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The Impact of High-Intensity Interval Training (HIIT) on VO_2Max Improvement in Futsal Athletes

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ABSTRACT

Physical condition is defined as a person's physical ability or capacity to work or exercise. One component of physical fitness is cardiorespiratory endurance, or VO_2 max. VO_2Max, short for maximum aerobic capacity, is typically expressed as the maximal oxygen uptake (VO_2Max). In essence, aerobic capacity is the extent of an athlete's motor ability derived from the aerobic process. VO2max is a measure of an individual's endurance, particularly aerobic endurance, which requires sufficient oxygen supply for aerobic energy metabolism. The purpose of this study is to determine the effect of HIIT on improving VO_2Max in futsal athletes. The research method was an experimental pre-posttest one-group design. Data were obtained through VO_2 max measurements after HIIT implementation using the Harvard Step Test and analyzed using SPSS. Conclusion: The results showed that HIIT increased VO_2Max in Venus Academy futsal athletes in Tembalang.
Keywords: Harvard Step Test, VO_2 max, HIIT

BACKGROUND

Physical activity is an integral part of life. People have different reasons for exercising: some for health, some for performance, and some for recreation. One of the most important national development goals in the field of sports is to enhance athletic performance through the systematic development of talented athletes across the entire country. Consistent, structured, and integrated efforts to nurture athletes based on their interests produce high-performing athletes. Achievement refers to the best abilities and skills an athlete or team demonstrates during training, competitions, or matches. However, achievement is influenced by several factors. These factors can be internal or external. Internal factors include an athlete's physical ability, technique, tactics, and mental state. External factors arise from outside the athlete and include coaches, facilities, family, weather conditions, and access to nutritious food. Among these various factors, physical condition is considered to be the most important for an athlete to possess, as an athlete's performance in competition is largely determined by their physical condition. Physical condition is a measure of good performance and a crucial component of fitness for athletes (Subagiyo, 2021).

VO_2Max is the term used to describe one component of physical condition: cardiac endurance. VO_2Max is the maximum volume of oxygen that the body can consume within a given time period (mL/kg/min). Aerobic capacity describes an athlete's motor skills during aerobic processes. VO_2 max is the body's ability to process oxygen during high-intensity exercise. In other words, it is an individual's optimized ability to utilize oxygen during work or exercise. Maximum work capacity (VO_2 max) is the maximum level of oxygen the body can use and maintain (Parwata, 2022). VO_2max is the ability of the lungs and heart to absorb and process oxygen, enabling the body to perform physical activities and sports that involve large muscles over an extended period without feeling completely fatigued (Pranata, 2020). Umar (2014) states that the level of VO_2 max affects an individual's endurance, particularly aerobic endurance, as aerobic endurance requires an adequate oxygen supply for aerobic energy metabolism. Therefore, to have high aerobic endurance, one must also have a high VO_2Max. Several factors can influence VO_2 max values, including age, gender, temperature, and physical exercise (Bafirman, 2013).

One type of exercise that can be used is HIIT (High-Intensity Interval Training). HIIT combines high-intensity exercises with moderate or low-intensity exercises. Performed within a specific time frame, this training stimulates the heart to work harder, thereby increasing oxygen consumption and boosting metabolism (Kravitz, 2014). Examples of exercises that can be performed using HIIT include walking, running, cycling, stair climbing, and swimming. HIIT consists of three stages: a warm-up, maximum-intensity exercise, and a cool-down. The warm-up lasts 3 minutes, followed by six cycles. Each cycle consists of two minutes of maximum-intensity exercise at 80–90% of the reserve heart rate and one minute of moderate-intensity exercise at 50–60% of the reserve heart rate.

The exercise concludes with a 3-minute cool-down period. HIIT can serve as an alternative to traditional aerobic exercise. It has the ability to increase VO_2Max and metabolic enzyme activity. This can happen in a relatively shorter exercise period (20–30 minutes) (Nugraha, 2017).

HIIT affects the body, particularly blood pressure, hormones, blood glucose, lactate levels, and the autonomic nervous system. In the cardiovascular system, HIIT can cause physiological thickening of the left ventricular myocardium of the heart, thereby increasing the strength and ability of the heart to pump blood with each contraction and reducing the number of heartbeats per minute (Nugraha, 2017). This study used the Harvard Step Test (stair climbing) to evaluate physical fitness, which reflects the heart, lungs, and blood vessels' ability to deliver oxygen to working muscles and tissues, as well as those muscles' and tissues' ability to utilize that oxygen. The objectives of the fitness test (Harvard Step Test) include determining an individual's physical ability/strength to perform a task (determining work capacity). Additionally, it is useful for assessing physical fitness levels based on heart rate frequency (Tkachenko, 2019).

