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The Influence of Tabata Training and Interval Training on VO_{2max} Endurance Improvement in Pencak Silat Martial Arts Athletes

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ABSTRACT

The purpose of this study is to examine how interval and tabata training affect the improvement of VO2 max endurance in pencak silat athletes. This study uses a pre-experimental design. The Multi-stage Fitness Test (MFT) is the measurement instrument used in this study, employing a two-group pre-test and post-test design. The study involved a total of 14 athletes from the Central Java Pencak Silat PPLOP, divided into two groups, each consisting of 7 athletes. The results show that both training methods significantly improve the athletes' VO2 max endurance. Based on the SPSS series 26 data analysis, it was found that: 1. Tabata training has a significant effect on the VO2 max endurance results of pencak silat athletes with a p-value of 0.004 < (p<0.05). 2. Interval training has a significant effect on the VO2 max endurance results of pencak silat athletes with a p-value of 0.000 < (p<0.05). 3. There is a significant difference between the two training methods in terms of VO2 max endurance results in pencak silat athletes. However, based on the final Paired Sample T-Test, VO2 max improvement was more significantly influenced by Tabata training compared to interval training. The average VO2 max improvement in the Tabata group was 5.4000, while in the Interval Training group it was 4.9714. This study provides practical implications for designing more effective training programs to improve the aerobic endurance capacity of athletes. Future research is recommended to use a larger sample size and consider other factors that may influence training outcomes.

Keywords : VO2 Max Endurance; Tabata Training; Interval Training; Pencak Silat.

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INTRODUCTION

Training is crucial for enhancing athletes' performance, especially in sports that require endurance, such as pencak silat (Lestari, 2024). Pencak silat is a martial art that combines technique, strength, and speed, creating optimal physical fitness to maximize performance during competitions (Hambali et al., 2020). Endurance is essential in sports as it helps maintain energy and focus throughout a match (Subekti et al., 2021). An athlete must be trained and developed to possess high physical endurance. This capacity is crucial when facing the dynamic patterns of competition, which involve explosive movements, agility, strength, and stamina consistency over long durations (Muhammad Wahyono et al., 2024). Therefore, endurance improvement through a well-planned and proper training program is necessary for athletes, as it is a key component for success (Kenta, 2020).

One of the most popular sports in Central Java is pencak silat. Athletes from Central Java have achieved outstanding accomplishments, earning 3 gold medals, 1 silver medal, and 4 bronze medals at the 2024 PON XXI Aceh-Sumut. This year, the Central Java pencak silat team made significant improvements in their medal count compared to previous editions. At the 2021 PON XX Papua, they earned 1 gold and 6 bronze medals, while at the 2018 PON XIX Jabar, their achievement was 3 gold medals, 1 silver, and 3 bronze. Most of the athletes competing in prestigious events like PON come from the talent pool developed through PPLOP (Student Sports Education and Training Center) Central Java. These athletes are intensively trained at a young age, aiming to become potential champions who can support achievements at regional, national, and international levels. According to data from PPLOP Central Java, this year the province managed to retain its title as the overall champion of Zone III in the PRA POPNAS 2024 competition, held in Solo from November 11 to 18, 2024. They won 9 gold medals, 4 silver, and 4 bronze, which is an improvement compared to the PRA POPNAS 2022 in Banjarmasin, South Kalimantan. According to pencak silat coach at PPLOP, Sigit Infantoro, Central Java brought home 9 gold, 3 silver, and 4 bronze medals, all achieved by the pride of Central Java athletes. Thus, this year, the pencak silat sport continues to maintain the quality of its athletes and improve its achievements in various competitive events.

