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Application of Intermediate Interval Training Method Based on High Maximum Aerobic Speed Capacity to Improve Aerobic Capacity

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ABSTRACT

This study aims to determine the effect of the Intermediate Interval Training (IIT) method based on high Maximum Aerobic Speed (MAS) on improving aerobic capacity. The research employed a one-group pretest-posttest design using the 15-minute Balke Test. The subjects were four athletes with high MAS who underwent an IIT training program for 16 sessions. Results showed an increase in the athletes' aerobic capacity after completing the program. The 15-minute Balke Test showed an improvement in distance of 53.75 meters from the initial 2554 meters to 2608 meters. This increase corresponded to an improvement in VO_2max from 39.70 ml/kg/min to 40.32 ml/kg/min, or an increase of 0.62 ml/kg/min. The paired t-test yielded a significance value of 0.017 (<0.05), indicating a significant difference between the pre- and post-treatment values. Thus, Intermediate Interval Training at high MAS has a significant effect on improving athletes' aerobic capacity. This training method is worth considering as part of a training program to enhance athletes' aerobic capacity.

Keywords: Intermediate Interval Training; Maximum Aerobic Speed; Aerobic Capacity

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INTRODUCTION

Sport is defined as a skill-based physical activity that is competitive in nature and governed by specific rules. Sport also involves unique social and historical elements, where participants not only adhere to rules but also strive to achieve competitive goals, such as winning a match (Borge, 2020). Some definitions emphasize that sport must involve human physical skills and be institutional in nature, distinguishing it from activities such as chess or jogging, which do not meet these criteria (Mareš & Novotný, 2023). Thus, sport is generally associated with physical activity.

One of the important components of physical fitness is aerobic capacity, which relates to an athlete's endurance in maintaining consistent high-level performance during long-duration competitions (Sepriani & Rahman, 2019). Someone aerobic and anaerobic capabilities can be measured using Maximum Aerobic Speed (MAS), although there is no single standard for MAS measurement (Balasekaran et al., 2023). MAS is the highest speed

that can be maintained by an individual through maximal aerobic energy use and minimal anaerobic energy use(Balasekaran et al., 2023). MAS is an important indicator in assessing aerobic capacity and is a critical parameter in predicting performance and training program progress(Casado et al., 2022). Knowledge of MAS is not only essential for monitoring athletes' aerobic development and determining training load, but it also serves as an important indicator in evaluating athletes' physical condition (Yakoub et al., 2021).

Research has shown that a well-structured training program can enhance aerobic capacity. One such method is interval training, including Intermediate Interval Training, which has become a popular approach to improve aerobic power and capacity (Yakoub et al., 2021). Interval training involves alternating periods of high-intensity work followed by recovery periods. Intermediate Interval Training typically includes intervals lasting between 30 to 90 seconds (Coswig et al., 2020). This approach allows athletes to train in a high-intensity aerobic zone, which can improve oxygen utilization efficiency (Hermassi et al., 2018). Interval training stimulates important physiological adaptations, including increased cardiac capacity and the development of capillary networks in muscles. These adaptations contribute to improved aerobic ability.

Several studies have shown that Intermediate Interval Training can produce better results in improving aerobic capacity compared to other training methods. Research conducted by Ma et al (2023) demonstrated significant improvements in aerobic performance among athletes who underwent this training program. Training intensity and duration are crucial factors in determining the effectiveness of interval training (Almeida et al., 2021) . Research indicates that the optimal combination of these two factors can result in significant performance gains. Implementing Intermediate Interval Training requires the correct methodology. Factors that must be considered include the distance or time needed for each interval, speed, number of work interval repetitions, recovery time, and type of recovery activity (Rosdiana et al., 2019). Choosing the right interval duration, recovery time, and intensity level is essential to ensure that athletes can adapt and experience improved aerobic capacity.

Improvements in aerobic capacity through Intermediate Interval Training can have a positive impact on athletic performance during competitions. Athletes with high aerobic capacity are generally able to sustain greater speed and endurance throughout matches (McCormick et al., 2015). When compared to other training methods, Intermediate Interval Training has shown greater effectiveness in enhancing aerobic capacity. Interval training can produce more significant improvements in a shorter period (Gist et al., 2014). A training pattern such as the Resistance Band Ladder Drill using the interval method has shown a more significant impact on aerobic capacity compared to the same drill using the pyramid method (Rosdiana & Sidik, 2023). However, the implementation of Intermediate Interval Training also presents challenges, such as the risk of injury due to fatigue. Therefore, proper monitoring and adjustment of training programs are essential (McCormick et al., 2015).

