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Comparison of the Effectiveness of Circuit Training and Interval Training on the Physical Endurance of Basketball Athletes

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Abstract: Basketball is a team sport that requires physical, technical, and psychological abilities simultaneously. Improving aerobic endurance is essential for maintaining optimal performance throughout the game; therefore, selecting an appropriate training method is important. Interval training and circuit training are two commonly used methods to enhance aerobic endurance. This study aimed to compare the effects of interval training and circuit training on the aerobic endurance of basketball athletes at MAN 2 Mojokerto. This study employed a quantitative approach with a matching-only quasi-experimental design involving 20 male basketball athletes aged 16–18 years. Participants were divided into an interval training group (n = 10) and a circuit training group (n = 10). Aerobic endurance was measured using the Multistage Fitness Test (Bleep Test). Data were analyzed using descriptive statistics, paired-sample t-tests, and the Mann–Whitney U test. The results showed that both interval training and circuit training significantly improved aerobic endurance ($p < 0.05$). The interval training group demonstrated a slightly greater mean improvement than the circuit training group; however, the difference in improvement between groups was not statistically significant ($p = 0.112$). Therefore, both interval training and circuit training can be considered effective methods for improving the aerobic endurance of adolescent basketball athletes.

Keywords: aerobic endurance, basketball athletes, circuit training, interval training, Vo_2Max.

INTRODUCTION

Basketball is one of the team sports that simultaneously demands physical, technical, and mental abilities. This game is played with high intensity as it involves sprinting, jumping, passing, dribbling, and repeated physical contact throughout four quarters (4 × 10 minutes). Therefore, aerobic endurance becomes a crucial component determining a player's performance throughout the match. Athletes with good aerobic endurance are able to maintain consistent performance until the final quarter, while those with low endurance tend to experience performance decline, technical errors, and even an increased risk of injury (Cao et al., 2025). Reduced aerobic endurance may also lead to excessive fatigue, which can accelerate muscle damage during repeated high-intensity activities. If not managed properly, excessive or prolonged muscle damage can result in chronic inflammation, impaired muscle function, and an increased risk of injury (Irawan et al. 2025). Aerobic endurance also plays an essential role in supporting cardiovascular efficiency and energy recovery during intense physical activity (Shalom et al., 2023).

In efforts to improve physical aerobic endurance, the choice of training methods becomes a critical factor. Interval training and circuit training are two widely used methods to enhance aerobic capacity and athletic performance. Interval training consists of short bursts of high-intensity exercise interspersed with recovery periods and has been proven effective in improving cardiorespiratory capacity and energy metabolism. Several studies have demonstrated the effectiveness of interval training in increasing VO_2Max, speed, agility, and sport-specific skills among basketball players (Shamim, 2021; Cao et al., 2025) . Research conducted at the school level has also found that interval training is efficient for improving physical fitness in a short period of time, making it relevant for students with tight academic schedules (Ridwandhani and Iskandar 2025).

In addition to interval training, another commonly used method to improve endurance is circuit training. This type of training combines elements of aerobic endurance, strength, and agility through a series of exercise stations with varied movements. Research on wheelchair tennis athletes showed that six weeks of circuit training significantly improved aerobic endurance (Dwi Yulianto, Sumaryanti, and Yudhistira 2021). Moreover, a study at the university level reported that circuit training was superior to interval training in enhancing muscular strength and aerobic endurance among college students (Latif et al. n.d.). These differing results indicate that the

effectiveness of a training method is not universal; it is influenced by the sport discipline, training context, and the individual characteristics of athletes (Raju 2024).

The fact that previous research findings remain varied raises the question of which training method is most effective in improving the physical aerobic endurance of basketball athletes, particularly at the school level. This issue is relevant for basketball athletes at MAN 2 Mojokerto, who actively participate in interschool competitions but often experience performance decline during the final quarter of games. Most prior studies have focused on adult or university-level athletes, while research comparing the effectiveness of interval training and circuit training among adolescent athletes at the secondary school level remains limited.

