



Effect of High-Intensity Interval Training (HIIT) on Increasing VO₂max in Pemalang Futsal Athletes

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Keywords

HIIT, VO₂Max, futsal,
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Abstract

This study analyzes the effect of High Intensity Interval Training (HIIT) on VO₂max capacity in futsal athletes at Corner Futsal Academy, Pemalang. Using an experimental pretest-posttest one-group design, 25 athletes were selected through total sampling. VO₂max was measured using the Multistage Fitness Test. The HIIT program was conducted for 8 weeks, twice weekly (16 sessions). Results showed VO₂max increased from 40.81 ± 5.64 to 44.38 ± 5.74 mL/kg/min (3.57 mL/kg/min; 8.7%). The Wilcoxon test indicated significant improvement ($Z = -3.87$; $p < 0.001$; $r = 0.77$). However, N-Gain analysis showed 5.9%, categorized as ineffective. It is concluded that HIIT significantly affects VO₂max, but practical effectiveness needs optimization through increased frequency, duration, or intensity control.

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INTRODUCTION

Futsal is a fast-growing sport and is very popular among various circles, especially teenagers and athletes of productive age. The sport is played by two teams of five players each, and the game is characterized by fast and dynamic play, which requires an optimal combination of technique, tactics, mentality, and physical fitness (Figueiredo Machado et al., 2023). As an intermittent sport, futsal requires players to perform high-intensity activities repeatedly in a relatively short period of time, such as running, changing direction, pressing, switching between attack and defense, and making quick decisions under the pressure of opponents. In futsal, physical fitness is a key factor in determining the success of athletes in maintaining performance throughout the match. One of the important components of physical fitness is cardiorespiratory endurance, which is closely related to aerobic capacity, or VO₂Max (Saadoon Hussein, 2022). VO₂Max is the body's maximum ability to consume oxygen during sustained intensive physical activity. The higher the athlete's VO₂Max, the better their body's ability to supply oxygen to the working muscles, allowing them to maintain an intensive game for longer without experiencing excessive fatigue. Low VO₂Max in futsal athletes can lead to a decrease in performance, especially towards the end of the match. This is characterized by decreased concentration, increased passing errors, poor ball control, slow transitions, and decreased effectiveness of the coach's strategy. This condition is a serious obstacle to achieving maximum performance, as physical fatigue significantly affects the quality of technique and decision-making of players on the pitch (Sekulic et al., 2021).

Based on observations at the Pemalang Futsal Corner, it was found that many players experienced fatigue in the last minutes of the match. Despite their technical abilities and potential to compete in various competitions, the players still show weaknesses in aerobic endurance. This can be seen from the frequent occurrence of fundamental errors such as inaccurate passes, decreased ball control, and delays in the transition from defense to attack and vice versa. This condition shows that the athlete's VO₂Max capacity is still suboptimal and needs to be improved through a proper training program. One of the training methods that is considered effective in increasing VO₂Max is *High-intensity interval training* (HIIT). HIIT is a training method that combines high-intensity training with a period of low to moderate intensity active recovery in a specific time interval (Balci et al., 2022). This method can maximize heart and lung function, increase oxygen consumption, speed up metabolism, and increase the aerobic and anaerobic capacity of athletes. In addition, HIIT offers the advantage of better workout time usage efficiency while providing significant results in improving physical fitness (Stöggl et al., 2023).

HIIT treatment consists of three main stages, namely warm-up, high-intensity core training, and cool-down. In practice, athletes perform multiple cycles of maximum intensity training at 80-90% of their heart rate, interspersed with moderate-intensity training at 50-60% of their heart rate. This pattern of training fits perfectly with the characteristics of futsal, which demands repetitive explosive activity with a short recovery time. Therefore, HIIT is considered a relevant training method to improve the performance of futsal athletes, especially in terms of cardiorespiratory endurance (Hesketh et al., 2021). Based on these problems, this study was conducted to analyze the effect of High Intensity Interval Training (HIIT) on increasing VO₂Max in futsal athletes at Corner Futsal Pemalang. This research is expected to make a scientific contribution to the development of effective physical training methods for futsal athletes, as well as a practical reference for coaches in developing appropriate training programs to optimally improve athletes' fitness, performance, and achievement.