This demonstrates progress in the development of the sport of pencak silat. This achievement serves as a great motivation for Central Java to remain optimistic about providing tough competition and continuously improving its position at the national level. To reach higher achievements, a thorough evaluation of the training system, competition, training programs, and athlete development is necessary. Athletes can achieve optimal performance in competitions if they have optimal physical condition (NASUKA NASUKA, 2020). Therefore, well-planned and comprehensive training is essential to support physical fitness and improve the strength, endurance, speed, flexibility, and coordination of athletes (Andriawan & Irsyada, 2022).

The quality of training conducted by an athlete greatly influences their success during the training process (Wali et al., 2024). Athletes are expected to have good physical condition, technical skills, tactical understanding, as well as favorable sociological and psychological/mental conditions (Ghrahani et al., 2015). While athletes strive to improve their performance, physical condition is crucial for their preparation and maintenance. This is because physical condition supports other aspects (Maliki et al., 2017). Generally, each athlete has a different level of endurance, so the training load provided needs to be adjusted, taking rest periods into account (Yudhistira, 2024). This is important to ensure adequate oxygen intake, allowing the body's metabolic processes to function smoothly (Muhammad Wahyono et al., 2024). Athletes with high endurance strength tend to perform activities for longer periods and recover more quickly compared to athletes with lower endurance (Sun, 2023).

From the movement pattern perspective, pencak silat is very fast but also includes intervals, so the appropriate training pattern to apply is high-intensity movement patterns accompanied by intervals and varied items (Chaabene et al., 2017). Therefore, the implementation of an aerobic system improvement program will significantly impose high loads over a certain period, potentially increasing VO2max endurance strength.

Pencak silat martial arts require significant endurance. Endurance refers to the ability of the cardiovascular system (heart and blood vessels) and the respiratory system to supply sufficient oxygen to the muscles during physical activity (Lichtenstein et al., 2021). The factors that influence endurance are the body's ability to meet oxygen demands maximally, which can be measured through VO2 max (Jafar, 2015). According to research conducted by (Rustiawan, 2020), athletes who train with an aerobic energy system tend to have higher VO2max levels. VO2max is a measure of the body's capacity to take in oxygen and distribute it to the muscles responsible for expelling metabolic waste products (Candra & Setiabudi, 2021). This explanation is supported by (Izzuddin et al., 2022), who revealed that VO2max helps in the expulsion of metabolic waste and in circulating oxygen to muscle tissues for continued activity. Other research has stated that training focused on the aerobic system can induce vascular adaptation in the body's tissues (Pinckard et al., 2019).

Good VO2 max endurance allows individuals to continue physical activity for extended periods without excessive fatigue (Paradiso et al., 2021). A good cardiovascular endurance capacity is not only crucial to endure 3x2 minutes during a match but also for efficiently applying techniques, tactics, and strategies (Perdana, 2024). In addition, VO2 max endurance also plays a role in stabilizing emotions during competition (Prayuda & Firmansyah, 2017). Previous studies have stated that cardiovascular endurance can improve VO2 max by 15-25% (Hernawan et al., 2021). Based on the explanations of VO2max endurance from previous studies, it can be concluded that VO2 max endurance is a specific measure of oxygen capacity resulting from the synergy between the heart, lungs, and muscles in distributing oxygen throughout the body. Thus, the body can perform activities for extended periods without experiencing excessive fatigue, ensuring the body is ready for further training.

In modern sports, various training methods have been developed to improve VO2max endurance, including Tabata training and interval training. Both Tabata training and interval training are recognized as effective methods for enhancing aerobic and anaerobic capacity, making them relevant for supporting the performance of pencak silat athletes (Tabata, 2019). Tabata training follows the same principles as High Intensity Interval Training (HIIT). Tabata training triggers physiological adaptation by involving periods of very intense work followed by short rest intervals, which enhances metabolic efficiency and makes muscles more efficient at using oxygen (Gibala et al., 2012). According to research conducted by Dr. Tabata, Tabata training significantly improves both aerobic and anaerobic capacity. In this case, the improvement in aerobic capacity refers to enhanced endurance during the long rounds of a pencak silat match (Tabata et al., 1996). In practice, coaches can implement workout programs like squat jumps, burpees, lateral hurdle jumps, explosive push-ups, resistance band exercises, or punch and kick drills using the Tabata pattern to specifically improve stamina and endurance in pencak silat martial arts (Yudhistira et al., 2021).

