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Effects of concurrent aerobic–anaerobic conditioning on aerobic capacity, anaerobic performance, and body composition in university basketball players: a randomized controlled trial

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Abstract

Background and Study Aim Basketball performance depends on the effective development of both aerobic and anaerobic capacities. Conditioning programs that combine aerobic and anaerobic training are commonly used to improve physical fitness, performance, and body composition in basketball players. Although these approaches are widely applied in practice, their effectiveness in enhancing multiple performance-related outcomes remains of practical interest. This study investigated the effects of an eight-week aerobic–anaerobic conditioning program on aerobic fitness, anaerobic performance, and body composition in university-level basketball players.

Material and Methods This study employed a randomized controlled trial design. Thirty-four male university basketball players (18–25 years) were randomly assigned to an experimental group (n = 17) or a control group (n = 17). In addition to regular basketball training, the experimental group completed a structured aerobic–anaerobic conditioning program three times per week, while the control group continued standard training only.

Results Outcome measures included estimated maximal oxygen uptake (VO_2max), maximal aerobic speed, time to exhaustion, heart rate recovery, repeated sprint ability, countermovement jump (CMJ), peak anaerobic power, and body composition. Data were analyzed using mixed-design ANOVA (group × time). Significant group × time interactions ($p < 0.05$) were observed for all performance variables. The experimental group showed improvements in estimated VO_2max (+5.8%), maximal aerobic speed (+4.9%), time to exhaustion (+11.6%), and heart rate recovery (+17.6%). Anaerobic performance also improved, reflected by reductions in repeated sprint time (−4.8%) and fatigue index (−18.2%), alongside increases in CMJ height (+9.1%) and peak anaerobic power (+7.9%). Body fat percentage decreased (−7.7%), while fat-free mass increased (+1.7%). No significant differences were observed between playing positions ($p > 0.05$).

Conclusions An eight-week aerobic–anaerobic conditioning program appears to be an effective approach for improving multiple aspects of performance in university basketball players. The findings support the use of integrated conditioning strategies in both sports training and physical education settings.

Keywords: aerobic fitness, anaerobic performance, neuromuscular performance, concurrent training, student athletes, physical education

Introduction

Basketball is a team sport characterized by frequent transitions between high- and low-intensity activities during training and competition. These demands require players to perform repeated sprints, jumps, accelerations, decelerations, and changes of direction while maintaining performance throughout a match. The combination of aerobic and anaerobic efforts creates diverse physiological demands that influence physical performance and recovery responses. As a result, the development of physical fitness in basketball involves the simultaneous adaptation of multiple performance-related capacities.

Basketball is commonly considered an intermittent, high-intensity team sport that consists of explosive movements interspersed with brief periods of lower-intensity activity. Players regularly perform sprints, jumps, accelerations, decelerations, and rapid changes of direction during competition. They are also frequently exposed to physical contact and tactical uncertainty [1]. These demands place considerable stress on multiple physiological systems and require the combined contribution of different energy pathways.

Although many high-intensity movements rely primarily on anaerobic energy production, overall match performance is also influenced by aerobic capacity [2]. Adequate aerobic fitness enables players to maintain work rate, recover more efficiently between repeated efforts, and sustain neuromuscular and technical performance throughout the game. Therefore, basketball performance cannot be attributed to a single energy system but rather reflects a dynamic interaction

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between aerobic and anaerobic pathways [3].

Time-motion analysis also suggests that players are repeatedly exposed to high-intensity work with minimal recovery periods. The ability to maintain performance under these demands may contribute to competitive success, particularly at higher levels of competition [4].

From a tactical perspective, players are commonly classified as perimeter or post players, with each position involving different functional roles. Perimeter players more frequently perform high-speed running, changes of direction, and rapid transitions. These activities place greater emphasis on aerobic capacity and repeated sprint ability. In contrast, post players operate closer to the basket, where physical contact, rebounding, and screening require greater muscular power and anaerobic effort [5, 6].

