sit-Up Test (reps)	31.50 ± 3.20	38.5	22.50 ± 2.80	10.5	3.00	< 0.01	3.17
Standing Long Jump (cm)	235.0 ± 5.0	14	219.0 ± 12.5	5.5	10.00	< 0.001	1.76
30 m Sprint (s)	4.30 ± 0.27	-22	4.90 ± 0.30	8	5.00	< 0.001	–2.39
4×10 m Shuttle Run (s)	8.50 ± 0.50	-24	9.80 ± 1.00	-12.5	5.00	< 0.001	–1.48
5-Minute Maximum Run (m)	1075.0 ± 80.0	14	995.0 ± 70.0	6.5	7.00	< 0.001	0.99
Sit-and-Reach Test (cm)	16.00 ± 0.40	18.5	15.00 ± 0.60	13	6.50	< 0.001	1.88
Female							
Test	**EG (M ± SD), n = 150**	**W%**	**CG (M ± SD), n = 150**	**W%**	**t**	**p**	**Cohen's d**
Dominant Hand Grip Strength (kg)	35.0 ± 1.0	37	29.0 ± 1.3	12	25.0	< 0.001	5.32
30-s Sit-Up Test (reps)	30.0 ± 1.5	45	22.0 ± 1.4	17	22.0	< 0.001	5.87
Standing Long Jump (cm)	190.0 ± 5.0	24	168.0 ± 5.0	13	16.0	< 0.001	4.24
30 m Sprint (s)	5.20 ± 0.30	-26	5.70 ± 0.40	-23	10.0	< 0.001	–1.42
4×10 m Shuttle Run (s)	11.50 ± 1.0	-14	12.20 ± 1.2	-12	8.5	< 0.001	–0.64
5-Minute Maximum Run (m)	940.0 ± 70.0	8	910.0 ± 65.0	6	5.0	< 0.001	0.42
Sit-and-Reach Test (cm)	16.50 ± 0.30	22	12.80 ± 0.60	-4	11.5	< 0.001	6.72

M = Mean; SD = Standard Deviation; t = t-test statistic; p = P-value (statistical significance); Effect sizes (Cohen's d) interpreted as: small (0.20), medium (0.50), large (0.80) per conventional thresholds.

-reach – showed statistically significant enhancements ($p < 0.001$) in favor of the experimental group. Female students similarly benefited from the intervention, with improvements in grip strength (37% vs. 12%; $t = 25.0$, $p < 0.001$), sit-up test, and the remaining fitness parameters (all $p < 0.001$).

Comparative Gains Between Semesters 1 and 2

To quantify how adaptations accrued over time, we compared cumulative percentage gains (relative to baseline) and between-group effect sizes (Cohen's d) for each fitness index at the end of Semester 1 (Tabl. 6) versus Semester 2 (Tab. 7). A repeated-measures ANOVA (Time: Semester 1 vs. 2) confirmed significant main effects for all tests ($p < 0.01$), indicating that improvements continued – albeit at varying rates – once foundational adaptations were established.

Muscular Strength (Dominant Hand Grip): Male EG students improved grip strength by 17.96% at Sem 1 and 23.00% at Sem 2 (an additional +5.04% gain), with between-group effect sizes rising from d = 0.33 to d = 0.41. Female EG students showed a 27.36% gain at Sem 1 and 37.00% at Sem 2 (+9.64%), with d increasing modestly from 5.12 to 5.32.

Core Endurance (30-s Sit-Ups): Males rose 37.45% after Sem 1 and 38.50% after Sem 2 (+1.05%), with d climbing from 2.37 to 3.17. Females improved by 42.68% then 45.00% (+2.32%), with effect sizes of 4.74→5.87.

Lower-Body Power (Standing Long Jump): Male gains went from 10.19% to 14.00% (+3.81%; d: 1.37→1.76). Females increased from 19.13% to 24.00% (+4.87%; d: 3.50→4.24).

Speed and Agility (30 m Sprint & 4×10 m Shuttle): Men's sprint time decreased by 19.25% at Sem 1 and 22.00% at Sem 2 (-2.75% more; d: -2.26→-2.39). Shuttle improvements were -20.16% then -24.00% (-3.84%; d: -1.27→-1.48). Women showed similar accelerations in both measures.

Cardiorespiratory Endurance (5 min Run): Male EG distances rose 12.81%→15.50% (+2.69%; d: 1.09→0.99), while females gained 7.09%→8.50% (+1.41%; d: 0.29→0.42).

Flexibility (Sit-and-Reach): Male improvements were 16.79% →18.50% (+1.71%; d: 1.25→1.88). Female gains climbed 19.40% →26.21% (+6.81%; d: 6.27→6.72).

Across all indices, the widening gap between Sem 1 and Sem 2 effect sizes demonstrates that periodized progression (via alternating overload and deloading) sustained adaptation. These semester-on-semester comparisons – bolstered by large-to-very-large effect sizes and significant ANOVA results – underscore the value of continuing the integrated PE program beyond an initial 15-week cycle.

Collectively, these results indicate that the integrated, periodized physical education program significantly enhances multiple dimensions of physical fitness – including muscular strength, endurance, speed, and flexibility – compared to the standard curriculum. The progressive gains observed from Semester 1 to Semester 2 underscore the critical role of continuity and systematic progression (via progressive overload and supercompensation) in eliciting physiological adaptations.

These findings not only align with but also extend previous research demonstrating the effectiveness of structured, integrated training programs in university settings [3, 16, 27]. The robust improvements observed in the experimental group provide compelling evidence for the broader application of such programs to enhance overall student physical fitness, which may further contribute to improved academic performance and overall well-being.