Current research on HIIT confirms its efficacy in improving individual strength and promoting muscle hypertrophy (muscle growth) in athletes (Garcia, et al 2023). HIIT activates fast-twitch muscle fibers, which are responsible for generating high levels of strength and power. This activation promotes muscle adaptation and an increase in strength [Parpa, 2022). Additionally, HIIT stimulates the production of anabolic hormones like testosterone and growth hormone, which are instrumental in muscle protein synthesis and, consequently, in muscle growth and hypertrophy (Cadiz, et al. 2023). HIIT also induces metabolic stress and causes micro tears in muscle fibers, triggering physiological responses that promote anabolic signaling and growth factors, leading to increased muscle strength and hypertrophy (Tschakert, et al. 2023). HIIT engages both aerobic and anaerobic energy systems, offering athletes the opportunity to enhance their speed and power in sports by targeting high-strength muscle fibers (Chen 2023).

METHOD

This study used an experimental design with a pre-posttest one-group design to determine the effect of HIIT on VO_2Max improvement in futsal athletes. The study population was all futsal athletes at Venus Academy. The study took place at the academy in Tembalang. The study was conducted in three sessions (pre-test and post-test) in November 2023. Data were collected in the form of VO_2 max measurements using the Harvard Step Test. The data obtained in this study were analyzed using SPSS.

RESULTS

The study on the effect of HIIT on improving VO_2 max in Venus Academy futsal athletes in Tembalang was conducted three times in November 2023. The data description consists of characteristics of the study respondents in diagram form. The following describes the characteristics of the respondents, including age and gender.

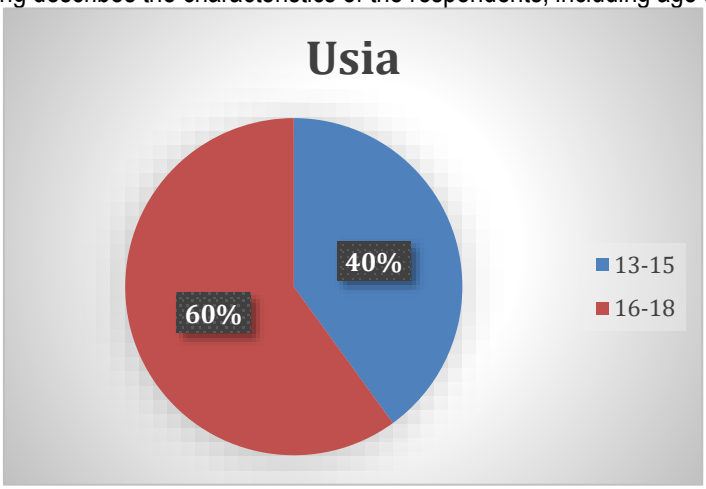

Diagram 1. Data Characteristics Based on the Age of Futsal Athletes in Tembalang

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Based on diagram 4.1, data characteristics based on age show that the highest frequency of age data is in the 16-18 age range, with 18 (60%) respondents, and the 13-15 age range, with 12 (40%) respondents.

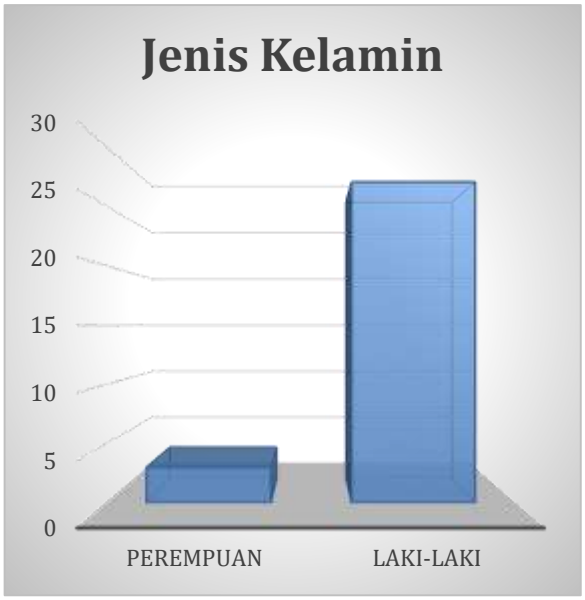

Diagram 2. Data Characteristics Based on Gender of Futsal Athletes in Tembalang

Based on diagram 2, data characteristics based on gender show that males are the most frequent, with 27 respondents (90%) compared to females with 3 respondents (10%).

a. Univariate Analysis

Data analysis was performed to determine the frequency distribution and percentage of the independent variable (HIIT) and dependent variable (increase in VO_2Max).

Table 1. Frequency Distribution Based on Physical Fitness Index Criteria (Harvard Step Test) Before and After HIIT for Futsal Athletes in Tembalang

Kriteria	Frekuensi		Presentase	
	Sebelum	Sesudah	Sebelum	Sesudah
Baik	0	12	0	40
Cukup	3	14	10	46,7
Sedang	6	4	20	13,3
Kurang	21	0	70	0
Total	**30**	**30**	**100**	**100**

Based on Table 1, it is shown that before HIIT was conducted, a Good fitness index was not achieved by any respondents (0%), a Fair fitness index was achieved by 3 respondents (10%), a Moderate fitness index was achieved by 6 respondents (20%), and a Poor fitness index was achieved by 21 respondents (70%). Meanwhile, it was shown by Table 4.2 that after HIIT, the number of respondents with a Good fitness index increased by 12 (40%), those with a Fair fitness index increased to 14 (46.7%), those with a Moderate fitness index decreased to 4 (13.3%), and those with a Poor fitness index decreased to 0 (0%).

b. Bivariate Analysis

Data analysis was performed to determine the effect of the independent variable on the dependent variable. The statistical test that the researchers used was the Paired Samples Test..

