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The Effect of Intensive Interval Training on Cardiovascular Endurance (Vo2max) in Badminton Athletes from The Mahmuda Club in Padang

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Abstrac: This study aims to determine the effect of high-intensity interval training (HIIT) on the cardiovascular endurance (VO_2Max) of badminton athletes from the Mahmuda Club in Padang. The research method used was an experimental study with a one-group pretest-posttest design. The study sample consisted of 10 athletes. The instrument used in this study was the Multistage Fitness Test (Bleep Test) to measure VO_2Max. Data analysis employed a paired-sample t-test. The results indicated an increase in the mean VO_2Max value from 34.96 at the pretest to 36.29 at the posttest. Based on the statistical test results, a significance value (Sig. 2-tailed) of 0.000 < 0.05 was obtained, indicating that there is a significant effect of high-intensity interval training (HIIT) on the improvement of cardiovascular endurance (VO_2Max) in athletes. Thus, the high-intensity interval training (HIIT) method is effective for improving the cardiovascular endurance of badminton athletes.

Keyword: Badminton, Cardiovascular endurance, HIIT, High-intensity interval training, VO_2Max

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INTRODUCTION

Physical activities such as sports are no longer merely a hobby; they have become an integral part of modern society's lifestyle. Physical exercise, when performed in a planned, routine, and consistent manner, aims to improve physical fitness, health, and individual performance. Regular exercise has been proven to improve organ function, enhance quality of life, and provide positive psychological effects, such as reducing stress and boosting self-confidence (Ganguly et al., 2020; Thacker, 2025). In the realm of competitive sports, physical training serves as the primary foundation for achieving peak athletic performance (Bangsbo, 2015).

Badminton is a popular sport played with a racket and shuttlecock to conquer the opponent's court. The game demands a complex combination of physical abilities such as speed, agility, strength, explosive power, coordination, and cardiovascular endurance. Due to its intermittent nature, athletes must maintain a high and rhythmic intensity throughout the game (Edel et al., 2024). During a match, an athlete's heart rate can reach 80–90% of their maximum capacity, reflecting a heavy load on the cardiovascular system (Cádiz Gallardo et al., 2023). Without adequate endurance, fatigue sets in quickly, thereby affecting the speed and accuracy of shots.

VO_2Max is a key indicator of cardiovascular endurance, reflecting the body's ability to absorb oxygen during intense activity. Elite badminton athletes have a VO_2Max of 55–65 ml/kg/min, while regional athletes range from 40–50 ml/kg/min (Tai et al., 2022). A high VO_2Max ensures that athletes can sustain performance throughout long matches, even up to three sets. Reality on the court shows that athletes do not yet possess maximum cardiovascular endurance. From initial observations of badminton players at the Mahmuda Club in Padang, it is evident that they tire easily in the middle to late stages of training, marked by declining physical performance and longer recovery times. The current training program focuses more on technique and strategy, while the development of VO_2Max has not been systematically addressed.

One way to improve cardiovascular endurance is through interval training, which combines work and rest phases at specific intensities to enhance cardiac and pulmonary efficiency (Fentaw et al., 2025; García-De Frutos et al., 2021). This study employed High-Intensity Interval Training (HIIT) at an intensity of approximately 80–95% of HRmax, consistent with the demands of repetitive explosive movements in badminton.

Although this method is popular, no previous study has specifically assessed the effects of interval training on the VO_2Max of athletes at the Mahmuda Club in Padang. This gap in the literature prompted the researchers to investigate the effectiveness of this method in improving athletes' physical capacity. Therefore, the objective of this study is to analyze the effect of interval training on improving the VO_2Max of badminton athletes at the Mahmuda Club in Padang, with the hope that it can serve as a practical guide for more efficient training programs.