Based on the above background, this study aims to analyze and compare the effects of interval training and circuit training on improving the physical aerobic endurance of basketball athletes at MAN 2 Mojokerto. Practically, the results of this study are expected to assist coaches in designing efficient and athlete-appropriate training programs, while theoretically, the findings are expected to enrich the literature on the effectiveness of various training methods in improving physical aerobic endurance, particularly in the context of school-level basketball.

METHOD

This study employed a quantitative approach using a quasi-experimental pre-test and post-test design with two intervention groups. The study aimed to compare the effects of Interval Training and Circuit Training on improving the aerobic endurance of male basketball athletes at MAN 2 Mojokerto. The research was conducted at MAN 2 Mojokerto, with data collection taking place in the school's training area and sports field. The intervention lasted for six weeks, with training sessions conducted three times per week, consisting of pre-test, treatment, and post-test stages. The study was carried out from September to October 2025.

The population consisted of all 20 male basketball athletes from MAN 2 Mojokerto aged 16–18 years Written informed consent was obtained from all participants and their parents or guardians before participation in the study. Since all eligible athletes participated in the study, a total population sampling approach was employed. Participants were then randomly allocated into two intervention groups, consisting of 10 athletes in the Interval Training group and 10 athletes in the Circuit Training group.

The primary outcome of this study was aerobic endurance. Aerobic endurance was assessed using the Multistage Fitness Test (20-m Shuttle Run Test/Bleep Test), a valid and reliable field test for estimating maximal oxygen uptake (VO_2max) [add reference]. Measurements were performed before the intervention (pre-test) and after the completion of the six-week training program (post-test) using identical testing procedures. Participants were then randomly allocated into two intervention groups, consisting of 10 athletes in the Interval Training group and 10 athletes in the Circuit Training group. The Interval Training group performed eight repetitions of 2-minute high-intensity running interspersed with 1-minute active recovery (jogging). Each session was preceded by a 10-minute warm-up and followed by a 10-minute cool-down. The intervention was conducted three times per week for six weeks.

The Circuit Training group performed a program consisting of five exercise stations: sit-ups, plank, lunges, squats, and skipping. Each station was performed continuously for 45 seconds, followed by a 15-second transition period before moving to the next station. Completion of all five stations constituted one circuit, which lasted approximately 5 minutes. Participants completed four consecutive circuits during each training session, resulting in a total exercise duration of approximately 20 minutes, excluding warm-up and cool-down periods. The intervention was conducted three times per week for six weeks under the supervision of the researchers.

The data collected were aerobic endurance test results, both *pre-test* and *post-test,* from both exercise groups. This test was used to assess the level of aerobic capacity improvement as a primary indicator of the effectiveness of the treatment. Descriptive statistics were expressed as mean ± standard deviation (SD). Data normality was assessed using the Shapiro–Wilk test. Differences between pre-test and post-test scores within each group were analyzed using paired-sample t-tests. The effectiveness of the two training methods was compared using N-Gain scores and analyzed with the Mann–Whitney U test because the normality assumption was not met for one of the groups. All statistical analyses were performed using IBM SPSS Statistics version 27, with statistical significance set at $p < 0.05$ to test the differences in results between the *Interval Training* and *Circuit Training groups* in increasing the aerobic endurance of male basketball athletes from MAN 2 Mojokerto.

RESULT AND DISCUSSION

Result

Descriptive Data of Research Subjects

Before further analysis is conducted, descriptive data are presented regarding the characteristics of the research subjects, consisting of variables such as age, height, weight, and body mass index (BMI) in both groups, namely group C and group I. This data aims to provide a general overview of the initial physical condition of the participants before receiving the exercise treatment. A summary of the results of the descriptive analysis can be seen in Table 1.