In addition to physiological demands, anthropometric characteristics are associated with basketball performance. Body height, body mass, limb length, and body composition influence playing positions and functional roles. Although larger body size may be advantageous in activities such as rebounding and defensive play, excessive body mass or body fat may negatively affect speed, agility, and repeated sprint performance [7, 8]. Body composition is also associated with movement efficiency and force production.

Aerobic capacity is one of the factors associated with performance in intermittent sports. Players with higher aerobic fitness typically demonstrate faster recovery between high-intensity efforts, greater resistance to fatigue, and a greater ability to maintain technical performance over time [9]. Therefore, measures such as maximal oxygen uptake (VO_2max), maximal aerobic speed, and heart rate recovery are widely used to assess an athlete's physiological preparedness for the demands of competition [10]. In addition, physical capacities have been shown to vary according to biological maturation, indicating that physiological characteristics may influence performance-related outcomes in young athletes [11]. Performance may also be affected by exercise-induced muscle damage, which has been associated with temporary reductions in physical test outcomes among elite basketball players [12].

Analysis of previous research has shown that aerobic fitness, anaerobic performance, and body composition are associated with basketball performance and the ability to meet the physiological demands of competition. Researchers emphasize that these factors interact and collectively influence physical performance, recovery, and the execution of sport-specific actions. At the same time, the interpretation of training-related adaptations remains challenging because physical fitness encompasses multiple domains that may respond differently to conditioning programs, while positional roles may influence both performance characteristics and training responses. A more comprehensive evaluation of these factors may provide additional evidence regarding the outcomes associated with integrated conditioning approaches in university basketball players.

The aim of this study was to examine the effects of an eight-week aerobic–anaerobic conditioning program on aerobic fitness, anaerobic performance, and body composition in university-level basketball players. In addition, differences in training adaptations between perimeter and post players were evaluated.

It was hypothesized that the experimental group would demonstrate greater improvements in aerobic fitness, anaerobic performance, and body composition than the control group. It was also hypothesized that training-induced adaptations would not differ significantly between playing positions.

Materials and Methods

Participants

Thirty-four (N = 34) male university basketball players aged 18 to 25 years, with at least three years of competitive experience, participated in the study. The participants were randomly assigned to either an experimental group (EXP) or a control group (CG) using a computer-generated randomization sequence. Each group consisted of 17 participants. Players were classified as perimeter or post players based on their roles on the court. All participants were healthy, engaged in regular training, and had no history of recent injury or clinically diagnosed conditions that could influence performance.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical guidelines of the Institutional Research Ethics Committee of Hindustan Institute of Technology and Science, Chennai, Tamil Nadu, India (HITS/CRC/004/24SR923003). Written informed consent was obtained from all participants prior to their participation in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki (2013 revision).

Study Design

The effects of a structured supplementary aerobic–anaerobic conditioning intervention on anthropometric, aerobic, and anaerobic variables were evaluated using a randomized controlled pre-test/post-test design in a cohort of university-level basketball players. Baseline and post-intervention measurements were performed under standardized conditions before and after the eight-week intervention period. The main variables included in the analysis were group (experimental vs. control) and time (pre- vs. post-intervention), with playing position (perimeter vs. post) included as an additional between-subject factor. Outcome measures included anthropometric characteristics, aerobic capacity, and anaerobic performance.

Intervention Protocol

Ecological validity was maintained by conducting the intervention during an eight-week competitive season period. Throughout the study, both groups continued their regular basketball training. In addition, the experimental group participated in a structured supplementary conditioning program performed three times per week, with sessions lasting approximately 40–50 minutes and scheduled on non-consecutive days.

The training program combined moderate-to-vigorous aerobic exercise with anaerobic activities, including repeated sprints, shuttle runs, and basketball-specific explosive movements. Training load was progressively increased throughout the intervention through systematic adjustments in intensity, volume, and repetitions. All sessions were supervised by strength and conditioning professionals to ensure adherence to the protocol.

