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INCREASING CARDIOVASCULAR ENDURANCE (VO2MAX) THROUGH HIGH INTENSITY INTERVAL TRAINING (HIIT) METHODE IN ATHLETES

Khalid Rijaluddin[1], Maria Herlinda Dos Santos[2], Alif Aryadi Hardi[3], Audri Kausar[4], Muh. Azwin[5],

[1]Universitas Muhammadiyah Bone, Sport Coaching Education, Bone, Indonesia
[2]Universitas Muhammadiyah Bone, Sport Coaching Education, Bone, Indonesia
[3]Universitas Negeri Makassar, Physical Education Health and Recreation, Makassar, Indonesia
[4]Universitas Muhammadiyah Bone, Sport Coaching Education, Bone, Indonesia
[5]Universitas Muhammadiyah Bone, Sport Coaching Education, Bone, Indonesia

*Coressponding Author. Email: alifaryadihardi@unm.ac.id
*Email Author: alifaryadihardi@unm.ac.id, khalidrijaluddin@unimbone.ac.id, audrikausar22@gmail.com, muh.aswin17@gmail.com

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Abstract
This study aims to determine the effect and effectiveness of the high-intensity interval training (HIIT) method on increasing cardiovascular endurance (VO2max) in athletes. This study used a quasi-experimental design. One group became the experimental group, and the other the control group. The research design used a nonequivalent control group design. The population in this study were all badminton athletes of the PB Kobar club, with a total of 24 people. Because the population size was less than 100, the sampling technique used a total sampling technique. So the sample of this study was 24 people. 12 people in the experimental group and 12 people in the control group. Each group (experimental and control) was given treatment with a frequency of 12 times, which was carried out 3 times a week. This study used a beep test as a research instrument. Data analysis used the Shapiro-Wilk test for data normality testing and Levene's test for data homogeneity testing. For hypothesis testing, the T-test (paired sample t-test) was used. The N-Gain score test was used to measure the effectiveness of the treatment using SPSS 27 software. The results showed that: (1) There was a significant effect on the cardiovascular endurance of athletes participating in high-intensity interval training (P<0.05). (2) There was a significant effect on the cardiovascular endurance of athletes participating in conventional training (P<0.05). (3) High-intensity interval training was more effective in increasing athletes' cardiovascular endurance with a percentage value of 59.67% compared to conventional training with a percentage value of 24.18%. It can be concluded that the application of the High-Intensity Interval Training (HIIT) method is more effective in increasing cardiovascular endurance compared to conventional training.
Keywords: Physical condition, cardiovascular, endurance, HIIT, Badminton

INTRODUCTION

Physical fitness is a fundamental factor that determines success in competitive sports, particularly in sports that demand high levels of endurance, speed, and technical proficiency. In

modern sports science, the development of athletes' physical components has become a primary focus of training programs, as optimal physical conditioning supports the effective execution of technical, tactical, and strategic skills during competition. Among various sports, badminton is characterized by high-intensity movements, rapid changes of direction, and prolonged rally durations, which require athletes to possess excellent cardiovascular endurance and overall physical fitness to maintain performance consistency.

Badminton is a very popular sport in Indonesia (Jayadi et al., 2024). This sport is enjoyed by people of all ages, from young to old, men and women (Anugrah et al., 2023). Badminton can be played anywhere, both indoors and outdoors. Badminton is a sport that uses a racket to hit a shuttlecock (Fadilla et al., 2024). The goal of the game is to send the shuttlecock over the net to the court to score points. Badminton is a competitive sport with complex training programs (Edmizal & Maifitri, 2021).

Athletes must be in prime physical condition to improve their performance (Plizga et al., 2024). A person's physical condition can be defined as the ability to engage in the functioning of body organs that facilitate psychomotor activity to enhance performance (Milana et al., 2022). Great skill is meaningless without excellent stamina. Optimal performance is influenced by a person's level of physical fitness (Afkhar, 2019).

A person's level of physical fitness is a crucial component of a training program. To help athletes achieve good performance, a physical fitness training program must be methodical and well-planned, aiming to improve the athlete's functional abilities and body systems (Hardi et al., 2024). Through physical fitness, mastery of technical skills, tactical and strategic abilities are essential for achieving sporting success (Susanto et al., 2024).

VO2max is a crucial physical component in badminton. VO2max is another term for cardiovascular endurance. VO2max is defined as the maximum oxygen consumption during prolonged physical activity without significant fatigue (Bansal, 2020). Factors including age, physical activity, body mass index, and exercise frequency and intensity influence a person's cardiovascular endurance, which is defined as the ability of the heart, lungs, and blood vessels to absorb, transport, and utilize oxygen (Husnul & Nida, 2021).

High-intensity interval training (HIIT) is a popular method for improving cardiovascular endurance (Fajrin et al., 2018). High-intensity interval training (HIIT) is a type of cardiovascular exercise that targets the development of fast-twitch muscle fibers by combining high-intensity exercise with a specific dose (Setiawan et al., 2024). High-intensity interval training (HIIT) is a training session interspersed with rest periods (Herlan & Komarudin, 2020).