Meanwhile, interval training is a training method involving high-intensity intervals followed by rest periods between sessions (Pelamonia et al., 2024a). Interval training focuses on short, high-intensity intervals that maximize power output, followed by short active recovery times (Bartram, 2021). This aligns with the view of (Saputra & Hanief, 2017) that interval training is a system involving work-rest intervals, such as a combination of sprint intervals followed by recovery intervals, and so on. Interval training is classified as both an aerobic and anaerobic exercise that is time-efficient and is often referred to as sprint interval

training (Guo & Wang, 2024). Interval training has positive effects on cardiorespiratory health, aerobic and anaerobic metabolism, and functional performance (Kinnunen et al., 2019), where the energy produced comes from oxidative interactions and the glycolytic system (Laursen, 2010). Based on various definitions from previous studies, interval training is a high-intensity training program in a short amount of time that efficiently meets energy demands. Therefore, this method is commonly used to improve cardiovascular endurance, muscle strength, and both aerobic and anaerobic capacity. Both Tabata and interval training techniques are also suitable for meeting the energy demands of pencak silat.

Previous research compared the Tabata training method with HIIT (High Intensity Interval Training) to assess their effects on cardiovascular endurance. The results indicated that both training methods had a significant impact on the endurance of soccer athletes (Rohendi & Kardani, 2021). Another study compared Tabata training with resistance band training to improve the speed of the scissor kick in PSHT martial artists. The results showed that resistance band training increased the speed of the scissor kick by 15.50%, compared to Tabata training, which only increased it by 2.82% (I. A. Kusuma & Wibowo, 2022). Furthermore, previous research on seven athletes tested the effects of interval training on VO2max endurance in long-distance runners. The findings demonstrated that this training method had a significant effect on improving VO2 max endurance in long-distance athletes (Herlan & Komarudin, 2020a). A related study on the application of interval training to improve VO2 max in futsal extracurricular players was conducted by (Nohrizal et al., 2020). The results indicated an increase in VO2 max in futsal athletes, with pretest averages at 13.1250 ml/kg/min and a standard deviation of 5.86550. Meanwhile, the posttest showed an average of 44.6100 ml/kg/min with a standard deviation of 5.49937, which was reinforced by significant t-test results. Additionally, previous literature stated that interval training had a much more significant impact than circuit training in improving endurance as the dependent variable (Bovas J, 2020).

Tabata training and interval training are the two independent variables to be tested. During direct observation at a competition, it was evident that there were weaknesses observed in the pencak silat athletes, particularly in the cardiovascular endurance component, which had decreased. The match lasted for three rounds of 2 minutes each. In the first and second rounds, the athletes expended all their power and speed, so by the third round, they started to lose focus in attacking or defending against their opponent. Additionally, the breath control that had been depleted early in the match made punches and kicks lose power and direction. The implementation of Tabata training and interval training provides a solution to train endurance. Both methods are highly appropriate because, when combined with the competition environment, athletes compete for short durations with high intensity. Moreover, Tabata training and interval training are characterized by workouts that do not require long periods but remain efficient. Therefore, it is hoped that pencak silat athletes will have good VO2 max endurance physical performance, allowing them to compete from start to finish with optimal physical condition. The author also hopes that the knowledge shared can provide broader insights into the field of sport science for coaches, helping them prepare the best-targeted training programs to produce athletes capable of becoming champions (Syaefulloh, 2022). This research focuses solely on improving VO2 max endurance, although there are still many aspects to address in physical condition issues. The consideration of time, readiness during matches, and athlete preparation led the author to limit the scope to focus only on VO2max endurance issues.

