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An Empirical Study on the Effect of Functional Physical Training on College Basketball Players: Based on Tests and Analysis of Body Fat, Heart Rate, and Endurance

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ABSTRACT

Functional physical training (FPT) has gained attention as a potential alternative to traditional physical training (TPT) for enhancing athletic performance, particularly in sports like basketball that require a combination of strength, endurance, and cardiovascular efficiency. This study aimed to explore the effects of FPT on body fat, heart rate, and endurance (strength endurance, anaerobic endurance, and aerobic endurance) among college basketball players. A pre/training/posttest design was employed, involving 24 college basketball players (ages 19–25) from two universities, divided into an experimental group (EG) receiving FPT and a control group (CG) receiving TPT. Both groups trained for 90 minutes three times a week over 10 weeks. Body fat, heart rate, and endurance metrics were measured before and after the training period, with data analyzed using SPSS 27.0 software for T-tests. Within-group comparisons revealed significant improvements in body fat, heart rate, and endurance for the EG (all $p < 0.01$), while the CG showed significant improvements except in anaerobic endurance ($p = 0.074$). Between-group comparisons demonstrated that FPT was superior to TPT in enhancing recovery period heart rate, strength endurance, and anaerobic endurance (all $p < 0.05$), though no significant difference was observed in aerobic endurance ($p = 0.114$). The findings suggest that FPT is more effective than TPT in improving recovery period heart rate, anaerobic endurance, and strength endurance, highlighting its potential as a preferred training method for optimizing the performance of college basketball players.

Key words: Functional Physical Training, Traditional Physical Training, College Basketball Players, Body Fat, Heart Rate, Endurance

INTRODUCTION

Basketball is a high-intensity, intermittent, and confrontational sport that requires athletes to possess exceptional physical qualities such as strength, speed, endurance, agility, and coordination (Stojanović et al., 2018). In recent years, with the rapid development of basketball, the physical fitness level of athletes has become one of the key factors determining the outcome of games (Scanlan et al., 2019). Traditional physical training (TPT) methods often focus on developing a single quality, neglecting the demand for comprehensive physical fitness in basketball (Haff & Triplett, 2015). This singular training model struggles to meet modern basketball's requirements for athletes' multi-dimensional physical qualities, especially in high-intensity confrontations and rapid transitions between offense and defense (Myers et al., 2017).

Functional physical training (FPT) is a comprehensive training method that is movement-oriented and emphasizes the involvement of multiple joints, planes, and muscle groups (Boyle, 2016). Compared to TPT, FPT emphasizes simulating sport-specific movement patterns, enhancing athletes' ability in power transfer, energy output, and movement control during sports activities (Behm et al., 2017). FPT can improve basketball players' power, speed, agility, and balance (Pienaar & Spamer, 2018). Furthermore, functional training can enhance athletes' sustained performance in high-intensity competitions by improving neuromuscular coordination and energy metabolism efficiency (García-Pinillos et al., 2020).

In basketball, body fat, heart rate, anaerobic, aerobic, and strength endurance are crucial indicators for assessing an athlete's physical fitness level. Excessive body fat percentage can impair an athlete's movement speed and agility, increasing the risk of sports injuries (Krustrup et al., 2019). Research shows that reducing body fat percentage positively correlates with an athlete's power and agility (Smith et al., 2020). Li et al. pointed out that reducing body fat can improve the overall performance of athletes, especially the endurance and recovery ability in high-intensity competitions (Li et al., 2020). Heart rate is a significant indicator of exercise intensity, and during basketball games, athletes' heart rates often remain at high levels. Good cardiorespiratory

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endurance helps athletes maintain their ability to perform high-intensity movements. Relevant studies have indicated a linear correlation between heart rate and exercise intensity. In a study on the heart rate responses of athletes from a LEB club during five games in the Spanish league, Vaquera found that the heart rate changes of athletes in different positions exhibited distinct positional characteristics during the games. Heart rate varies significantly among individuals. Therefore, it is often used to indicate the intensity of exercise (Vaquera, 2008). A 10-week randomized comparison experiment by Kim et al. showed that functional training significantly improved athletes' heart rate recovery ability and endurance performance (Kim et al., 2020). High-intensity interval training (HIIT) can effectively improve the body fat reduction, endurance, and power of basketball players, especially in heart rate recovery, which has obvious advantages (Nikolay et al., 2021).