METHOD

This study collected primary data directly through measurements of cardiovascular capacity (VO_2Max) among badminton athletes at the Mahmuda Club in Padang. The study was conducted at the Mahmuda Club Badminton Court from April to May 2026. The population consisted of all 21 athletes in the club, and the sample was selected purposively based on the criteria of being 14–18 years old and actively training. The instrument used was the Bleep Test (Multistage Fitness Test) to measure VO_2Max, which involved running back and forth over a 20-meter distance in accordance with an increasing beep rhythm. The results were measured in ml/kg/minute using a standard conversion table. The research method was based on quantitative experimentation with the implementation of an interval training program to observe its impact on VO_2Max. This study used a One-Group Pretest–Posttest design, in which a single group underwent a pretest, the intervention, and a posttest to monitor changes resulting from the intervention. The analysis was conducted in several stages.

1. Research Design

This study employs a quantitative approach using a quasi-experimental method. The design used is a one-group pretest-posttest design. In this design, the research participants are

not compared to a control group but are evaluated against their own baseline performance based on measurements taken before and after the intervention. Structurally, the research design can be described as follows:

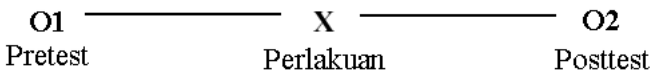

Figure 1. Research Design Diagram

Description:
O_1 = Pretest (VO_2Max measurement before treatment)
X = Treatment consisting of intensive interval training over 16 sessions
(4 weeks × 4 times/week)
O_2 = Posttest (VO_2Max measurement after treatment)

2. Normality Test (Shapiro-Wilk)

The Shapiro–Wilk (SW) test is often relied upon to test for normality, thanks to its robustness, especially when the sample size is not very large

Before proceeding to parametric tests such as the t-test or ANOVA, the Shapiro–Wilk test is used to check whether the data "conforms" to a normal distribution (Khatun, 2021).

Hypotheses:

a) H_0: The data is normally distributed
b) H_1: The data is not normally distributed

Mathematically, the Shapiro-Wilk test is formulated as:

$$W = \frac{(\sum a_i x_i)^2}{\sum (x_i - \bar{x})^2}$$

Test criteria:

If Sig. > 0.05, then the data is normally distributed.

3. Hypothesis Testing (Paired-Sample t-Test)

The paired-sample t-test is used to test hypotheses when comparing two means derived from paired data, rather than from separate groups (Pandis, 2015). Assuming the data follow a normal distribution, the paired-sample t-test was applied to examine the effect of interval training on VO_2Max.

Hypotheses:

a) H_0: There is no effect of interval training on VO_2Max
b) H_1: There is an effect of interval training on VO_2Max

T-Test Formula:

$$t = \frac{M_d}{\sqrt{\frac{\sum X_d^2}{N(N-1)}}}$$

Description:
Md = Mean difference between pre-test and post-test scores.
Xd = Deviation for each subject.
$\sum Xd^2$ = Sum of squares of deviations.
N = Number of subjects.
Df = Degrees of freedom, i.e., N – 1
Hypothesis criteria:
Sig. < 0.05 → significant effect
Sig. > 0.05 → non-significant effect
Non-normal data → use the Wilcoxon Signed Rank Test.

RESULT

This study was conducted at the Mahmuda Club in Padang, on the club's badminton court, from April to May 2026. Ten athletes participated in 16 training sessions using the HIIT method. The pre-test results showed that the athletes' average VO2Max was 34.96 ml/kg/min, with a minimum of 27.60 and a maximum of 47.10. Following the HIIT intervention, the post-test revealed an increase in the average VO2Max value to 36.29 ml/kg/min, with a minimum of 29.10 and a maximum of 48.40, indicating a significant cardiovascular improvement.

The Shapiro-Wilk test indicated data normality with a pre-test value of 0.935 (p=0.495) and a post-test value of 0.926 (p=0.408), thus the data distribution was considered normal.
The results of the paired sample t-test yielded t = -8.109 and sig = 0.000. With $p < 0.05$, H0 was rejected, proving that HIIT has a significant effect on increasing the VO2Max of badminton athletes at the Mahmuda Club.