In contrast, the control group continued its regular basketball training, which consisted of technical drills, tactical exercises, and scrimmage play without additional organized conditioning training. The progression of the aerobic–anaerobic conditioning program is presented in Table 1.

Training, Monitoring, and Compliance

Attendance was recorded for all training sessions, and only participants who achieved at least 90% attendance were included in the final analysis. Exercise intensity during the conditioning sessions was monitored using the Borg Rating of Perceived Exertion (RPE) scale [13], with target values ranging from 13 to 17 to ensure that training was performed within the prescribed intensity range. No injuries or adverse events were reported during the intervention period.

All outcome measures were assessed before and after the intervention under standardized testing conditions. To minimize the effects of diurnal variation, all assessments were conducted at the same time of day for each participant. Participants were instructed to refrain from strenuous physical activity for at least 24 hours before testing. The assessment battery included anthropometric measurements, measures of aerobic capacity, and measures of anaerobic performance, as presented in Table 2.

Anthropometric Assessment

Anthropometric measurements were performed using standardized procedures. Stature was measured to the nearest 0.1 cm using a calibrated stadiometer, and body mass was measured to the nearest 0.1 kg using a digital scale. Body fat percentage was estimated from skinfold measurements taken at standardized anatomical sites, and fat-free mass was derived from body composition assessment. Segmental girths were measured using a non-elastic anthropometric tape. To ensure measurement consistency, all assessments were conducted by the same trained investigator, thereby reducing inter-observer variability [14].

Aerobic Capacity Assessment

Aerobic capacity was assessed using a standardized incremental running test performed on a synthetic surface until volitional exhaustion. Estimated maximal oxygen uptake (VO_2max), maximal aerobic speed, and time to exhaustion were derived from test performance. Heart rate was

Table 1. Eight-week aerobic–anaerobic conditioning program (experimental group)

Week	Frequency (sessions/ week)	Session Duration (min)	Aerobic Component	Anaerobic Component	Intensity (RPE)	Work-to-Rest Ratio	Progression Focus
1–2	3	40	Continuous running/tempo drills	Basic sprint drills (10–20 m), low-intensity jumps	12–13	1:2	Technique familiarization, low volume
3–4	3	40–45	Interval running (short bouts)	Repeated sprints (20–30 m), shuttle runs	13–14	1:2 to 1:1.5	Gradual increase in volume and intensity
5–6	3	45	Intermittent aerobic intervals	Repeated sprint ability drills, multidirectional movements	14–15	1:1.5 to 1:1	Increased training density and reduced recovery
7	3	45–50	High-intensity intermittent running	Explosive drills (plyometrics, bounding), RSA circuits	15–16	1:1	High-intensity workload and sport-specific activities
8	3	45–50	Mixed aerobic intervals (variable pace)	Combined sprint and jump circuits, game-specific drills	16–17	1:1	Peak training load and performance integration

Note. Exercise selection included repeated sprint drills, shuttle runs, plyometric exercises, and basketball-specific movement patterns.

Table 2. Testing Battery and Outcome Measures

Domain	Variable	Test / Method	Unit	Assessment
Anthropometry	Stature	Stadiometer	cm	Pre & Post
	Body mass	Digital scale	kg	Pre & Post
	Body fat (%)	Skinfold assessment	%	Pre & Post
	Fat-free mass	Derived	kg	Pre & Post
	Segmental girths	Anthropometric tape	cm	Pre & Post
Aerobic Capacity	VO_2max (estimated)	Incremental running test	$ml\cdot kg^{-1}\cdot min^{-1}$	Pre & Post
	Maximal aerobic speed	Incremental running test	$km\cdot h^{-1}$	Pre & Post
	Time to exhaustion	Incremental running test	min	Pre & Post
	Heart rate recovery (1 min)	Heart rate monitor	bpm	Pre & Post
Anaerobic Performance	Repeated sprint time	Repeated sprint test	s	Pre & Post
	Sprint fatigue index	Derived	%	Pre & Post
	Countermovement jump (CMJ)	Vertical jump test	cm	Pre & Post
	Peak anaerobic power	Derived from CMJ	W	Pre & Post

continuously monitored throughout the test using a validated heart rate monitoring device. Heart rate recovery was assessed one minute after exercise as an indicator of autonomic function [15].