Strength endurance forms the foundation for basketball players to engage in multiple high-intensity confrontations and rapid movements during a game. In contrast, speed endurance determines the athlete's ability to maintain quick transitions between offense and defense in the match's latter stages. Anaerobic endurance refers to the athlete's capacity to perform high-intensity movements in short bursts, such as intense defensive plays and swift transitions. On the other hand, aerobic endurance is the athlete's ability to sustain prolonged physical activity, enduring an intense basketball game that lasts approximately 2 hours, during which players may run between 5000 to 6000 meters. Players must possess excellent aerobic capacity to maintain high performance throughout the game (Liu, 2006). The study by Smith and Jameson further confirmed that combining aerobic and anaerobic training helps improve athletes' endurance, strength, and competition performance (Smith & Jameson, 2022). In a 12-week comparative experiment on 30 basketball players, Perez and Martinez found that plyometrics and strength training can improve the athletes' heart rate recovery ability (Perez & Martinez, 2021. However, plyometrics training can significantly improve the athletes' explosive power and jump height, while strength training can reduce body fat and increase maximum strength. Therefore, improving body fat percentage, heart rate, strength endurance, and speed endurance is of significant importance for enhancing the competitive level of basketball players.

However, there is relatively limited research on the impact of functional physical training on indicators such as body fat, heart rate, and endurance in basketball players, and existing studies predominantly focus on professional athletes, with even more research targeting collegiate basketball players (Hammami et al., 2018). As an essential reserve force for basketball, the physical fitness level of collegiate basketball players directly influences the future development of the sport. Therefore, this study compares the effects of 10 weeks of FPT (Functional Physical Training) and TPT (Traditional Physical Training) on body fat, heart rate, and endurance in collegiate basketball players (Zouhal et al., 2019).

RESEARCH OBJECTIVE

This study aims to empirically investigate the effects of Functional Physical Training (FPT) on college basketball players' body fat percentage, heart rate, and endurance performance. Specifically, the research focuses on evaluating the impact of FPT on strength endurance, anaerobic endurance, and aerobic endurance through systematic testing.

RESEARCH METHODS

Participants

We recruited 12 basketball players from the university teams of two institutions, each consisting of 5 guards, four forwards, and three centers, aged between 19 and 25 years. Both university teams have consistently participated in the Chinese University Basketball Association League (CUBAL) in recent years, competing in the same division. They have achieved top-five rankings in their respective regions over the past two years. All 24 players were in good physical condition, with no significant sports injuries, and voluntarily participated in this study after signing informed consent forms. To ensure the experiment's fairness and the data's accuracy, both teams were required to strictly adhere to the training plan during the 10-week intervention period, with no additional training allowed. Additionally, they were instructed to maintain a scientifically balanced diet and adequate sleep.

Inclusion criteria for participants were as follows:

1. Must be a member of the university's basketball team and able to commit sufficient time to participate in the training,
2. Must be at least 18 years old,
3. Must be in good health with no underlying injuries or health concerns, and
4. Must be willing to participate in this experimental study.

Exclusion criteria for participants were as follows:

1. Athletes under 18 were excluded.
2. Athletes with potential injury risks or health concerns will be excluded
3. Athletes unwilling to participate in this experimental study will be excluded.
4. Athletes unable to regularly attend training sessions will be excluded.

Considering the full participation of all team members during training, potential injuries during training and matches, and adhering to the principle of maximizing data collection, all remaining athletes eager to undergo testing were included in the study. If a team member unexpectedly sustained an injury and withdrew from the experiment during the study, another team member would substitute and participate in the experiment. All participants signed informed consent forms.

This research was conducted with the approval of the Mahasarakham University Ethics Committee under the approval code 053-601/2024.

Experimental Design

This study is a controlled trial in which basketball players from two universities underwent a 10-week physical intervention training program consisting of three 90-minute sessions per week. The experimental group (EG) received FPT, while the control group (CG) received TPT. The experimental procedure is illustrated in Figure 1.