In high-intensity interval training (HIIT), there are several things to consider, including: a)

the load or intensity of the training, b) the training time, c) the rotation of the training, and d) the internal recovery or rest periods during the training. If you want to adapt to the fast-paced nature of high-intensity interval training (HIIT), you must perform the training consistently (Holtzman & Ackerman, 2021). For those unfamiliar with such training, the short duration and strenuous nature of the training can be incredibly stressful. Furthermore, not everyone can handle the rigors of high-intensity interval training (HIIT).

Fundamentally, implementing a good and appropriate training program, particularly cardiovascular endurance training, is crucial. During observations of badminton athletes from the PB Kobar club, researchers observed that cardiovascular endurance training still used methods that tended to be monotonous and boring, leading to athletes feeling unmotivated and reluctant to perform. Therefore, researchers were interested in conducting this study in the hope of improving cardiovascular endurance in PB Kobar athletes, thereby achieving success.

METHODOLOGY

This study used a quasi-experimental design. A quasi-experimental design is a development of a true experimental design (Nugroho et al., 2021). Two or more groups are required for a quasi-experimental research design (Rusdy A Siroj, 2024). One group serves as the experimental group and the other as the control group, but the control group cannot fully control external variables that influence the implementation of the experiment. In this study, VO2max capacity serves as the dependent variable and high-intensity interval training (HIIT) as the independent variable. A nonequivalent control group design was used in this study (Maksum, 2012).

The population in this study was all 24 badminton athletes from the PB Kobar club. Because the population size was less than 100, the sampling technique used total sampling (Sugiyono, 2017). Therefore, the sample size of this study was 24 individuals: 12 individuals in the experimental group and 12 individuals in the control group. Each group (experimental and control) was given the treatment 12 times, three times a week.

Research instruments are very important for researchers. This study used the beep test (Dwitama & Wibowo, 2022). The following is how to administer the beep test: Test: First, the testee stands at the starting line and prepares to run from one point to the next following the beep. The testee must place one foot on or past the 20 m marker each time the beep sounds. If the testee arrives before the beep sounds, they must wait for the beep to continue the test/run. The testee tries to run as long as possible following the beep. The testee stops voluntarily or is stopped if the testee is no longer able to run following the beep, with the following conditions: a) Failure to reach the 20-meter line after the beep sounds. The assistant gives a tolerance of 2 chances. b) If during the

tolerance period the testee fails to adjust their running speed to the beep, they are stopped from the test.

The data analysis technique used descriptive statistics with the help of the computer program SPSS (Statistical Program for Social Science) 27.0. The Shapiro-Wilk test was used to test data normality and Levene's test to test data homogeneity. The paired sample t-test was used to test the hypothesis. The N-Gain score test was used to measure the effectiveness of the treatment.

RESULTS

The data obtained consisted of pretest data obtained before treatment and posttest data obtained after treatment. This data was then processed through a series of analyses intended to answer the research questions.

Table 3. Summary of data analysis of the athletes' cardiovascular endurance results.

Test	N	Minimum	Maximum	Mean	Standard Deviation
Pretest high-intensity interval training	12	33,1	36,1	34,4	1,053
Posttest high-intensity interval training	12	41,7	45,3	43,7	1,222
Pretest control	12	33,1	36	34,5	0,8595
Posttest control	12	36,2	40,8	38,2	1,4419

Based on the analysis of pretest and posttest data in the experimental group, the lowest pretest score for cardiovascular endurance among PB. Kobar athletes was 33.1, while the highest score was 36.1. The average cardiovascular endurance score for PB. Kobar athletes was 34.4 with a standard deviation of 1.053. The posttest score was 41.7 and the highest score was 45.3, with an average of 43.7 and a standard deviation of 1.222. Meanwhile, in the control group, the lowest pretest score for cardiovascular endurance among PB. Kobar athletes was 33.1, and the highest score was 36. The average cardiovascular endurance score for PB. Kobar athletes was 34.5 with a standard deviation of 0.8595. The posttest score was 36.2, and the highest score was 40.8, with an average of 38.2 and a standard deviation of 1.4419.

Furthermore, the study conducted several types of tests, including normality tests, homogeneity tests, hypothesis tests, and effectiveness tests. The results of data processing from the four tests can be seen in more detail in tables 4, 5, 6, and 7.

Table 4. Normality Test

Group	Test of Normality	Shapiro-Wilk		
		Statistic	df	Sig.
Experimental	Pretest	0,920	12	0.288
	Posttest	0,933	12	0.411
Control	Pretest	0,969	12	0.897
	Posttest	0,962	12	0.813

Based on Table 4, the pretest and posttest data for both the experimental and control groups were obtained with a sig. value >0.05, thus concluding that the data were normally distributed.

Table 5. Homogeneity Test

Test	Levene's Statistic	Df1	Df2	Sig.
Posttest	0,170	1	22	0,684

Based on Table 5, the posttest data of both groups were homogeneous (sig. > 0.05); therefore, hypothesis testing was conducted.