Anaerobic Performance Assessment

Anaerobic performance was assessed using field-based tests designed to reflect the physical demands of basketball. Repeated sprint ability was evaluated using a standardized repeated sprint protocol, from which total sprint time and fatigue index were calculated. The fatigue index was derived from repeated sprint test performance. Lower-body explosive power was assessed using the countermovement jump (CMJ) test. Participants performed three maximal jumps, and the highest value was retained for analysis. Peak anaerobic power was calculated from CMJ performance using predictive equations based on jump height and body mass. Adequate recovery was provided between trials to minimize the effects of fatigue [16].

Statistical Analysis

Statistical analyses were performed using SPSS (Version 26.0; IBM Corp., Armonk, NY, USA). Data are presented as mean ± standard deviation (SD). The Shapiro-Wilk test and Levene's test were used to assess the assumptions of normality and homogeneity of variance, respectively. An a priori sample size estimation was conducted using G*Power (Version 3.1; Heinrich Heine University Düsseldorf, Germany) with an assumed moderate effect size ($f = 0.25$), statistical power of 0.80, and an alpha level of 0.05, confirming the adequacy of the sample size. A 2 × 2 × 2 mixed-design analysis of variance (ANOVA) (group × time × position) was used to evaluate intervention effects, with Bonferroni-adjusted pairwise comparisons applied where appropriate. Effect sizes were calculated using partial eta squared (η^2p) and interpreted as small (0.01), medium (0.06), and large (⩾ 0.14). Percentage changes and mean differences with 95% confidence intervals (CI) were calculated to aid interpretation. Statistical significance was set at $p < 0.05$.

Results

Baseline comparisons showed no significant differences between groups, indicating initial group homogeneity. The mixed-design ANOVA revealed significant Group × Time interactions for key performance and body composition variables, indicating an effect of the conditioning intervention. No significant Group × Time × Position interactions were observed, suggesting similar training adaptations across playing positions. Baseline characteristics of the experimental (EXP) and control (CG) groups are presented in Table 3.

Table 3 provides descriptive statistics for the baseline characteristics of the experimental (EXP) and control (CG) groups. No statistically significant between-group differences were observed for age, training experience, anthropometric characteristics, aerobic capacity, or anaerobic performance measures (all $p > 0.05$), indicating comparable baseline conditions between groups.

Anthropometric changes following the intervention are presented in Table 4. Table 4 shows the changes in anthropometric variables following the intervention. Significant Group × Time interactions were observed for body composition measures and thigh girth. Bonferroni-adjusted pairwise comparisons indicated significant changes in the experimental group, whereas no significant changes were observed in the control group. No significant Group × Time × Position interactions were detected (all $p > 0.05$), suggesting similar anthropometric responses across playing positions.

Changes in aerobic and anaerobic performance outcomes measured before and after the intervention are presented in Table 5. The table reports pre- and post-intervention values, percentage changes, mean differences, and interaction effects for the experimental and control groups.