Test

Indicators and tools

We selected five experts to screen the test indicators and measurement tools. These experts have long been engaged in basketball theory and training research or have extensive experience in physical training research. They are highly renowned professors, doctors, coaches, or physical trainers. Through the experts' screening of test indicators and measurement tools, it was determined to use body fat percentage to evaluate body composition, quiet heart rate, and exercise heart rate (maximum heart rate during the 15m*17 shuttle run, immediate heart rate post-exercise, and heart rate at 1min, 2min, and 4min during the recovery period) to evaluate heart rate. Additionally, 90-second bench press, 90-second squat, and 1-minute sit-up tests were chosen to evaluate the strength endurance of the upper limbs, lower limbs, and core. The 15m*17 shuttle run was used to evaluate anaerobic endurance, and the 3200m run was used to evaluate aerobic endurance, shown in Table 1 in detail.

Test methods

To collect the data the following measurements were performed:

Body fat

The Visbody 3D body composition analyzer was employed to evaluate the body composition index of athletes. Subjects stood barefoot on the measurement platform, selected their age and gender on the screen, and clicked to start the test. They then held the electrode handles with both hands. Within seconds, the system displayed the subject's body composition index, including body fat percentage.

Heart rate

This is used to assess the adaptability to exercise intensity and the level of fatigue. Quiet heart rate was measured by conducting a 1-minute morning pulse test on the subjects before they left bed, and the morning pulse count was recorded. Exercise heart rate was monitored using the Polar H10 heart rate monitor20. Before the test, the heart rate chest strap was secured to the chest, and the device was connected via Bluetooth. Subjects underwent a 15m*17 shuttle run test, during which the maximum heart rate during the shuttle run, the immediate heart rate after exercise, and the heart rate change at 1 minute, 2 minutes, and 4 minutes during the recovery period were monitored.