Table 6. T-Test Results

Test	Mean Difference	Sig.	Description
Pretest – Posttest high-intensity interval training	9,25	0,00	Significant
Pretest – Posttest control	3,72	0,00	Significant

Based on Table 6, the pretest and posttest data analysis shows that the high-intensity interval training and control groups had a significant effect, with significance values <0.05 for each.

Table 7. Effectiveness Test Results

Group	N-Gain Score	Category
Experimental	59,67%	Quite Effective
Control	24,18%	Not Effective

Based on Table 7, the N-Gain analysis shows that the experimental group achieved a quite effective improvement with an N-Gain value of 59.67%, while the control group showed an ineffective improvement with an N-Gain of 24.18%. Therefore, high-intensity interval training is effective in improving athletes' cardiovascular endurance.

DISCUSSION

Based on the data analysis, a significant difference was found between the experimental group, which received high-intensity interval training, and the control group, which underwent conventional or regular exercise. The greater increase in VO_2Max values in the experimental group indicates that high-intensity interval training is quite effective in improving cardiovascular endurance. Pretest results showed that the average VO_2max between the two groups was relatively insignificant, indicating that the initial conditions of the two groups were equivalent. The average VO_2Max in the experimental group before treatment was around 34.4 ml/kg/min, while in the control group it was 34.5 ml/kg/min. After four weeks of implementing the training program, a significant increase occurred in the experimental group, with the average VO_2max increasing to 43.7 ml/kg/min. The control group, on the other hand, experienced only a small increase to 38.2 ml/kg/min.

High-intensity interval training has been shown to provide a highly effective training stimulus because it involves high-intensity activity (80–95% of maximum heart rate) interspersed with rest periods. This training pattern forces the body to work at maximum capacity in a short period of time, triggering increased adaptation in the heart, lungs, and muscles. This aligns with research by Mappaompo (2025), which states that high-intensity interval training can improve aerobic capacity and athlete performance more efficiently than continuous moderate-intensity training. Furthermore, Rahmatulloh (2025) confirms that HIIT can increase oxidative capacity and energy metabolism efficiency, even in shorter training durations than conventional methods.

The significant improvement in the experimental group can be explained by the physiological mechanisms that occur during the training adaptation process. High-intensity training increases oxygen demand in the muscles, causing the body to adapt by strengthening the oxygen transport system. Increased blood volume pumped by the heart, increased hemoglobin capacity, and pulmonary ventilation efficiency are all adaptive responses to high workloads. Furthermore, HIIT also increases the activity of oxidative enzymes in muscles, which play a role in aerobic energy production.

In the control group, although there was a slight increase in VO_2max, this was due to the regular training activity that maintained the athletes' baseline fitness. However, because the training intensity was relatively stable and did not reach the maximum work zone, the physiological adaptations that occurred were not as significant as in the experimental group. This suggests that to produce significant improvements in cardiovascular endurance, a training stimulus that exceeds the body's adaptation threshold is required, such as that provided by the HIIT method.

Overall, this study demonstrates that high-intensity interval training (HIIT) has a significant

effect on increasing athletes' cardiovascular endurance (VO_2max) compared to conventional training. The significant increase in the experimental group compared to the control group indicates that HIIT is able to provide a more optimal training stimulus to the cardiovascular system and the body's energy metabolism. Therefore, HIIT can be recommended as an effective training method for improving athletes' physical performance in various endurance sports.

In addition to the observed improvements in VO_2max, the implementation of high-intensity interval training (HIIT) also offers practical advantages in the context of sports training programs. HIIT is characterized by relatively shorter training durations compared to conventional endurance training, making it time-efficient without compromising training outcomes. This efficiency is particularly beneficial for athletes who must balance physical conditioning with technical and tactical training demands. By optimizing training time, HIIT allows coaches to design more comprehensive training programs that address multiple performance components simultaneously while still ensuring significant improvements in cardiovascular endurance.

Moreover, the findings of this study have important implications for coaches and practitioners in selecting appropriate training methods based on athletes' physiological needs. The substantial increase in VO_2max in the experimental group suggests that HIIT can be strategically integrated into periodized training programs, especially during phases aimed at enhancing aerobic capacity. However, it is essential to consider individual athlete characteristics, such as training experience, fitness level, and recovery capacity, to minimize the risk of overtraining or injury. Therefore, while HIIT is proven to be effective, its application should be carefully planned and supervised to maximize benefits and ensure long-term athletic development.

CONCLUSION

Based on the research results, it can be concluded that High-Intensity Interval Training (HIIT) significantly improves athletes' cardiovascular endurance (VO_2Max) and is more effective than conventional training. This is shown by the greater increase in VO_2Max in the experimental group compared to the control group. The improvement indicates that HIIT provides an effective training stimulus to enhance the function of the heart, lungs, and muscles, as well as the body's efficiency in using oxygen during physical activity. These effects are driven by physiological adaptations resulting from high-intensity exercise. Therefore, HIIT can be recommended as an efficient training method to improve cardiovascular endurance, particularly for athletes who require strength, speed, and aerobic capacity, and can be effectively integrated into regular training programs within a shorter time frame.

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