Although many studies have examined other training methods, research on Intermediate Interval Training remains limited. Further studies are needed to explore the effects of Intermediate Interval Training on MAS and aerobic capacity in specific contexts. This study aims to investigate how the application of the Intermediate Interval Training method at high MAS levels influences the improvement of athletes' aerobic capacity.

METHOD

This study employed an experimental method. The research design used was a one-group pretest – post-test design, which is a type of pre-experimental design involving a single group that is assessed both before and after treatment. The difference between the pre-test and post-test measurements is considered as the result or effect of the treatment (Yuwanto, 2019).

Table 1. One-Group Pretest-Post-tests Design

Pre-test	Treatment	Post-test
O1	X	O2

Source : (Yuwanto, 2019)

The population is a group of individuals or objects that possess certain characteristics to be studied (Candra Susanto et al., 2024). The population in this study consisted of 24 female student-athletes from the UPI Women's Futsal Student Activity Unit (UKM), aged between 18 and 21 years. The total of 24 athletes were divided into three groups: the Short Interval Training group consisted of 7 athletes (4 with high MAS and 3 with low MAS), the Intermediate Interval Training group consisted of 8 athletes (4 with high MAS and 4 with low MAS), and the Long Interval Training group consisted of 9 athletes (4 with high MAS and 5 with low MAS). The research subjects for the Intermediate Interval Training group with high MAS capacity are 4 individuals.

The instrument used in this study was the Balke Test (15-minute run), which required participants to run continuously around a 400-meter track, recording the total distance covered in 15 minutes. The test was conducted in two stages: a pre-test and a post-test. The treatment was administered over 16 sessions, with two training sessions per week. The formula used to calculate VO_2max was (Mackenzie, 2005):

$$VO_2max = (((Total\ distance / 15) - 133) \times 0.172) + 33.3.$$

Data analysis was conducted using statistical methods. The data obtained from the pre-test and post-test were processed and analyzed using statistical calculations with the assistance of SPSS software. A paired sample t-test was used to determine whether there was a significant effect based on the paired data (Yuwanto, 2019).

RESULTS AND DISCUSSION

Findings

The results of the study showed an increase in the aerobic capacity of athletes following the application of the Intermediate Interval Training method at high MAS levels. The results of the pretest and post-tests using the 15-minute Balke Test are presented in Table 2 below.

Table 2. Descriptive Statistics of the Aerobic Capacity of UPI Women's Futsal Student Athletes

No	Description	Balke Test (m)			MAS (m/s)			VO2MAX (ml/kg/min)		
		Initial	Final	% Gains	Initial	Final	% Gains	Initial	Final	% Gains
1	Min	2400	2475		2,67	2,75		37,94	38,8	

2	Max	2700	2770		3	3,08		41,38	42,19	
3	Average	2554	2608	2,11	2,84	2,9	2,11	39,7	40,32	1,56

Source: Processed data (2025)

Based on the table above, the average initial aerobic capacity measured using the 15-minute Balke Test was 2554 meters, while the final average was 2608 meters, indicating an increase of 2.11%. This improvement in aerobic capacity is aligned with the observed increases in Maximum Aerobic Speed (MAS) and maximum oxygen uptake (VO_2max). The average initial MAS was 2.84 m/s, which increased to 2.90 m/s, resulting in a 0.08 m/s improvement. Similarly, the VO_2max increased from 39.70 ml/kg/min to 40.32 ml/kg/min, reflecting an increase of 1.56%.

Statistical analysis was conducted to determine whether the application of Intermediate Interval Training at high MAS levels significantly affected aerobic capacity. This was done by comparing pretest and post-test aerobic capacity values using a paired sample t-test. Before conducting Paired Sample T-Test, the research hypothesis had to meet the assumptions of normality and homogeneity.

The first assumption, normality, requires the dependent variable (Y) to be normally distributed. In this study, the normality test was conducted using the Shapiro-Wilk test, as the sample size (n) was fewer than 50. Based on the results in Table 3, the Shapiro-Wilk significance values for the pretest and post-tests were 0.996 and 0.903, respectively. Since both values are greater than 0.05, it can be concluded that the data are normally distributed.

Table 3. Normality Test Results

Variable	Shapiro-Wilk		
	Statistic	Df	Sig.
Pretest	0,999	4	0,996
Postest	0,980	4	0,903

Source: Processed using SPSS 20 (2025)

The homogeneity test was conducted to determine whether the data were homogeneous. The results of the analysis showed a significance value of 0.567 (Table 4), which is greater than the standard error of 0.05. Therefore, the data are considered homogeneous and meet the requirements for parametric testing using the t-test.