Table 1. Characteristics and Descriptive Statistics of the Interval Training Group

Variable	N	Mean ± SD	Min–Max
Height (cm)	10	167.60 ± 5.78	160–177
Weight (kg)	10	62.80 ± 13.36	48–90
BMI (kg/m²)	10	22.33 ± 4.33	16.90–29.40
Pre-Test	10	40.77 ± 3.95	34.81–46.23
Post-Test	10	44.30 ± 4.07	36.54–50.04

Based on the descriptive statistical analysis of the Interval Training group, this study involved 10 participants. The anthropometric characteristics showed that the participants had an average height of 167.60 cm, ranging from 160 to 177 cm, with a standard deviation of 5.78 cm. Meanwhile, the average body weight was 62.80 kg, with a minimum value of 48 kg, a maximum value of 90 kg, and a standard deviation of 13.36 kg. The average Body Mass Index (BMI) was 22.33 kg/m², ranging from 16.90 to 29.40 kg/m², with a standard deviation of 4.33 kg/m². The pre-test results assessing endurance performance showed a mean score of 40.77, with values ranging from 34.81 to 46.23 and a standard deviation of 3.95. After completing the Interval Training program, the post-test results demonstrated an improvement, with a mean score of 44.30, a minimum value of 36.54, a maximum value of 50.04, and a standard deviation of 4.07.

The increase in the mean score from the pre-test to the post-test by 3.535 points indicates a positive improvement in the participants' endurance performance following the Interval Training program. These findings suggest that interval training provides physiological adaptations that enhance physical capacity, particularly aerobic endurance, which is essential for basketball performance.

Table 2. Characteristics and Descriptive Statistics of the Circuit Training Group

Variable	N	Mean ± SD	Min–Max
Height (cm)	10	172.20 ± 5.98	165–184
Weight (kg)	10	68.70 ± 15.19	51–97
BMI (kg/m²)	10	22.94 ± 3.59	18.60–28.70
Pre-Test	10	35.57 ± 5.01	29.28–43.46
Post-Test	10	38.72 ± 4.81	32.05–47.27

Based on the descriptive statistical analysis of the Circuit Training group, this study involved 10 participants. The anthropometric characteristics indicated that the participants had an average height of 172.20 cm, ranging from 165 to 184 cm, with a standard deviation of 5.98 cm. The average body weight was 68.70 kg, with a minimum value of 51 kg, a maximum value of 97 kg, and a standard deviation of 15.19 kg. The average Body Mass Index (BMI) was 22.94 kg/m², ranging from 18.60 to 28.70 kg/m², with a standard deviation of 3.59 kg/m². The pre-test assessment of endurance performance yielded a mean score of 35.57 ± 5.01, with values ranging from 29.28 to 43.46. Following the Circuit Training program, the post-test results showed an increase in the mean score to 38.72 ± 4.81, with values ranging from 32.05 to 47.27.

The mean score increased by 3.15 points from the pre-test to the post-test, indicating an improvement in endurance performance after the implementation of the Circuit Training program. These findings suggest that circuit training effectively enhances participants' physical capacity through a sequence of exercises performed consecutively with limited recovery periods. This improvement supports the effectiveness of circuit-based training as a practical approach for improving endurance performance in basketball athletes.

Results of the Normality Test of Research Data

A normality test was performed to determine whether the endurance data (bleep test) was normally distributed. This normality test is important for determining the appropriate statistical analysis method, namely whether to use parametric or non-parametric tests. Because the sample size in this study was less than 50 participants, the Shapiro–Wilk test was used to verify the normality of the data.

Table 3. Results of the Normality Test for Training Interval Data

Variable	Shapiro–Wilk Statistics	df	Sig.	Results
Pre-Test A (Experiment)	0.889	10	0.166	Normal

Post-Test A (Experiment)	0.935	10	0.498	Normal

The results of the data normality test using the Shapiro–Wilk test show that the significance value for Pre-Test A (Experiment) is 0.166 and for Post-Test A (Experiment) is 0.498. Both values are greater than the significance level of 0.05, so it can be concluded that the pre-test and post-test data are normally distributed. Thus, the data meets the assumption of normality and further analysis can be carried out using the test. Paired Sample t-Test.