DISCUSSION

Based on the results of this study, it can be concluded that the application of the High-Intensity Interval Training (HIIT) method has a positive impact on improving the aerobic capacity (VO_2Max) of badminton athletes at the Mahmuda Club in Padang. Conceptually, physical training is the primary foundation for improving athletic performance, particularly in sports that demand a combination of complex physical abilities, such as badminton. HIIT, as a form of modern interval training, combines periods of high-intensity work (approximately 80–95% of HRmax) with periods of active recovery, thereby stimulating physiological adaptations in the cardiovascular and respiratory systems. These adaptations include increased cardiac output (stroke volume), improved oxygen utilization efficiency by muscles, and increased capillary and mitochondrial density (García-De Frutos et al., 2021; Fentaw et al., 2025). Thus, HIIT is highly relevant for badminton, a sport characterized by fast, explosive, and repetitive (intermittent) movements.

The results of this study show an increase in the average VO_2Max from 34.96 to 36.29 ml/kg/min following HIIT training, with a p-value of $0.000 < 0.05$. These findings indicate that HIIT training is effective in significantly improving athletes' cardiovascular endurance. Physiologically, the increase in VO_2Max occurs because the body adapts to the repeated high-intensity training loads. This adaptation includes an increase in the heart's ability to pump blood, an increase in blood volume, and an improvement in the muscles' ability to extract and utilize oxygen (Edel et al., 2024). These results align with recent research by Astuti et al. (2022), which found that a 4–6-week HIIT program significantly improved the VO_2Max of athletes in team sports. Additionally, research by Pratama and Nugroho (2023) also demonstrated that high-intensity interval training is more effective than continuous exercise in improving the aerobic capacity of adolescent athletes.

In the context of badminton, improving VO_2Max plays a crucial role due to the intermittent nature of the game, which involves alternating between periods of high-intensity activity and brief recovery phases. Athletes with high VO_2Max tend to recover more quickly after long rallies, allowing them to maintain intensity throughout the match. Additionally, good cardiovascular endurance contributes to technical stability, movement speed, and shot accuracy, particularly in the late stages of a match when fatigue sets in (Cádiz Gallardo et al., 2023). Research by Hidayat et al. (2021) also confirms that a high VO_2Max is positively correlated with technical performance and consistency in badminton players.

Furthermore, the effectiveness of HIIT in this study can also be explained by the principle of training specificity, whereby training patterns that mimic the demands of a match will result in more optimal adaptations. HIIT, with its high intensity and relatively short rest periods, mirrors the actual conditions of a badminton match. This is supported by research by Putra et al. (2024), which states that high-intensity interval training is capable of improving the physical performance and match readiness of badminton athletes more effectively than conventional methods.

Thus, the results of this study not only demonstrate a statistically significant increase in VO_2Max but also have practical implications for the design of training programs. HIIT can serve

as an efficient and effective training method for improving the aerobic endurance of badminton athletes, particularly at the club level. However, its implementation must still take into account the principles of exercise individualization, such as age, initial fitness level, and the athlete's recovery capacity, so that optimal results can be achieved and the risk of injury can be minimized.

CONCLUSION

This study concludes that the implementation of High-Intensity Interval Training (HIIT) has a significant effect on improving the VO_2Max of badminton athletes at Klub Mahmuda, Padang. The results showed an increase in the average VO_2Max value from 34.96 in the pre-test to 36.29 in the post-test, with a significance value of 0.000 < 0.05. This indicates that HIIT is an effective training method for enhancing cardiovascular endurance. The improvement occurs due to physiological adaptations in the cardiovascular and respiratory systems, enabling athletes to utilize oxygen more efficiently during high-intensity and intermittent activities typical of badminton matches.

From a practical perspective, improved VO_2Max contributes to better endurance, faster recovery, and more consistent performance throughout the game, especially during long rallies and decisive match situations. Therefore, coaches are recommended to incorporate HIIT systematically into training programs to optimize athletes' physical performance. For future research, it is suggested to involve a larger sample size and include a control group to strengthen the validity of the findings. Additionally, further studies may explore the combination of HIIT with other training methods or examine its effects on other physical components such as agility, speed, and muscular endurance in badminton athletes.

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