Table 3. Baseline Characteristics of Experimental and Control Groups

Variable	EXP (n = 17)	CG (n = 17)	F (1,32)	p
Age (years)	21.1 ± 1.3	20.9 ± 1.4	0.25	0.62
Training experience (years)	6.1 ± 1.5	5.9 ± 1.6	0.14	0.71
Height (cm)	182.6 ± 6.8	181.9 ± 7.1	0.11	0.74
Body mass (kg)	77.9 ± 8.5	78.3 ± 9.1	0.02	0.88
Body fat (%)	14.2 ± 3.1	14.5 ± 2.9	0.16	0.69
VO_2max (estimated) ($ml \cdot kg^{-1} \cdot min^{-1}$)	53.8 ± 4.6	54.1 ± 4.9	0.06	0.81
CMJ height (cm)	51.6 ± 5.8	51.9 ± 6.1	0.02	0.90

Note: Values are presented as mean ± SD. No significant baseline differences were observed ($p > 0.05$).

Table 4. Anthropometric changes following the intervention

Variable	Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	% Change	Mean Difference (95% CI)	F (1,32)	p	η^2p
Body mass (kg)	EXP	78.0 ± 8.4	77.2 ± 8.1	−1.0%	−0.80 (−1.52 to −0.08)	4.52	0.04*	0.16
	CG	78.3 ± 9.1	78.4 ± 9.0	+0.1%	—	—	—	—
Body fat (%)	EXP	14.2 ± 3.1	13.1 ± 2.8	−7.7%	−1.10 (−1.89 to −0.31)	7.83	0.01*	0.21
	CG	14.5 ± 2.9	14.6 ± 3.0	+0.7%	—	—	—	—
Fat-free mass (kg)	EXP	66.3 ± 5.9	67.4 ± 6.1	+1.7%	+1.10 (0.18 to 2.02)	6.12	0.02*	0.18
	CG	66.1 ± 6.2	66.0 ± 6.3	−0.2%	—	—	—	—
Thigh girth (cm)	EXP	56.1 ± 3.8	56.9 ± 3.9	+1.4%	+0.80 (0.07 to 1.53)	4.96	0.03*	0.15
	CG	56.3 ± 4.1	56.2 ± 4.0	−0.2%	—	—	—	—

Note: Values are mean ± SD. G×T = Group × Time interaction. $p < 0.05$.

Table 5. Pre- and post-intervention changes in aerobic and anaerobic performance variables

Variable	Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	% Change	Mean Difference (95% CI)	F (1,32)	p	η^2p
Aerobic Capacity								
VO_2max (estimated) ($ml \cdot kg^{-1} \cdot min^{-1}$)	EXP	53.8 ± 4.6	56.9 ± 4.8	+5.8%	+3.10 (1.62 to 4.58)	16.82	<0.001*	0.34
	CG	54.1 ± 4.9	54.3 ± 5.0	+0.4%	—	—	—	—
Maximal aerobic speed ($km \cdot h^{-1}$)	EXP	16.4 ± 1.2	17.2 ± 1.3	+4.9%	+0.80 (0.28 to 1.32)	12.44	0.002*	0.29
	CG	16.5 ± 1.3	16.6 ± 1.4	+0.6%	—	—	—	—
Time to exhaustion (min)	EXP	12.9 ± 1.9	14.4 ± 2.1	+11.6%	+1.50 (0.72 to 2.48)	14.21	0.001*	0.31
	CG	13.1 ± 2.0	13.0 ± 2.1	−0.8%	—	—	—	—
HR recovery (bpm)	EXP	31.8 ± 5.6	37.4 ± 6.2	+17.6%	+5.60 (3.21 to 7.79)	18.09	<0.001*	0.36
	CG	32.1 ± 5.9	32.4 ± 6.0	+0.9%	—	—	—	—
Anaerobic Performance								
Repeated sprint time (s)	EXP	43.6 ± 2.4	41.5 ± 2.2	−4.8%	−2.10 (−3.21 to −1.09)	15.76	<0.001*	0.33
	CG	43.8 ± 2.6	43.7 ± 2.5	−0.2%	—	—	—	—
Sprint fatigue index (%)	EXP	6.6 ± 1.4	5.4 ± 1.2	−18.2%	−1.20 (−1.92 to −0.48)	10.98	0.002*	0.27
	CG	6.7 ± 1.5	6.8 ± 1.6	+1.5%	—	—	—	—
CMJ height (cm)	EXP	51.6 ± 5.8	56.3 ± 6.1	+9.1%	+4.70 (2.41 to 6.99)	19.44	<0.001*	0.38
	CG	51.9 ± 6.1	52.1 ± 6.2	+0.4%	—	—	—	—
Peak anaerobic power (W)	EXP	5210 ± 590	5620 ± 610	+7.9%	+410 (210 to 610)	17.31	<0.001*	0.35
	CG	5190 ± 610	5205 ± 620	+0.3%	—	—	—	—