Table 4. Results of Circuit Training Data Normality Test

Variable	Shapiro–Wilk Statistics	df	Sig.	Interpretation
Pre-Test B (Experiment)	0.926	10	0.414	Normal
Post-Test B (Experiment)	0.950	10	0.672	Normal

Results of data normality test using the Shapiro–Wilk test shows that the significance value in Pre-Test B (Experiment) is 0.414 and in Post-Test B (Experiment) is 0.672. Both values are greater than the significance level of 0.05, so it can be concluded that the pre-test and post-test data are normally distributed. Thus, the data meets the assumption of normality and further analysis can be carried out using the test Paired Sample t-Test.

Table 5. Results of Paired Sample t-Test Interval Training and Results of Paired Sample t-Test Circuit Training

Variables	Mean Difference	t	df	Sig. (2-tailed)	Interpretation
Pre-Test – Post-Test A (Experiment)	-3,665	-8,063	9	0.000	Significant
Pre-Test – Post-Test B (Experiment)	-3,150	-7,278	9	0.000	Significant

The results of the *paired sample t-test* showed a significant difference between the pre-test and post-test scores in the experimental group. Based on the analysis, the average difference was -3.665 , with a *t- value* of -8.063 and a significance level of 0.000 ($p < 0.05$) . These results indicate that there was a significant increase in the endurance test results (bleep test) after participants participated in the interval training program . Thus, it can be concluded that the application of interval training has a significant effect on increasing aerobic endurance in basketball athletes.

The results of the *paired sample t-test* showed a significant difference between the pre-test and post-test scores in the experimental group. Based on the analysis, the average difference was -3.150 , with a *t- value* of -7.278 and a significance level of 0.000 ($p < 0.05$). These results indicate that there was a significant increase in the endurance test results (bleep test) after participants participated in the Circuit training program. Thus, it can be concluded that the implementation of circuit training has a significant effect on increasing aerobic endurance in basketball athletes.

Table 7. Results of the Shapiro–Wilk Normality Test for N-Gain Scores

Group	Shapiro-Wilk Statistic	df	Sig.	Interpretation
Interval Training	0.947	10	0.635	Normal
Circuit Training	0.709	10	0.001	Not Normal

The normality test was conducted using the Shapiro–Wilk test because the study sample consisted of fewer than 50 participants. The results showed that the N-Gain data for the Interval Training group had a significance value of 0.635 ($p > 0.05$), indicating that the data were normally distributed. In contrast, the N-Gain data for the Circuit Training group had a significance value of 0.001 ($p < 0.05$), indicating that the data were not normally distributed.

Table 8. Descriptive Statistics of N-Gain Scores in the Interval Training Group

Variable	N	Mean ± SD	Min–Max
N-Gain Score	10	0.464 ± 0.250	0.14–1.00
N-Gain Percentage (%)	10	46.44 ± 25.01	11.36–100.00

Table 9. Descriptive Statistics of N-Gain Scores in the Circuit Training Group

Variable	N	Mean ± SD	Min–Max
N-Gain Score	10	0.329 ± 0.254	0.14–1.00
N-Gain Percentage (%)	10	32.90 ± 25.43	13.77–100.00

Based on the results of the Shapiro–Wilk normality test, the improvement in endurance performance measured by the N-Gain Score showed different distribution patterns between the two groups. The Interval Training group obtained a significance value of 0.635 ($p > 0.05$), indicating that the data were normally distributed. Conversely, the Circuit Training group obtained a significance value of 0.001 ($p < 0.05$), indicating

that the data were not normally distributed. These findings suggest that the improvement data in the Circuit Training group exhibited greater variability than those in the Interval Training group.

Descriptive statistical analysis showed that the Interval Training group achieved a mean N-Gain Score of 0.464 ± 0.250, with values ranging from 0.14 to 1.00. When expressed as a percentage, the average improvement was 46.44 ± 25.01%. Meanwhile, the Circuit Training group obtained a mean N-Gain Score of 0.329 ± 0.254, with the same score range (0.14–1.00), corresponding to an average improvement of 32.90 ± 25.43%.

These findings indicate that both training methods improved the endurance performance of basketball athletes following the intervention. However, based on the mean N-Gain Score, the Interval Training group demonstrated a greater improvement than the Circuit Training group. These findings indicate that the Interval Training group demonstrated a greater mean improvement than the Circuit Training group. However, the statistical significance of this difference was further examined using the Mann–Whitney U test.