The first independent variable is Tabata training, a training method that adopts the HIIT Special Periodization for Kumite Athletes program, modified to suit the physical condition of pencak silat martial arts athletes (Yudhistira et al., 2021). The experimental implementation of

the Tabata training program lasts for 30 minutes, with each set at 1 minute of work time per station and 20 seconds of recovery, repeated for 4 sets. The exercises are conducted with low to moderate intensity, ranging from 65% to 85%. The second independent variable is the interval training program, which focuses on intensive interval training. (Suhdy, 2018) sets the intensity of intensive interval training between 80%-90%. The experimental program includes sprints at distances of 200 and 400 meters, with a total distance of 2.4 kilometers. Each sprint interval lasts 2 minutes, followed by adjusted repetitions.

After presenting the background and literature review of previous studies on the Tabata training and interval training methods, the author plans to conduct a study titled "The Effect of Tabata Training and Interval Training on VO2max Endurance Improvement in Pencak Silat Athletes." The following are the research questions that form the basis of the study: (1) To determine whether the Tabata training method can affect the VO2max endurance of PPLOP Central Java pencak silat athletes. (2) To determine whether the interval training method can affect the VO2max endurance of PPLOP Central Java pencak silat athletes. (3) To determine whether there is a difference in the effects of Tabata training and interval training on the VO2max endurance improvement of PPLOP Central Java pencak silat athletes.

METHOD

The type of research

This study falls under the category of pre-experimental research design. It focuses on two independent variables: Tabata training and interval training, with VO2 max endurance improvement as the dependent variable. The study uses a "Two-group pre-test and post-test design," meaning the design starts with a pre-test and ends with a post-test (Mahardika, 2015). This design allows for a more accurate comparison of results before and after the intervention.

The time and location

This study was conducted at the PPLOP Pencak Silat Jawa Tengah, where athletes underwent interval and Tabata training for six weeks, starting from November 10, 2024, to December 19, 2024, with three sessions per week. All training sessions were held at the Gor Jatidiri PPLOP Pencak Silat Jawa Tengah. After six weeks of treatment, a post-test was administered using the MFT (Multilateral Fitness Test) at the same location to evaluate whether the training program had a positive impact on the development of the athletes at PPLOP Pencak Silat Jawa Tengah.

The goals or target

The population in this study consists of 14 athletes from PPLOP Central Java. The entire population is taken as the sample, using total sampling method (Amin et al., 2023). The ranking system, also known as ordinal pairing technique, is used to divide the sample into two groups, with each group consisting of 7 people (Mackenzie, 2005). To assess the VO2max of each athlete, the MFT test is conducted. The MFT scores are used to divide the groups, ensuring both groups have similar starting points for VO2max (Jasmin et al., 2023). The goal of evaluating and comparing the impact of two training methods on athlete performance is to support the development of more efficient training programs at PPLOP Central Java.

Instruments

The study uses the Multi-stage Fitness Test (MFT) as an instrument to measure cardiovascular endurance in pencak silat athletes (I. D. M. A. W. Kusuma, 2019). The test is conducted on a 20-meter track (Kurniawan & Pudjianto, 2017). Participants run back and forth according to the beep rhythm, with speed increasing as the levels progress. Participants are

considered out if they cannot complete two consecutive laps according to the beep rhythm. The pre-test MFT results are used to evaluate the maximum cardiovascular endurance (VO2max) of each athlete (Bacon et al., 2013).

Data collection techniques

The data collection technique in this study was carried out through two stages of testing. The first stage involved the collection of baseline data (pre-test) conducted before the training program began. This pre-test used the Multilateral Fitness Test (MFT) to assess the athletes' initial physical condition. After six weeks of treatment involving Tabata and interval training, the second stage was conducted with a post-test using the same MFT to evaluate changes in the athletes' physical condition. Both tests were carried out at the Gor Jatidiri PPLOP Pencak Silat Jawa Tengah to ensure consistency in measurement and evaluation of the effectiveness of the training program.