Note: Values are mean ± SD. % change calculated from pre- to post-test in the EXP group. CI = confidence interval. η^2p = partial eta squared. *$p < 0.05$.

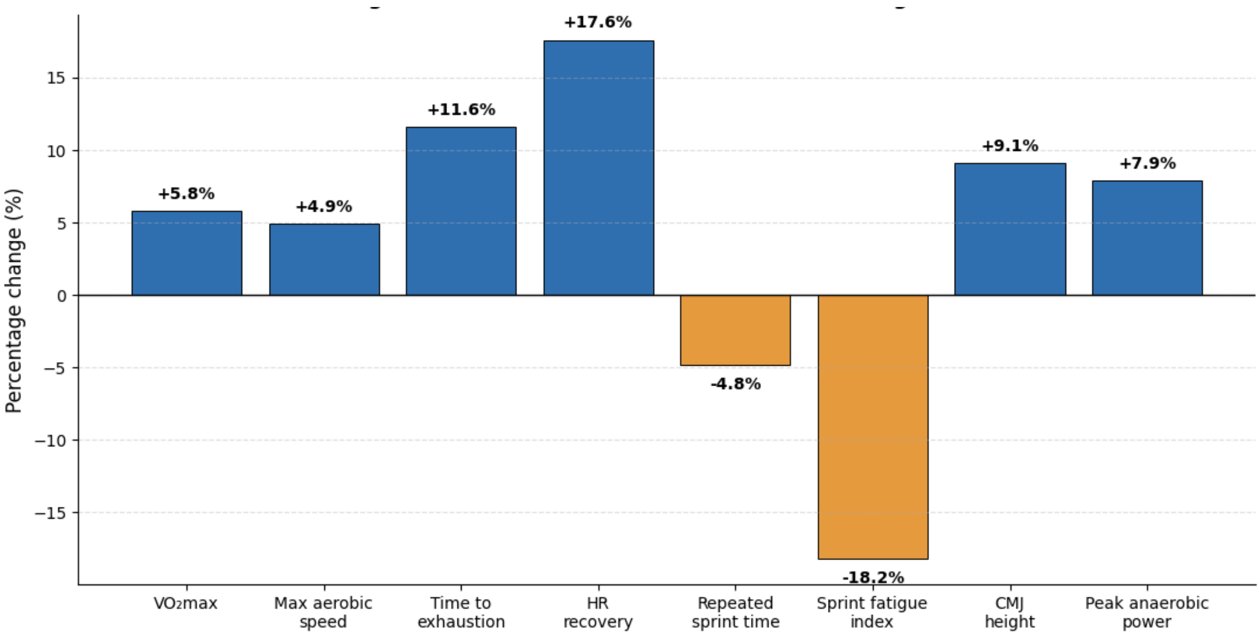

Figure 1. Percentage changes in aerobic and anaerobic performance variables following the 8-week aerobic–anaerobic conditioning intervention

Table 5 summarizes the pre- and post-intervention changes in aerobic and anaerobic performance variables. Significant Group × Time interactions were observed for all aerobic outcomes, including estimated VO_2max, maximal aerobic speed, time to exhaustion, and heart rate recovery. Bonferroni-adjusted pairwise comparisons indicated significant improvements in the experimental group, whereas no significant changes were observed in the control group. No significant Group × Time × Position interactions were detected (all $p > 0.05$), suggesting similar aerobic adaptations across playing positions.