Table 10. Comparison of N-Gain Scores Between the Interval Training and Circuit Training Groups Using the Mann–Whitney U Test

Variable	Group	N	Mean Rank	Mann–Whitney U	Z	p-value (2-tailed)	Interpretation
N-Gain Score	Interval Training	10	12.60	29.000	-1.589	0.112	Not Significant
	Circuit Training	10	8.40				

Based on the comparison of improvements in endurance performance using the Mann–Whitney U test on the N-Gain Scores, the Interval Training group obtained a mean rank of 12.60, whereas the Circuit Training group obtained a mean rank of 8.40. This indicates that the Interval Training group tended to demonstrate greater improvements in endurance performance than the Circuit Training group based on the ranking of improvement scores. However, the statistical analysis yielded a Mann–Whitney U value of 29.000, with $Z = –1.589$ and a p-value of 0.112 ($p > 0.05$). Therefore, there was no statistically significant difference in the improvement of endurance performance between the Interval Training and Circuit Training groups.

These findings indicate that although the Interval Training group demonstrated a descriptively greater improvement, both training methods produced relatively similar

effects on enhancing the aerobic endurance of basketball athletes. Therefore, both Interval Training and Circuit Training may be considered effective training approaches for improving aerobic endurance capacity in adolescent basketball athletes.

DISCUSSION

The results showed that the group undergoing *interval training* experienced a significant increase in aerobic endurance with an average difference of -3.665 and a t-value of -8.063 ($p < 0.05$). This finding is in line with the results of research (Cao et al. 2025)which stated that *interval training* is effective in increasing aerobic capacity and oxygen utilization efficiency in basketball athletes. According to (Muslim Bin Ilyas and Agus Sutriawan 2025), high-intensity interval training can increase *stroke volume* , cardiac efficiency, and muscle oxidative capacity through adaptations in the oxygen transport and utilization system. The results of a meta-analysis by (Shamim 2021)also confirmed that *interval training* significantly improves aerobic capacity, cardiovascular endurance, and basketball-specific performance. This strengthens the findings of this study that interval training is very effective in the context of intermittent sports such as basketball. Research by (Čaprić et al. 2025)and (Mačinskas et al. 2023)also shows that HIIT can trigger significant adaptations in the cardiovascular system and aerobic metabolism through increased oxygen efficiency. Furthermore, they added that interval-based functional training can improve basketball players' general fitness and motor skills, which are important for maintaining optimal performance on the court.

In the context of technical performance, interval training also plays a crucial role in developing skills such as shooting, *passing* , and *dribbling* . Explosive exercises such as *jump shots* and *medicine ball throws* in a HIIT program can increase leg and upper arm muscle strength, which impacts shot stability and accuracy (Hammami et al., 2021) ; (Aksović et al. 2020). For *passing skills* , HIIT involving coordination exercises such as *ball throws* and *wall passes* helps improve response speed and neuromuscular coordination (Al Kitani 2024). Meanwhile, for *dribbling skills* , exercises such as *high knees* , *burpees* , and *cone drills* have been shown to improve foot speed, agility, and body control, which are crucial for sudden changes of direction (Lennemann et al. n.d.); (Buchheit and Laursen 2013); (Ahmed 2015).

Meanwhile, the group undergoing *circuit training* also showed a significant increase in aerobic endurance with an average difference of -3.150 and a t-value of -7.278

($p < 0.05$). This finding supports the results of research (Mallesh, Tn, and Vpr 2017), which showed that *circuit training* can increase aerobic capacity and muscle strength through a combination of multi-station training. Circuit training requires athletes to perform a series of exercises involving various large muscle groups alternately in one session, interspersed with minimal rest periods. According to (Muslim Bin Ilyas and Agus Sutriawan 2025), this training pattern trains general endurance *and* improves the efficiency of the respiratory and circulatory systems. Research (Joni Harianto et al. 2025)shows that a circuit training program can increase aerobic capacity and reduce resting heart rate in high school basketball players. Furthermore, *circuit-based training* combines the benefits of strength and aerobic training simultaneously, making it a suitable method for developing multidimensional performance. With its high intensity, *circuit training* can also improve a player's anaerobic endurance and energy efficiency.