METHODS

This study uses a quantitative approach with a pre-experimental design, specifically a one-group pretest-posttest design. This design was chosen because all the athletes are in the same team and actively train together, making it difficult to form a control group without interfering with the main training program. Nonetheless, repeated measurements were taken before and after treatment to identify changes resulting from the training intervention. This research was conducted at Corner Futsal Pemalang, Pemalang Regency, for 8 weeks. The study population consisted of 25 active futsal athletes, and the entire population was sampled using the total sampling technique. All participants are male and regularly participate in team training programs.

The instrument used to measure $VO_{2\max}$ capacity is the Multistage Fitness Test (MFT) or bip test, which has a validity level of 0.92 and a reliability level of 0.96. Measurements are taken twice, before treatment (pretest) and after treatment (posttest), to determine changes in the aerobic capacity of athletes.

The treatment program consisted of 16 sessions of High-Intensity Interval Training (HIIT) during the study period. Each session consists of three phases: a 10-minute warm-up, a 20–25 minute HIIT core workout, and a 5–10 minute cool-down. Core exercises are performed using an interval pattern: 30 seconds of high-intensity work at 80–90% of the maximum heart rate, followed by 30 seconds of active recovery at 50–60% intensity. Each training session consists of 2–3 sets of 6–8 reps each, with a 2-minute rest period between sets. The exercises used include functional movements such as jumping jacks, high knees, burpees, mountain climbers, squat jumps, and short sprints, which gradually increase from light to high intensity during the training period. Improvements are made by gradually increasing the number of reps and sets each week. Throughout the study, athletes were required to attend all scheduled training sessions and maintain consistent physical activity outside of the training program. However, variables such as diet, rest quality, and additional activities outside of exercise could not be completely controlled and were a limitation of this study. The data obtained was analyzed using descriptive statistics to determine the average and distribution of the data. Normality was tested using the Shapiro-Wilk test. Because the change data is not distributed normally, the Wilcoxon test is used to test the difference between the pretest and the posttest at a significance level of 0.05. The effect size is calculated using the formula $r = Z/\sqrt{N}$. Furthermore, N-Gain analysis is used to evaluate the practical effectiveness of the exercise program.

RESULTS AND DISCUSSION

This research was conducted at the Pemalang Futsal Corner, Pemalang Regency, from February to March 2026. The study began with a pretest to measure the athlete's initial $VO_{2\max}$ capacity. Then followed by *High Intensity Interval Training* (HIIT) exercises, and ended with a posttest to determine the increase in $VO_{2\max}$ after treatment. The study lasted for 8 weeks, with exercises twice a week, on Fridays and Sundays, with a total of 16 meetings. The exercise program is given gradually, with light, medium, and high intensity to increase the cardiorespiratory endurance of the athlete.

Data on the results of the pretest and posttest of cardiovascular endurance ($VO_{2\max}$) using the Multistage Fitness Test instrument conducted on 25 Corner Futsal athletes. Posttest scores are generally higher than pretest scores, indicating a consistent positive response to the HIIT program.

Table 1. Descriptive statistics of $VO_{2\max}$ scores

Variabel	n	Average +/- SD	Median	Min-Max
Pretest	25	40.81 +/- 5.64	40.5	28.7 - 53.1
Posttest	25	44.38 +/- 5.74	43.9	35.7 - 58.5
Changes	25	3.57 +/- 3.69	3.4	-3.1 - 16.3

Descriptively, the average $VO_{2\max}$ increased from 40.81 +/- 5.64 mL/kg/min in the pretest to 44.38 +/- 5.74 mL/kg/min in the posttest. The average increase was 3.57 +/- 3.69 mL/kg/min, equivalent to an 8.7% increase at the group level. Practically, 22 athletes (88%) improved, 1 athlete remained unchanged, and 2 athletes showed a slight decrease. This pattern suggests that the intervention benefited most participants although the magnitude of improvement varied from individual to individual.