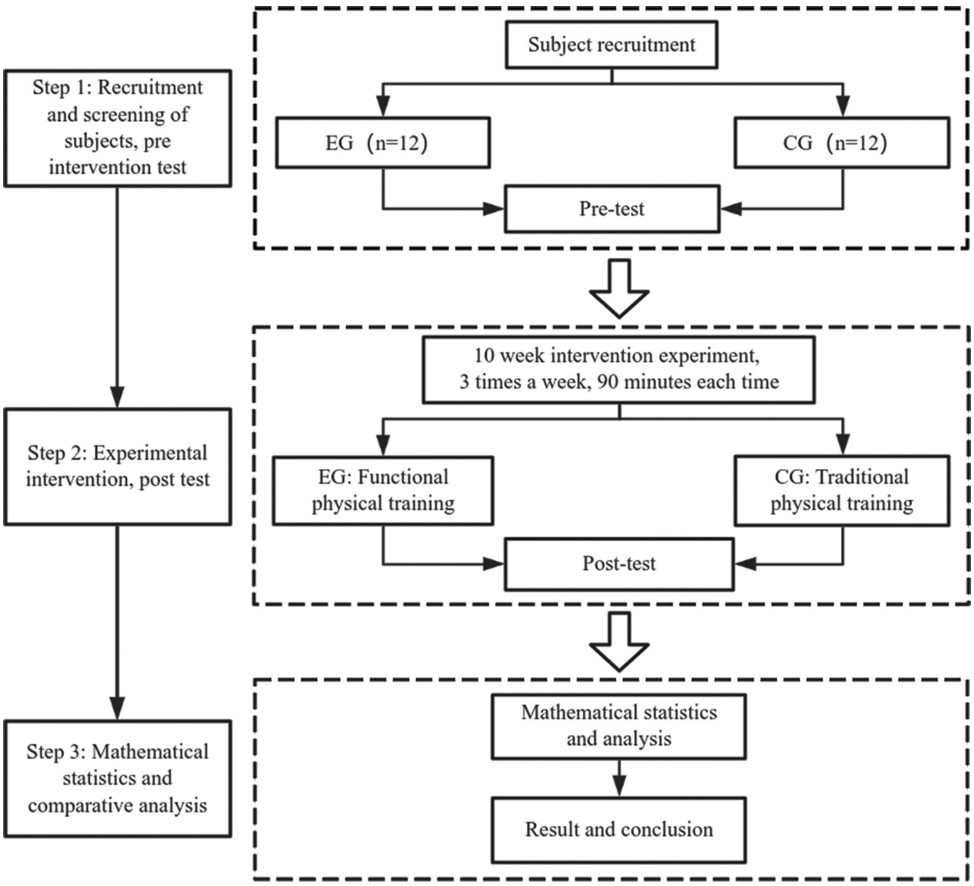

Figure 1. Experimental flowchart
Note: EG: experimental group, CG: control group

Table 1. Schedule of functional physical training cycle

Period	Purpose	Content	Frequency	Interval
The first stage: Basic adaptation period (Week 1-3)	1. Improve basic physical fitness, enhance core stability and joint flexibility. 2. Adapt to functional training mode, improve movement mode and control ability. 3. Reduce body fat rate and improve cardiopulmonary function.	1. Core stability: plank support (static, dynamic), side bridge support (left, right), Bird-Dog	3*60s	30s
		2. Basic strength: freehand squat, lunge squat, Single-leg Deadlift (left, right)	3*15reps	45s
		3. Aerobic endurance: moderate intensity jogging (60%-70% Max heart rate).	20-30 min	5 min
		4. Anaerobic endurance: short sprint	6*30m	60s
		5. Strength and endurance: circuit training (squats→push-ups→jump rope)	3*30s	60s
		6. Flexibility: dynamic stretch (high leg lift, side lunge stretch)	2*20reps	30s
		7. Regeneration and recovery: Foam axis relaxation (thighs, hips, back)	1-2 min/ part	-
The second stage: Strengthening period (Week 4-7)	1. Enhance strength, power and endurance, and improve the special physical fitness of basketball. 2. Improve heart rate recovery ability and enhance body adaptability under high-intensity exercise. 3. Further reduce body fat percentage and create a better body shape.	1. Strength and power: weight squat (medium weight), Box Jump, Medicine Ball Throw	4*10reps	60s
		2. Aerobic endurance: moderate intensity interval running (3 minutes fast running→2 minutes jogging)	6reps	2 min
		3. Anaerobic endurance: high-intensity interval training (HIIT, 20s sprint+40s jog)	15-20 min	-
		4. Strength and endurance: circuit training (weight lunges→pull-ups→jump rope)	4*40s	60s
		5. Core and stability training: Russian twist, side plank with leg lift	20reps	30s
		6. Flexibility: Dynamic stretching (Spider-Man stretching, stride stretching)	2*20reps	30s
		7. Regeneration and recovery: Yoga ball stretching (shoulders, hips)	1-2 min/ part	-
The third stage: Special optimization period (Week 8-10)	1. Optimize the special physical fitness of basketball and improve the sports performance in the game. 2. Further improve heart rate recovery and endurance levels. 3. Consolidate the control effect of body fat, enhance body coordination and explosive power.	1. Strength and power: Squat jump, weighted lunge jump, barbell push press	4*10reps	60s
		2. Aerobic endurance: Long distance jogging (70%-80% Max heart rate)	30-40 min	5 min
		3. Anaerobic endurance: interval training for basketball (full court sprint→shooting)	10-15reps	60s
		4. Strength and endurance: high-intensity circuit training (squat jump→push up→jump rope→medicine ball throwing)	5*45s	60s
		5. Core and stability training: Hanging leg raise, side medicine ball throw	3*12reps	30s
		6. Flexibility: dynamic stretching (stride turn, lunge turn)	2*20reps	30s
		7. Regeneration and recovery: static stretching (back of thighs, hips, shoulders)	30s/part	-