The comparison of N-Gain scores showed that the interval training group demonstrated a higher mean rank (12.60) than the circuit training group (8.40). However, the Mann–Whitney U test indicated that the difference in improvement between the two groups was not statistically significant ($U = 29.000$; $Z = -1.589$; $p = 0.112$). These findings suggest that although interval training tended to produce greater improvements in aerobic endurance, both training methods resulted in relatively comparable improvements among adolescent basketball athletes.

The absence of a statistically significant difference between groups may be attributed to several factors. First, both interventions were implemented for the same duration and training frequency, allowing sufficient physiological adaptations in both groups. Second, the limited sample size may have reduced the statistical power to detect differences between interventions. Third, the baseline aerobic endurance scores differed significantly between groups, with the interval training group having higher initial VO_2Max values. Therefore, the superiority of one training method over the other cannot be conclusively established in the present study. This finding may be partially explained by previous studies, including the meta-analysis conducted by (Shamim 2021) which reported that HIIT tends to produce greater improvements in VO_2Max than moderate-intensity training. Although the interval training group in the present study demonstrated a greater mean improvement, the absence of a statistically significant between-group

difference suggests that the superiority of interval training cannot be confirmed under the current experimental conditions.

In terms of its characteristics, basketball is an intermittent sport that demands simultaneous work between the aerobic and anaerobic energy systems. Basketball players must sprint, stop suddenly, jump, and change direction in a short period of time and repeatedly. These characteristics are very suitable for interval training work patterns, which also consist of high-intensity work and short, repeated rest periods. According to (Muslim Bin Ilyas and Agus Sutriawan 2025), the suitability of training characteristics to the pattern of sports activity (*specificity principle*) is a major factor in the effectiveness of training in generating optimal physiological adaptation. Thus, the slightly greater improvement observed in the interval training group may be explained by the compatibility between the training stimulus and the specific physiological demands of basketball performance.

Overall, the findings suggest that interval training demonstrated a tendency toward greater improvements in aerobic endurance than circuit training, as supported by studies (Mallesh, Tn, and Vpr 2017)and (Mourgan et al. 2024), which found that *interval training* provides faster cardiovascular adaptation than conventional methods. however, the difference between the two interventions was not statistically significant (Cao et al. 2025); (Permadi, Adhi Putra, and Wahjuni 2020). Therefore, both methods can be considered comparably effective for improving aerobic endurance in adolescent basketball athletes.

However, this study has limitations because it was conducted in only one high school basketball club with a limited sample size. This situation requires caution in generalizing the results, especially to populations of athletes with different levels of training or physical condition. Motivational factors, variations in intensity between individuals, and training environment conditions can also influence the results of aerobic endurance improvements. Nevertheless, the findings provide empirical evidence that both interval training and circuit training are effective methods for improving aerobic endurance in adolescent basketball athletes. Further studies involving larger samples and more rigorous experimental designs are recommended to determine whether one training method provides superior benefits.

The results of this study have practical implications for coaches and physical education teachers. Both interval training and circuit training may be incorporated into conditioning programs for basketball athletes. Interval training can be prioritized when the objective is to mimic the intermittent physiological demands of basketball, whereas circuit training may be used to simultaneously develop aerobic endurance, muscular strength, and body stability. A combination of these two training methods can be applied periodically, for example through the use of *circuit training* during the general conditioning phase and *interval training* during the pre-competition phase to optimize the increase in aerobic capacity specific to the demands of the game.

CONCLUSION

Based on the results of this study, both interval training and circuit training significantly improved the aerobic endurance of basketball athletes. Although the interval training group demonstrated a slightly greater mean improvement than the circuit training group, the difference in improvement between groups was not statistically significant. Therefore, both training methods can be considered effective approaches for improving aerobic endurance in adolescent basketball athletes.

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