Table 2. Normality testing and hypothesis

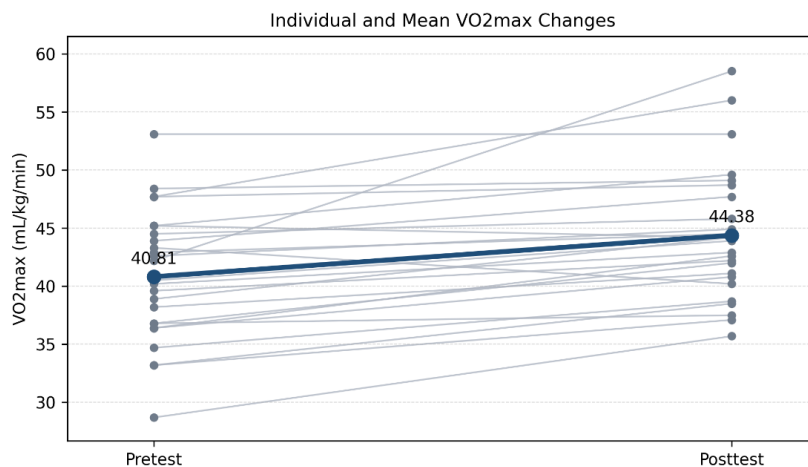
Analysis	Statistics	p	Interpretation
Pretest Shapiro-Wilk	W = 0.991	0.997	Normal
Posttest Wilk Shapiro-Wilk	W = 0.946	0.203	Normal
Change Shapiro-Wilk	W = 0.888	0.010	Abnormal
Wilcoxon signs with the rank W = 14.5; Z = -3.87; r = 0.77 < 0.001 Significant improvement			

Normality testing showed that the pretest score (W = 0.991, p = 0.997) and the posttest score (W = 0.946, p = 0.203) were distributed normally, while the change score (W = 0.888, p = 0.010) was not. Therefore, the Wilcoxon-marked rating test was used as the primary inferential test and confirmed a significant increase in VO₂max (W = 14.5, Z = -3.87, p < 0.001, r = 0.77). As a durability check.

Table 3. N-Gain Descriptive

Descriptive N_Gain Test				
Experimental Group	Mean	Minimum	Maximum	Range
	5,9048	-5,47	28,2	33,67

Based on the results of the calculation of the N-gain Score Test above, it was found that the average score for the experimental class (*High Intensity Interval Training*) was 5.9048 or 5.9% included in the ineffective category. With a minimum value of -5.47 and a maximum of 28.2. Thus, it can be concluded that HIIT training in 16 meetings is not effective in improving VO₂max results in Pemalang Corner Futsal players.

**Figure 1.** Individual and average VO₂max changes

Most of the cuts are upwards, which means that the increase is not driven by just a few athletes. The images also show an upward shift in group averages, supporting the conclusion that HIIT interventions improve aerobic fitness at the team level.

The results of the study show that *High-intensity interval training* (HIIT) which is carried out for 16 sessions in 8 weeks has a positive effect in increasing the VO₂max capacity of futsal athletes at Corner Futsal Pemalang. Descriptively, there was an increase in the average VO₂max from 40.81 mL/kg/min in the pretest to 44.38 mL/kg/min in the posttest, which showed a difference of 3.57 mL/kg/min or about 8.7%. This increase showed a physiological adaptation to the athlete's cardiorespiratory system after following a HIIT treatment program, in line with the findings stating

that *High-intensity interval training* can increase aerobic capacity by improving the efficiency of transportation and oxygen utilization in the body (Wu et al., 2026). Statistically, the Wilcoxon test showed a significance value of $p < 0.001$ with a Z-value of -3.87 and an effect size (r) of 0.77, which was considered large. This confirms that HIIT training significantly increases the athlete's VO_{2max} . These findings support the theory that repetitive high-intensity exercise with active recovery rest can improve the efficiency of heart and lung function and the body's ability to utilize oxygen optimally (Way et al., 2026).