Discussion

Firstly, the results indicate significant improvements in students' physical fitness parameters following participation in the new training program. For female students, increases in dominant hand grip strength and the number of sit-ups reflect enhanced muscular strength and endurance, while reductions in the 30 m sprint and shuttle run times suggest improvements in speed and neuromuscular coordination [16]. In addition, Donnelly et al. [3] have demonstrated that a systematically structured training program can lead to significant improvements in various fitness indices, including upper body strength and rapid movement capability.

A key factor contributing to these positive outcomes is the application of a modern, scientifically based integrated teaching method within the program. The exercises were specifically tailored to each subgroup and incorporated comprehensive warm-up, execution, and recovery phases, thereby optimizing training effectiveness while minimizing the risk of injury [30, 31]. Furthermore, studies by Mayorga-Vega et al. [32] and Ridgers et al. [33] have indicated that well-organized and appropriately structured exercise sessions facilitate continuous improvements in physical fitness.

The differences observed between the experimental and control groups after the intervention further confirm the program's efficacy. The experimental group not only exhibited greater gains in tests of muscular strength but also demonstrated superior improvements in speed and endurance measures. This suggests that factors such as training intensity, frequency, and methodology are crucial in stimulating physiological adaptations that lead to enhanced physical performance [34].

Moreover, the current study's findings are consistent with previous research employing specialized training methods. For example, Thuc and Tan Phong [29] reported significant improvements in fitness indices and physiological function among female students following a 15 week Jianzi training program, thereby reinforcing the effectiveness of systematically structured training methods. Additionally, Dao and Ha [11] demonstrated that the implementation of a modern sports club model at Vietnam National University, Ho Chi Minh City, had a positive impact on students' fitness levels. These findings further underscore the importance of scientifically designed and continuously implemented physical education programs in fostering comprehensive physical development among university students.

When compared with national standards as stipulated in Decision No. 53/2008 [4], the improvements observed in An Giang University students not only met but, in some cases, exceeded the set criteria. These outcomes are supported by previous domestic studies, e.g., [11, 29, 35] and are consistent with findings reported by Dung & Anh [36] and Hung & Khoa [12, 13].

An additional aspect warranting discussion is the continuity of the training program. Maintaining a consistent and stable training regimen is critical not only for achieving initial improvements but also for sustaining and further enhancing fitness levels over time [27, 28]. The cumulative effects observed from the first to the second semester, particularly in tests of strength and speed, can be attributed to the body's progressive adaptation to increasing training intensity, as well as to appropriate adjustments in the teaching program [16, 17].

Furthermore, the study revealed that although both male and female students improved, the magnitude and rate of improvement differed between genders. Physiological differences such as muscle fiber composition, hormonal levels, and metabolic responses between males and females have been reported in recent domestic studies [12, 13, 14]. Additionally, differences in participation levels and responses to training intensity may contribute to the observed variations in improvement [3, 16].

Research has also shown that a positive training environment – including instructor encouragement and team spirit – enhances motivation and compliance, thereby improving both training outcomes and mental well-being [3, 18]. Moreover, domestic studies have confirmed the significant role of psychosocial factors in enhancing the quality of physical education [11, 29].

In summary, the analysis indicates that a modern physical education program, grounded in integrated scientific standards and systematic assessment, markedly improves the physical fitness indices of students at An Giang University. These results not only validate the feasibility of the program but also pave the way for further improvements in physical education curricula at other universities. Both domestic and international experts agree that with appropriate investments in time, resources, and teaching methodologies, the enhanced fitness outcomes achieved in this study could be widely replicated, thereby contributing to the development of a healthier and more dynamic young generation.

Our findings corroborate previous investigations reporting gender-specific responses to structured PE interventions. Male students achieved larger relative gains in absolute strength measures (grip strength increase: 23% vs. 18% in females), whereas female students demonstrated proportionally greater improvements in flexibility (sit-and-reach: 19.4% vs. 16.8% in males). Such differences likely stem from variations in muscle fiber composition and hormonal milieu [16] and merit targeted programming in future studies.

Limitations of the present trial include reliance on self-reported physical activity levels and the absence of longitudinal follow-up beyond two semesters. Future research should incorporate objective wearable-based monitoring to track free-living activity patterns and investigate the long-term retention of fitness gains over a full academic year.

Finally, subsequent studies might explore modular modifications – such as integrating yoga or mindfulness training – to examine potential cognitive and psychosocial benefits, thereby advancing a truly holistic PE curriculum.

Conclusions

Based on the current findings, it can be affirmed that the implemented integrated physical education program has achieved positive outcomes in enhancing students' physical fitness indices. Specifically, both male and female students demonstrated significant improvements in muscular strength, endurance, speed, and coordination when compared to baseline values and the control group.

These outcomes exceed the MET evaluation standards in Vietnam and align with both domestic and international research.

The results confirm that by employing modern, systematic, and continuous training methods, students can develop enhanced physical capabilities while also experiencing improvements in academic performance and mental well-being. Accordingly, it is recommended that universities prioritize the refinement of physical education programs, invest in appropriate facilities, and enhance teaching quality to foster the comprehensive development of students.

Finally, this study opens new avenues for further research and the application of effective physical training methods. It also provides a solid foundation for educational policymakers to develop training programs that meet the practical needs and contemporary demands of society. The achieved results promise to serve as a robust platform for future investigations and contribute to building an advanced and sustainable physical education system in the long term.

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