Data analysis techniques

The data analysis technique used in this study is quantitative data analysis. The collected data is processed using SPSS 26 statistical software. The applied analysis techniques include: (1) Normality test using the Kolmogorov-Smirnov and Shapiro-Wilk tests to examine whether the data is normally distributed. (2) Homogeneity of variance test using Levene's Test. (3) Hypothesis testing (H0) using the Paired Sample t-test (Landau et al., 2004).

RESULTS AND DISCUSSION

1. Data Description

The table 1 below presents the processed data results, which will be explained descriptively. This statistical analysis aims to present the data information concisely and clearly, making it easier to draw conclusions based on the available data.

Table 1. Description of Pre-Test MFT Data
Tabata Training Group and Interval Training Group

Sample Group	N	Mean	Standar Deviasi	Varians	The Lowest Score	The Highest Score
Tabata	7	43,89	5,21	27,15	39,2	51,6
Interval	7	43,13	4,69	22,04	37,1	51,6

Based on Table 1, the pre-test VO2max results for the Tabata Training group showed a mean of 43.89 ml/kg/min with a standard deviation (STDV) of 5.21 and a variance of 27.15. The lowest score obtained was 39.2 ml/kg/min, while the highest score reached 51.6 ml/kg/min. For the Interval Training group, the average post-test result was 43.13 ml/kg/min with a standard deviation (STDV) of 4.69 and a variance of 22.04. The lowest score in this group was 37.1 ml/kg/min, and the highest score was 51.6 ml/kg/min.

Table 2. Description of Post-Test MFT Data
Tabata Training Group and Interval Training Group

Sample Group	N	Mean	Standar Deviasi	Varians	The Lowest Score	The Highest Score
Tabata	7	49,29	4,95	24,54	44,8	57,1

Interval	7	48,10	3,98	15,85	43,9	55,7

For table 2 Tabata Training group, the average post-test VO2max was 49.29 ml/kg/min, with a standard deviation of 4.95 and a variance of 24.54. In the Interval Training group, the average post-test result was 48.10 ml/kg/min, with a standard deviation of 3.98 and a variance of 15.85. The lowest recorded value was 43.9 ml/kg/min, and the highest score was 55.7 ml/kg/min.

2. Normality Test

The normality test is a statistical technique used to evaluate the data collected in a study to determine whether the data follows a normal distribution or not. Additionally, the normality test is used to decide the next statistical test to perform, between parametric and non-parametric tests. If the collected data follows a normal and homogeneous distribution, the subsequent testing steps will be conducted using parametric statistics. The Result of the pretest and posttest normality test can be seen in table 3 and 4 below.

Table 3. Normality Data of Pre-Test (MFT)
Tabata Training Group and Interval Training Group

Test of Normality						
Pre-Test	Kolmogorov-Smirnov Standar Deviasi			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Tabata	,327	7	,023	,701	7	,033
Interval	,183	7	,200	,949	7	,717

The decision criteria are as follows:

1. A significance value or probability less than 0.05 indicates a non-normal distribution;
2. A significance value or probability greater than 0.05 indicates a normal distribution.
   1) **Pre-Test:**
      a. Tabata Training: Kolmogorov-Smirnov shows a value of 0.023, which is above 0.05 (normal distribution),
      b. Tabata Training: Shapiro-Wilk shows a value of 0.33, which is above 0.05 (normal distribution).
      c. Interval Training: Kolmogorov-Smirnov shows a value of 0.200, which is above 0.05 (normal distribution),
      d. Interval Training: Shapiro-Wilk shows a value of 0.717, which is above 0.05 (normal distribution).