The increase in VO_{2max} in this study can be explained by several physiological mechanisms, such as increased heart rate, increased muscle capillaries, and increased activity of oxidative enzymes that play a role in aerobic metabolism. This adaptation allows the body to transport and utilize oxygen more efficiently during repetitive and high-intensity physical activity. (Ma et al., 2023). This is especially relevant to the characteristics of futsal, which requires athletes to run, press, and transition alternately throughout the game. By increasing VO_{2max} , athletes can maintain longer performance and delay fatigue in the final phase of the game (Li et al., 2023). In the context of training, progressively structured and repetitive programs have been shown to significantly improve the physical abilities of athletes (Irwanto et al., 2022). In addition, variations in exercise intensity also make an important contribution to improving physical fitness as it determines the amount of adaptive stimuli received by the body (Sari & Putra, 2021). However, the N-Gain analysis showed an average increase of only 5.9%, which was considered ineffective. These findings show a difference between the statistical significance and practical effectiveness of such improvements. Statistically, HIIT workouts are able to produce consistent changes in most athletes, but the relative magnitude of the increase is not considered high. This condition suggests that the stimulation of exercise given is sufficient to induce early adaptation, but does not achieve *Overload threshold* optimal to produce a significant increase in aerobic capacity. One of the reasons is that the frequency of training is only twice a week with a total of 16 sessions, so the cumulative volume of training received by athletes is still relatively limited (Nindorera et al., 2025).

More substantial increases in VO_{2max} through HIIT generally occur in programs with higher frequency, longer intervention durations, and consistent intensity control in the $HR_{max} > 90\%$ zone. Therefore, although the interventions in this study were sufficient to produce a significant difference, the total training dose was not strong enough to produce improvements that could be considered practically effective (Ma et al., 2023). The ineffectiveness of the N-Gain value can also be affected by the athlete's initial aerobic capacity, which is already in the moderate category, with an average of 40.81 mL/kg/min. In the theory of training adaptation, the principle *Reduced returns or ceiling effects*, i.e. the better the athlete's initial fitness condition, the smaller the percentage of improvement that can be achieved through short-term interventions. In accordance with the principle of reduced returns, athletes who already have basic aerobic fitness will show a more gradual increase in VO_{2max} as some central and peripheral adaptations have been established (Saadoon Hussein, 2022). It is emphasized that individuals who have been actively practicing tend to experience a gradual increase in VO_{2max} because their oxygen transport system and metabolic function have undergone previous adaptations. This results in a narrower window for physiological improvement compared to subjects with lower baseline fitness. Therefore, the absolute increase of 3.57 mL/kg/min in this study actually showed a positive response, but if calculated using the relative improvement score approach, the percentage still seems low. In addition, low N-Gain is also associated with variations in individual responses among athletes. The data shows that while most athletes experience improvement, some experience small, stagnant, or even slight declines. This phenomenon is known as *Inter-individual variability in response to training*, which refers to the difference in the body's ability to adapt to the same exercise stimulus (Sarkar et al., 2021). N-Gain analysis on physiological variables such as VO_{2max} also has a lower sensitivity compared to the study of learning outcomes, since the maximum physiological capacity of each individual is not absolute (Lee & Zhang, 2021).

The results of this study are in line with previous research that showed that HIIT is an effective training method to increase aerobic capacity in various sports, including futsal, basketball, and football (Kumari et al., 2023). HIIT is also known to offer an advantage in terms of time efficiency without sacrificing the effectiveness of results (Stöggl et al., 2023). However, the

study has limitations, including a lack of control groups and a lack of objective monitoring of exercise intensity, such as the use of *Heart Rate Monitor*. Therefore, further research is recommended to use a more robust experimental design and include other performance variables such as speed, agility, and sprint repeatability to provide a more comprehensive picture (de Andrade et al., 2021). Overall, the results of this study show that HIIT training has a significant effect in increasing VO₂max in futsal athletes, although its practical effectiveness still needs to be optimized through a more systematic and measurable training program.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the High Intensity Interval Training (HIIT) program which was carried out for 16 sessions in 8 weeks significantly increased the VO₂max capacity of futsal athletes at Corner Futsal Pemalang. This is evidenced by the Wilcoxon test which shows a p value of <0.001 with an increase in the average VO₂Max from 40.81 mL/kg/min to 44.38 mL/kg/min. However, based on the results of the N-Gain test, an average value of 5.9048% was obtained, which is included in the ineffective category, the level of increase in VO₂max obtained is still relatively low and practically ineffective. This suggests that although HIIT is able to significantly increase aerobic capacity, the magnitude of the increase is not optimal. This is likely to be influenced by relatively short duration of exercise, limited frequency of exercise, and variations in individual responses to exercise programs. Therefore, it can be concluded that HIIT training is statistically effective in increasing VO₂max in futsal athletes. However, its implementation still requires optimization to achieve maximum results practically.

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