90s bench press/deep squat

This test is used to evaluate the strength endurance of an athlete's upper and lower limbs. The subjects warm up thoroughly and perform light equipment bench presses or squats first. 1) When doing the bench press, the subject lies on the bench press bench, lowers the barbell to touch the chest with both hands and then pushes the barbell up with force until the elbows are fully extended. They do this as many times as possible continuously within 90 seconds, and the number of consecutive bench presses within 90 seconds is recorded. 2) When performing deep squats, the subjects should leave the barbell rack with the barbell on their shoulders, land on the entire sole of their feet, squat down fully until reaching the angle of the reference marker pole, then forcefully stand up. They should repeat this process as often as possible within 90 seconds, and the number of consecutive deep squats within this period will be recorded. 3) According to the physical fitness test evaluation standards for Chinese youth men's basketball players, the test results of the 90-second weighted bench press (deep squat) are scored based on the weight-bodyweight coefficient of the bench press (squat). The calculation formula is: Bench press weight-bodyweight coefficient = (bench press weight * bench press repetitions)/body weight; Deep squat weight-bodyweight coefficient = (deep squat weight * deep squat repetitions)/body weight. The coefficient is accurate to one decimal place. 4) Generally, the greater the body weight, the greater the strength. Therefore, the test scoring criteria are divided into two groups based on the subject's body weight: under 90kg and 90kg or above (including 90kg).

1-minute sit-ups

This was used to evaluate the strength and endurance of an athlete's waist and abdominal muscles. The test subject lies flat on the test mat with knees bent. Upon hearing the signal, the test begins. The subject must touch or exceed their knees with both elbows and then return to the supine position with both shoulder blades touching the mat to complete one repetition. During the test, if the subject uses the force of their elbows on the mat to perform the sit-up or if their elbows do not touch or exceed their knees, it is considered an incorrect movement and will not be counted by the instrument. The subject must continuously complete the exercise for 1 minute, and the number of repetitions completed within 1 minute is recorded.

Plank

Plank was used to evaluate the athlete's core strength endurance level. The subject lies on his stomach with elbows bent and supported on the ground, shoulders and elbows perpendicular to the ground, feet on the ground, body off the ground, torso straightened, shoulder nails retracted, abdominal muscles tightened so that the head, spine and hip joints remain at the same level. We recorded the maximum time the subject could sustain it at one time.

15m×17 shuttle run

This test was used to evaluate athletes' anaerobic endurance. Participants should warm up thoroughly and receive a clear explanation of the shuttle run route and rules.

1. Starting from one sideline of a basketball court, the participant sprints to the opposite sideline. Each completion (touching or crossing the line with one foot) counts as one repetition, totaling 17 shuttle sprints.
2. Participants must touch or cross the line with at least one foot during each turn; failure to comply will result in a violation.
3. Each participant performs two trials with a 2-minute rest interval between attempts. The average performance is recorded.

3,200m run

This is used to evaluate athletes' aerobic endurance. Participants warm up adequately and begin with a standing start upon the signal. At maximum speed, they must complete the designated distance (3,200 meters, equivalent to 8 laps on a standard track).

Intervention

Five experienced experts were interviewed before the experiment, including university professors, coaches, and physical trainers who have been engaged in basketball theory and practice research for a long time. Based on the literature, combined with the characteristics of basketball and the physical characteristics of college basketball players, a set of targeted functional physical training methods for college basketball players is designed. The experimental group received functional physical training, and the control group received traditional physical training. The intervention period was 10 weeks, 90 minutes each time, 3 times a week. The functional physical training program of the experimental group is shown in Table 1.

Data Analysis

All statistical analyses were performed using SPSS 27.0, and all data were expressed as mean ± standard deviation (SD). Kolmogorov-Smirnov test was used to test the normality of all data, and the significance level was more significant than 0.05. Process t-tests for pre - and post-intervention data. If $p < 0.05$, the difference is considered significant.

RESULTS

Basic Information

An independent sample t-test was conducted before intervention for subjects in the two groups. Since the pretest data of body fat percentage in the CG did not conform to a normal distribution, a Mann-Whitney U test was adopted, and the results are shown in Table 2. There were no statistically significant differences in age, height, weight, BMI, body fat percentage, and other basic information between the two groups, and they were homogeneous.

Body Fat

The results of within-group and between-group comparisons of body fat are shown in Figure 2. Before the intervention, the two groups had no significant difference in body fat ($p > 0.05$). After the intervention, the body fat of the EG was significantly lower than before the intervention ($p < 0.001$), and the body fat percentage of the CG was also significantly improved ($p = 0.002$). However, there was no statistical significance between the experimental and control groups ($p = 0.292$).