Table 4. Homogeneity Test Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5778.125	1	5778.125	0,367	0,567
Within Groups	94393.750	6	15732.292		
Total	100171.875	7			

Source: Processed using SPSS 20 (2025)

The paired sample t-test was conducted to examine whether there was a significant difference between the pretest and post-test values. The results showed a significance value of 0.017 (Table 5), which is less than the standard threshold of 0.05. Thus, it can be concluded that there is a significant difference between the values before and after the

treatment. Therefore, the application of Intermediate Interval Training at high MAS levels has a statistically significant effect on improving the aerobic capacity of athletes.

Table 5. Paired Sample T-Test Results

Variabel		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-53.750	22.127	11.063	-88.958	-18.542	-4.858	3	0,017

Source: Processed using SPSS 20 (2025)

Discussion

Based on data analysis, the results show a positive and significant improvement in the athletes' aerobic capacity following the application of the Intermediate Interval Training method at high MAS levels. These findings align with previous studies which also demonstrated that interval training has a significant effect on increasing athletes' VO_2max (Dhuha et al., 2024; Dwisetyo Radif et al., 2019; Mubarok & Kharisma, 2022; Rustiawan, 2020; Suliarno et al., 2024). These findings indicate that Intermediate Interval Training programs utilizing high Maximum Aerobic Speed are a valid and effective method for improving aerobic capacity in athletes.

After 16 training sessions, the research data show an increase in the average 15-minute Balke Test result, from 2554 meters (pretest) to 2608 meters (posttest) with an improvement of 2.11%. These results are consistent with the findings of Dhuha et al. (2024), in which a significant improvement was observed from 2736 meters in the initial test to 2861 meters, reflecting a 4.52% increase.

The implementation of Intermediate Interval Training at high MAS levels is considered effective for improving aerobic capacity because this training method physiologically targets adaptations in the cardiovascular and metabolic systems (Setiawan et al., 2024). The improvement in aerobic capacity through interval training is influenced by physiological principles, whereby an increased number of repetitions, longer duration, and greater distance covered result in better adaptive responses (Sidik & Rosdiana, 2022). Intermediate Interval Training involves high-intensity exercise performed at moderate intervals—typically lasting 2 to 5 minutes, followed by active recovery periods. The training intensity is usually 90–100% of MAS, the speed at which maximum VO_2max is achieved.

The MAS-based training method is particularly strategic for exercise programming, as it allows the intensity to be adjusted according to each athlete's capacity. Maximum Aerobic Speed (MAS) refers to the highest speed an individual can sustain using aerobic energy. The findings of this study demonstrate that the application of Intermediate Interval Training resulted in an average increase of 2% in Maximum Aerobic Speed (MAS), consistent with previous research showing that interval training at 95–110% of MAS significantly enhances MAS in intervention groups (Gonzalez-Mohino et al., 2016). Among runners, although running economy—measured by energy expenditure or VO_2—did not change significantly, biomechanical efficiency improved exclusively in the interval training group, as evidenced by increased stride length and reduced ground contact time (CT) at 100% of Maximum Aerobic Speed (MAS).

Intermediate Interval Training at high MAS levels is effective in improving aerobic capacity because MAS is directly related to VO_2max or the maximum volume of oxygen that the body can utilize. Training at or near Maximum Aerobic Speed (MAS) compels the body to utilize oxygen at its maximum capacity, resulting in increased stroke volume (the amount of blood pumped per heartbeat), enhanced capillarization (the development of more small blood vessels in the muscles), and elevated levels of hemoglobin and mitochondria (Herlan & Komarudin, 2020). Consequently, VO_2max improves, allowing for a higher rate of oxygen consumption during physical activity, which supports enhanced aerobic performance.

The findings of this study revealed a 1.56% increase in VO_2max, rising from an average of 39.70 ml/kg/min to 40.33 ml/kg/min. These results are consistent with the study conducted by Dwisetyo Radif et al. (2019), which demonstrated that systematically applied interval training led to a significant improvement in VO_2max, with mean values increasing from 34.0 to 39.5 ml/kg/min in the intervention group ($p < 0.05$).

CONCLUSION

This study investigated the effects of Intermediate Interval Training (IIT) based on high Maximum Aerobic Speed (MAS) on the aerobic capacity of female futsal athletes from the Universitas Pendidikan Indonesia Student Sports Unit. The results indicate that the implementation of IIT at high MAS levels significantly enhances athletes' aerobic capacity. In light of these findings, it is recommended that coaches and training program developers adopt Intermediate Interval Training based on high MAS as part of athletes' conditioning programs to effectively improve aerobic performance.

CONFLICT OF INTEREST

There were no conflicts that occurred in this study.

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