Table 4. Normality Data of Post-Test (MFT)
Tabata Training Group and Interval Training Group

Test of Normality						
Pre-Test	Kolmogorov-Smirnov Standar Deviasi			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Tabata	,283	7	,091	,852	7	,129
Interval	,174	7	,200	,909	7	,386

2) Post- Test

a. Tabata Training: Kolmogorov-Smirnov shows a value of 0.091, which is above 0.05 (normal distribution),
b. Tabata Training: Shapiro-Wilk shows a value of 0.129, which is above 0.05 (normal distribution),
c. Interval Training: Kolmogorov-Smirnov shows a value of 0.200, which is above 0.05 (normal distribution), and
d. Interval Training: Shapiro-Wilk shows a value of 0.386, which is above 0.05 (normal distribution).

Tables 3 and 4 show the results of the pre-test and post-test multi-stage fitness test for the Tabata and interval training groups, based on the normality test criteria. The test results for both groups show a normal distribution. As a result, one of the requirements for parametric statistical data processing has been met. The normality test for the pre- and post-test, based on the data processed using the SPSS version 26 program, shows results greater than 0.05, indicating that the research results are normally distributed.

3. Homogeneity Test

The results of the homogeneity test are shown in Table 5 below. This test is used to determine whether the sample groups have the same or homogeneous variance, or the opposite.

Table 5. Homogeneity Data for Pre-Test and Post-Test MFT (Multi-Stage Fitness Test) for the Tabata and Interval Training Groups

Test of Homogeneity of Variance				
	Levene Statistic	df1	df2	Sig.
Based on mean	,460	3	24	,713
Based on Median	,101	3	24	,959
Based on Median and with adjusted df	,101	3	22,260	,959
Based on trimmed mean	,416	3	24	,743

The decision-making criteria are as follows:

1. If the significance value or probability value is less than 0.05, the data comes from a population with unequal variance (non-homogeneous).
2. On the other hand, if the significance value or probability value is greater than 0.05, the data comes from a population with equal variance.

According to Levene's Test for Homogeneity of Variance:

a. Based on the mean value, the significance value (sig.) is 0.713, which is greater than 0.05, and
b. Based on the median value, the significance value (sig.) is 0.959, which is greater than 0.05. The probability value (Sig.) for the multi-stage fitness test mean is 0.733, which is above 0.05, and the probability value for the median is 0.959, which is above 0.05. Therefore, it can be concluded that the results of the Multi-Stage Fitness Test (MFT), both pre-test and post-test, have the same and homogeneous variance.

4. Hypothesis Test

The hypothesis test used in this research is the Paired Sample T-Test.

Results of the Paired Sample T-Test

The paired sample t-test aims to determine whether there is an improvement or not in each group. The results can be seen in Table 6 below.

Table 6. Hypothesis Data for Pre-Test and Post-Test MFT (Multi-Stage Fitness Test) for the Tabata and Interval Training Groups

Paired Sample T-test								
MFT	Paired Differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pre_Tabata-Post_Tabata	-5,4000	3,1633	1,1956	-8,3256	-2,4744	-4,516	6	,004
Pre_Interval-Post_Interval	-4,9714	1,6987	,6421	-6,5425	-3,4004	-7,743	6	,000

First hypothesis:

1. H0 = Tabata training does not have a significant effect on the VO2 max endurance improvement of pencak silat athletes.
2. Ha = Tabata training has a significant effect on the VO2 max endurance improvement of pencak silat athletes.

Decision Criteria:

1) H0 is accepted if the probability (Sig.) result is greater than 0.025.
2) H0 is rejected if the probability (Sig.) result is less than 0.025.

From the above criteria, it can be concluded that the probability (Sig.) value from the MFT (Multi-Stage Fitness Test) for the tabata training group is 0.004 < 0.025. Therefore, H0 is rejected, meaning that tabata training has a significant effect on the improvement of VO2 max endurance in pencak silat athletes.

Second hypothesis:

1. H0 = Interval training does not have a significant effect on the VO2 max endurance improvement of pencak silat athletes.
2. Ha = Interval training has a significant effect on the VO2 max endurance improvement of pencak silat athletes.