Heart Rate

As can be seen from Figure 3, before the intervention, there were no statistically significant differences in quiet heart rate (QHR), maximum heart rate (HRmax), immediate heart rate (IHR), and recovery period HR (RPHR) between the two groups ($p > 0.05$). After the intervention, all data differences between the two groups were statistically significant ($p < 0.001$), and QHR, exercise heart rate (EHR), and RPHR were all significantly decreased. In comparing post-test data between groups, there was no significant difference in QHR, HRmax, and IHR ($p = 0.600$, 0.669, and 0.365, respectively). However, there was a significant difference in heart rate during the recovery period (1min: $p = 0.019$, 2min: $p = 0.003$, 4min: $p < 0.001$).

Table 2. Comparison of subjects' characteristics

	CG		EG		*t*	*p*
	$\bar{x}$	SD	$\bar{x}$	SD		
Age (years)	21.42	1.24	21.00	1.54	0.731	0.473
Height (cm)	185.08	8.16	186.17	7.30	-0.343	0.735
Weight (kg)	84.94	13.31	85.38	11.71	-0.085	0.933
BMI (kg/m²)	24.68	2.45	24.57	2.35	0.102	0.92
Body fat (%)	15.62	3.23	16.16	6.42	—	0.713

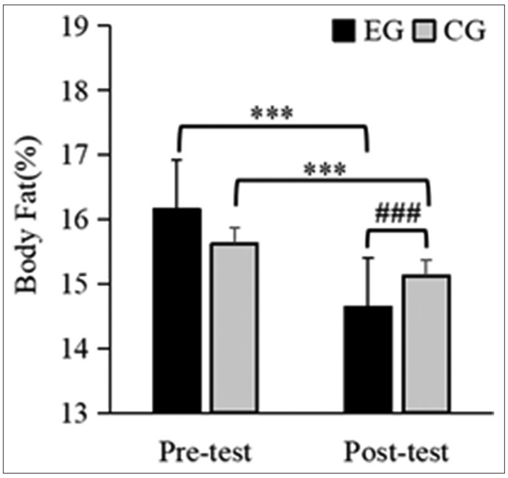

Figure 2. Comparison of body fat percentage within and between groups
Note: EG-experimental group, CG-control group,
*** significant difference within group ($p < 0.001$)
significant difference between groups ($p < 0.001$)

Endurance

Figure 4 shows the changes in the subjects' anaerobic and aerobic endurance. Before the intervention, there was no significant difference between the test data of 15m*17 retrace run and the 3200m run ($p > 0.05$). After the intervention, the 15m*17 return performance of the experimental group was significantly improved ($p < 0.001$), but there was no significant difference in the control group ($p = 0.074$). The difference was significant in the post-test comparison between groups ($p = 0.025$).

After the intervention, an intra-group comparison of the 3200m running group showed that the difference between the experimental and control groups was statistically significant (EG: $p = 0.003$, CG: $p < 0.001$). In contrast, there was no statistical significance between groups ($p = 0.114$).

Figure 5 shows the change in strength and endurance of the subjects. Before the intervention, there was no significant difference between the experimental and control groups in the 90s bench press, 90s deep squat, 1-minute sit-up, and plank ($p > 0.05$). After the intervention, intra-group comparisons showed statistically significant differences in all four indicators between the two groups ($p < 0.001$). In the