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Table 2. Normality Test of VO_2 Max Increase Before and After HIIT for Futsal Athletes in Tembalang

Kriteria	**VO_2Max** *(Harvard Step Test)* *Saphiro Wilk Test*
	p-value
Sebelum HIIT	0,144
Sesudah HIIT	0,177

Based on Table 2, the normality test using the Shapiro-Wilk test obtained an Asymp. Sig. values of 0.144 and 0.177, respectively, which are both greater than the p-value of 0.05. Therefore, it can be concluded that the data before and after are normally distributed, so that a paired t-test can be performed.

Table 3. Results of HIIT Effectiveness Test on Futsal Athletes in Tembalang

Kelompok	***p-value***	***Ket***
High Intensity Interval Training	0,000	Ha diterima

Based on Table 3, the influence test using the paired samples t-test obtained a p-value of 0.000, with Ha accepted, which means that there is an influence of high-intensity interval training on the increase in VO_2Max in Venus Academy futsal athletes.

DISCUSSION

The study was conducted in November 2023 at the Venus Futsal Academy in Tembalang and included 30 respondents. The majority of respondents were between the ages of 16 and 18, with 18 respondents (60%), and the majority of respondents were male, with 27 respondents (90%). Age is one factor that can influence VO_2 max values. This aligns with research conducted by Ariyantini (2016), which states that peak VO_2Max values are typically reached around the age of 18-20 years. VO_2 max values in boys tend to increase between the ages of 12 and 18. VO_2 max values in children are lower than in adults because the cardiovascular system is less mature, which decreases VO_2 max capacity. The increase in VO_2Max capacity is significantly influenced by age and pubertal status in children. Age is considered to affect VO_2 max levels. By the age of 20, the maturity of the cardiopulmonary system can increase until the age of 30, at which point it begins to decline after 30 years of age (Pedersen and Saltin, 2015).

Statistical test results show that high intensity interval training (HIIT) has an effect on increasing VO_2Max in futsal athletes. HIIT is a physical training model that is more intensive than regular training, with high intensity and relatively short recovery times. Endurance is the most important factor in supporting player performance. Cardiorespiratory endurance is the physical ability to sustain the functioning of the heart, blood circulation, and muscles continuously over a relatively long period without experiencing excessive fatigue (Saputra & Nurrochmah, 2019). Futsal is an activity with high-intensity movements, such as sprinting and jumping, as well as low-intensity activities, such as running and walking. All athletes are required to demonstrate their technical quality and physical ability over a 90-minute match. To achieve peak performance within the 90-minute timeframe, whether engaging in high- or low-intensity activities, athletes need training that enhances their physical condition (Rahman, Nurkholis, & Ismalasari, 2020). Cardiorespiratory endurance is one of the physical components that must be improved and trained, as it is a critical factor supporting a player's performance in both technical and tactical aspects (Warni, Arifin, & Bastian, 2017).

This aligns with research conducted by Blüher et al. (2016), which found that high-intensity interval training (HIIT) on 28 adolescents with high Body Mass Index (BMI) values resulted in increased VO_2Max and improved body composition, as more oxygen was utilized during high-intensity interval training compared to non-interval training. The alternating training periods help the body increase oxygen consumption during exercise. This is

because cells consume the least oxygen when muscles are at rest (ACSM, 2014). In line with research conducted by Kurniandani (2017), the high-intensity interval training (HIIT) group experienced a 25.03% increase in VO_2Max, while the continuous training group experienced a 17.52% increase in VO_2Max. This difference occurs because HIIT includes a recovery phase that helps eliminate metabolic waste from the muscles during the rest period while the body is performing high-intensity interval training.

HIIT has an effect on cardiovascular endurance, and this exercise can also strengthen the respiratory muscles, providing significant benefits for maintaining heart and lung fitness. Continuous exercise without rest breaks uses the aerobic system, which requires more oxygen. As a result, the heart of someone who exercises regularly is larger. As a result, stroke volume (SV) increases. With increased stroke volume, the heart does not need to pump at a high frequency to meet oxygen demands or remove carbon dioxide. Consequently, heart rate decreases, resulting in a higher heart rate reserve (HRR).

CONCLUSION AND SUGGESTION

The results of the study indicate that HIIT has an effect on increasing VO_2Max. High-intensity interval training (HIIT) is an effective exercise for increasing VO_2Max in futsal athletes because it improves fitness, particularly cardiovascular health, thereby maximizing the lungs' maximum capacity to hold oxygen. For recommendations, further research is needed by adding other variables and improving the design of the exercise protocol developed by the researchers.

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