Significant Group × Time interactions were also observed for all assessed anaerobic performance outcomes. Improvements in repeated sprint time, sprint fatigue index, countermovement jump height, and peak anaerobic power were identified in the experimental group, whereas no significant changes were observed in the control group. No significant Group × Time × Position interactions were detected (all $p > 0.05$), indicating similar anaerobic adaptations across playing positions.

The conditioning program resulted in significant changes in anthropometric, aerobic, and anaerobic variables in the experimental group compared with the control group (Tables 4 and 5). Large effect sizes were observed for VO_2max, heart rate recovery, countermovement jump height, and peak anaerobic power, indicating substantial training-related adaptations. Although changes in anthropometric variables were smaller, they also reached statistical significance. No significant Group × Time × Position interactions were detected ($p > 0.05$), suggesting similar training adaptations across playing positions.

Comparison of effect sizes (η^2p) across variables indicated that the largest effects were observed for aerobic and neuromuscular performance measures. In contrast, anthropometric variables demonstrated smaller, although still significant, effects. Overall, the findings suggest that the intervention was associated with greater improvements in performance-related outcomes than in body composition variables.

Percentage changes in aerobic and anaerobic performance variables observed in the experimental group are presented in Figure 1.

Discussion

The present study examined the effects of an eight-week aerobic–anaerobic conditioning program on anthropometric characteristics, aerobic capacity, and anaerobic performance in male university basketball players. The results indicated improvements in aerobic and anaerobic performance, accompanied by smaller but statistically significant changes in body composition. These adaptations were observed irrespective of playing position, as no significant Group × Time × Position interactions were detected. The findings suggest that a structured concurrent conditioning program may be effective for inducing adaptations across multiple physiological domains under controlled training conditions. The results also indicate that training responses were similar between perimeter and post players across the measured outcomes.

The present findings indicate that aerobic, anaerobic, and anthropometric adaptations can occur concurrently within a single conditioning framework. Previous studies have reported improvements in these performance domains following training interventions [17, 18]. The current results are consistent with these observations, as significant changes were identified across measures of aerobic capacity, anaerobic performance, and body composition. Improvements in VO_2max, heart rate recovery, countermovement jump performance, and repeated sprint ability further suggest that the intervention was associated with adaptations across multiple aspects of physical performance [19].

The aerobic capacity findings are consistent with previous studies reporting that combined training can improve cardiovascular and metabolic function [20]. The observed increases in VO_2max, maximal aerobic speed, and time to exhaustion suggest improvements in aerobic performance, while enhanced heart rate recovery may reflect adaptations in autonomic regulation [20]. These changes may be associated with physiological adaptations such as increased mitochondrial density, enhanced capillary networks, and greater oxidative enzyme activity. Such adaptations are relevant to basketball, where repeated high-intensity efforts are interspersed with brief recovery periods [21, 22].

The observed improvements in anaerobic performance suggest adaptations in neuromuscular function. Reductions in repeated sprint time and fatigue index, together with increases in countermovement jump height and peak anaerobic power, indicate enhanced explosive performance and anaerobic capacity. These changes may be associated with adaptations such as improved motor unit recruitment, enhanced neuromuscular coordination, and more effective utilization of the stretch-shortening cycle [23, 24]. The relatively large effect sizes observed for these variables further indicate the responsiveness of neuromuscular performance measures to combined conditioning programs.

The concurrent improvements observed in both aerobic and anaerobic performance are consistent with findings from studies examining concurrent training approaches. Earlier research suggested that combining endurance and strength-oriented training stimuli could attenuate specific training adaptations [25]. However, the present findings are in agreement with more recent evidence indicating that appropriately designed concurrent training programs can support adaptations across multiple performance domains [26, 27]. This may be particularly relevant in basketball, where players are required to respond to varying metabolic demands throughout training and competition. From an applied perspective, the findings suggest that integrated training models can be incorporated into performance development programs.