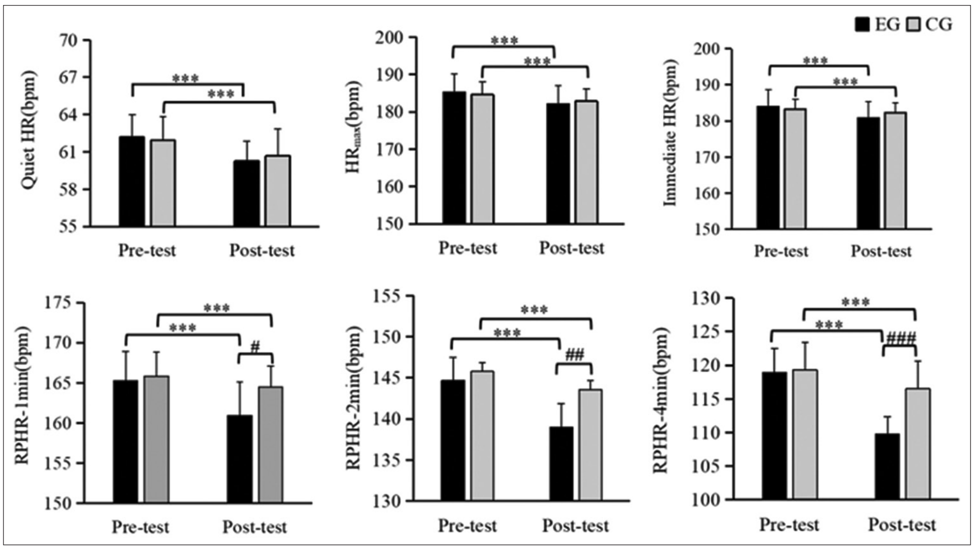

Figure 3. Comparison of heart rate (HR) within and between groups
Note: EG-experimental group, CG-control group, HR-heart rate, HRmax-maximum heart rate, Immediate HR-Immediate heart rate, RPHR-recovery period heart rate
*significant difference within group ($p < 0.05$), ** significant difference within group ($p < 0.01$); *** significant difference within group ($p < 0.001$); # significant difference between groups ($p < 0.05$); ## significant difference between groups ($p < 0.01$), ### significant difference between groups ($p < 0.001$)

post-test comparison between groups, there were statistically significant differences in the 90s bench press, 90s deep squat, 1-minute sit-up, and plank (p values were 0.041, 0.045, 0.02, and 0.034, respectively).

DISCUSSION

This study compared the effects of functional physical training (FPT) and traditional physical training on body fat percentage, heart rate, and endurance in college basketball players. The findings indicate that both interventions significantly reduced body fat, consistent with prior research highlighting the role of structured exercise in improving body composition through increased energy expenditure and metabolic efficiency. Fat loss mechanisms involve negative energy balance, enhanced fat oxidation, and improved basal metabolic rate (BMR) due to increased muscle mass. The results also demonstrated that both training methods significantly lowered resting heart rate, exercise heart rate, and recovery heart rate. FPT showed a statistically significant advantage in heart rate recovery, suggesting superior cardiopulmonary and post-exercise adaptation improvements. In terms of endurance, both interventions improved aerobic capacity, but FPT was particularly effective in enhancing anaerobic endurance, which is crucial for

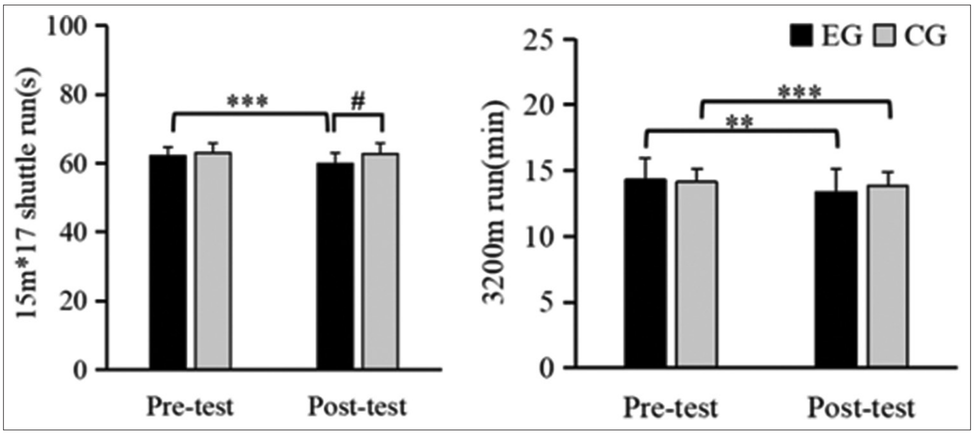

Figure 4. Comparison of anaerobic endurance and aerobic endurance within and between groups
Note: EG-experimental group, CG-control group, ** significant difference within group ($p < 0.01$); *** significant difference within group ($p < 0.001$); # significant difference between groups ($p < 0.05$)