An additional aspect of this study was the inclusion of playing position as a factor in the analysis. Although physiological and anthropometric differences between perimeter and post players have been reported previously, the absence of significant interaction effects suggests that both groups responded similarly to the intervention. This finding may indicate that the conditioning program was associated with comparable adaptations across playing positions. From a practical perspective, a common conditioning approach may be applicable to players with different positional roles, while individual adjustments can be implemented when necessary to address specific training needs [28, 29].

With regard to anthropometric outcomes, the intervention was associated with modest but statistically significant changes in body composition, including a reduction in body fat percentage and an increase in fat-free mass. These changes were smaller than those observed for the performance-related variables. This pattern is consistent with previous studies reporting that functional adaptations may be more apparent than structural changes following short-term interventions in trained individuals [30]. The findings indicate that performance-related outcomes may be particularly responsive to conditioning programs of this duration.

Several methodological aspects should be considered when interpreting the findings. The study employed a randomized controlled design and included assessments of anthropometric characteristics, aerobic capacity, and anaerobic performance within the same intervention framework. However, some limitations should also be acknowledged. Field-based measurements, although conducted under standardized conditions, may be associated with greater variability than laboratory-based assessments. The eight-week intervention period may not have been sufficient to observe longer-term structural adaptations. In addition, the sample consisted exclusively of trained male university basketball players, which may limit the applicability of the findings to female athletes, younger populations, or professional players. Match-performance indicators and technical skill outcomes were not evaluated; therefore, the relationship between the observed physiological adaptations and competitive performance remains to be clarified.

From an applied perspective, the findings suggest that combined aerobic–anaerobic conditioning programs may be incorporated into basketball training to target multiple performance-related outcomes within a single training framework. The absence of significant positional differences in training adaptations indicates that a common conditioning approach may be applicable across different playing positions, with individual modifications implemented when necessary. Improvements in repeated sprint ability, explosive performance, and recovery-related measures may be relevant to the physical demands of basketball, which involves repeated high-intensity efforts interspersed with brief recovery periods. In educational settings, integrated conditioning strategies may also be incorporated into physical education programs aimed at developing physical fitness and sport-related movement skills. Such approaches may assist in the planning and organization of training activities at the university level.

Several directions may be considered for future research. Studies involving longer intervention periods may provide additional information regarding changes in body composition and other structural adaptations. Investigations including elite or professional athletes may help determine whether similar responses are observed at higher levels of competition. In addition, the assessment of match-related performance indicators may contribute to the evaluation of the relationship between physiological adaptations and competitive performance. Further research may also examine different approaches to training periodization and load management within concurrent training programs.

Conclusions

The results of this study indicate that an eight-week aerobic–anaerobic conditioning program was associated with improvements in aerobic capacity, anaerobic performance, and selected body composition variables in university basketball players. Similar adaptations were observed across playing positions, as no significant position-related differences in training responses were detected. The findings suggest that aerobic and anaerobic performance can improve concurrently within a structured conditioning program. Improvements were observed in measures related to aerobic fitness, repeated sprint ability, recovery, and neuromuscular performance. These findings may be relevant for the design of conditioning programs in basketball and other activities characterized by repeated high-intensity efforts interspersed with short recovery periods. The results also indicate the potential applicability of integrated conditioning approaches within university-based physical activity and training programs.

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Conflict of Interest

The authors declare no conflict of interest.

Availability of Data

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

AI Transparency Statement

Artificial intelligence (AI)-assisted tools were used exclusively for linguistic refinement and grammatical editing. The scientific content, data analysis, interpretation, and conclusions were developed entirely by the authors. All AI-assisted outputs were carefully reviewed and validated by the authors, who assume full responsibility for the content of the manuscript.

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