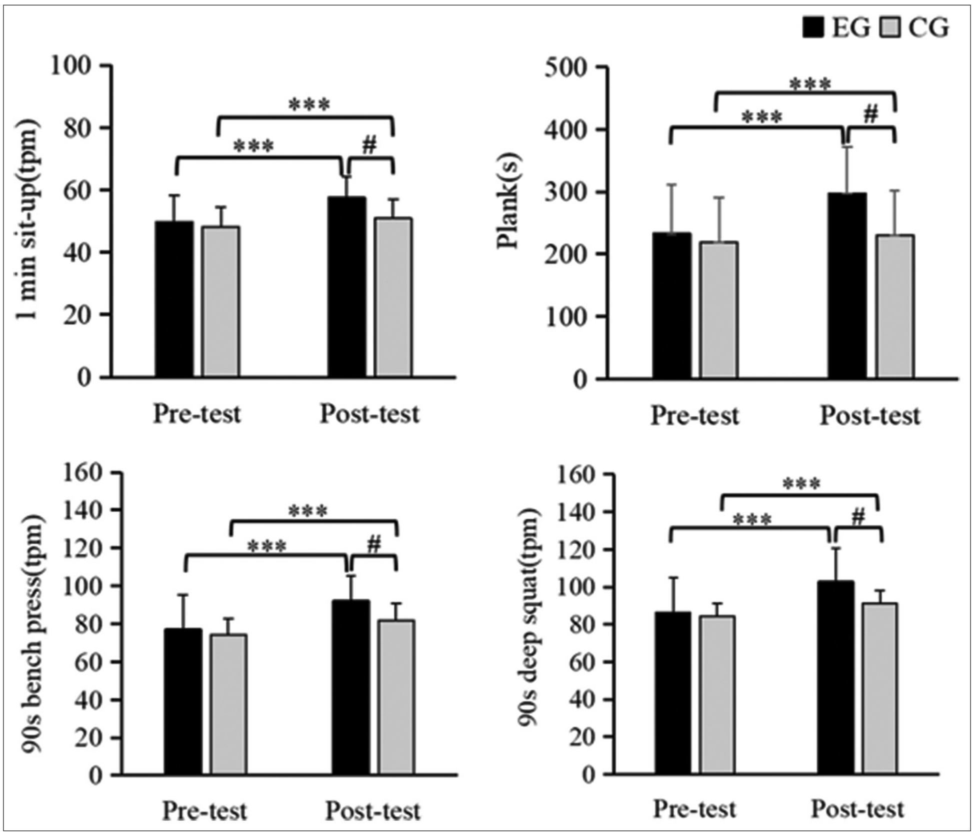

Figure 5. Comparison of strength endurance within and between groups
Note: EG-experimental group, CG-control group, *** significant difference within group ($p < 0.001$); # significant difference between groups ($p < 0.05$)

basketball performance. FPT's more significant improvements in strength endurance may be attributed to its multi-dimensional and sport-specific approach, integrating multi-joint, compound movements that closely mimic game actions, thereby improving muscle endurance, coordination, and explosive power. However, despite these findings, the study has limitations, including small sample size, potential intervention inconsistencies due to different coaching conditions, and a lack of multi-dimensional assessment incorporating factors such as muscle mass, metabolic rate, and hormonal response. Future research should expand the sample size, examine position-specific adaptations to FPT, incorporate competition load analysis, and conduct long-term follow-ups to assess the sustained impact of FPT on athletic performance and overall fitness. These insights will help refine training strategies to optimize basketball player development and performance enhancement.

CONCLUSION

This study investigated the effects of functional training on body fat percentage, heart rate, strength endurance, anaerobic endurance, and aerobic endurance of college basketball players. The results show that both training methods can effectively reduce the body fat percentage of athletes. However, functional training has a remarkable effect in improving the physical quality of college basketball players, especially in strength and anaerobic endurance, which is better than traditional training and enhances the athletic performance of athletes in training and competition. Similarly, functional training was more effective in improving heart rate during convalescence, improving heart function and parasympathetic nerve activity, thus accelerating heart rate recovery.

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