Decision Criteria:

1) H0 is accepted if the probability (Sig.) result is greater than 0.025.
2) H0 is rejected if the probability (Sig.) result is less than 0.025.

The probability (Sig.) value from the Multi-Stage Fitness Test (MFT) for the interval training group is 0.000, which is less than 0.025. Therefore, H0 is rejected, meaning that interval training can help pencak silat athletes improve their VO2max endurance. Based on the analysis of the Paired Sample T-test results, it can be assumed that, although the data is provisional, there is a significant effect.

DISCUSSION

Based on the results of the study, both training methods, Tabata Training and Interval Training, have been proven to significantly improve VO2 max endurance. This can be seen from the results of the Paired Sample t-test, which showed a significance value (Sig. 2-tailed) < 0.05 for both groups. This improvement indicates that both training methods are effective in enhancing athletes' aerobic capacity, particularly in supporting the performance of sports like pencak silat, which requires high endurance.

However, the Tabata Training method shows a greater impact on VO2 max improvement compared to Interval Training. The average increase in VO2max for the Tabata Training group is higher (5.4000) compared to the Interval Training group (4.9714). This can be explained by the characteristics of Tabata Training, which is a form of moderate-intensity exercise with short intervals, thus triggering more optimal physiological adaptations in the cardiovascular and respiratory systems. This training pushes the body to work near its maximum capacity, improving oxygen utilization efficiency, and significantly enhancing aerobic endurance. Meanwhile, Interval Training, although also effective, has high intensity but is more controlled with longer recovery intervals. As a result, the adaptations that occur tend to be more moderate compared to Tabata Training. However, this method remains a good alternative for athletes who require training with less extreme intensity.

Overall, these results indicate that Tabata Training can be a more effective training method to improve VO2max endurance, especially for athletes who are ready for high-intensity training. Meanwhile, Interval Training remains relevant as a variation in training programs, particularly for individuals who are just starting an aerobic capacity improvement program. Tabata training is conducted gradually to improve heart function (Herlan & Komarudin, 2020b). The Tabata Training method used in this study adopts a High-Intensity Interval Training (HIIT) program with a special periodization approach for pencak silat athletes. This program is designed as a structured workout to optimize the improvement of aerobic capacity and VO2max endurance.

The training is implemented with a total duration of 30 minutes, where each training position has a work time of 1 minute followed by a recovery time of 20 seconds. The entire workout sequence is performed in 4 sets, with the goal of providing a high workload to trigger maximal physiological adaptations, such as increasing the efficiency of the cardiovascular system, respiration, and oxygen utilization by muscles. This approach aligns with the basic principles of HIIT, which involve providing high-intensity work in a short amount of time, interspersed with brief recovery intervals. This characteristic allows the body to work close to its maximum capacity during the work phase, followed by sufficient recovery time to reduce fatigue while still maintaining the body in a "training stress" condition. In the context of this training, the structure that adopts special periodization provides an additional advantage with the adjustment of intensity and duration in a measured way. This training not only improves VO2 max endurance but also provides specific adaptations to the physical demands of pencak silat athletes. With intense work periods and short recovery breaks, this method enhances overall physical performance, both in terms of aerobic and anaerobic endurance. As a result, the application of the Tabata training method in this pattern is highly effective in creating high physiological stress and better cardiovascular adaptation, ultimately contributing to a significant increase in VO2max endurance.

The Interval Training method used in this study was designed with a specific approach involving 400-meter and 200-meter sprints. The training was performed with a 2-minute recovery interval between each repetition, with the total distance covered during the entire training session adjusted to reach 2.4 km. This method was designed based on the principle of high-intensity training, at 80-90% of the athlete's maximum capacity, aimed at optimally enhancing both aerobic and anaerobic endurance. This approach focuses on a combination of challenging work duration and sufficient recovery time to minimize fatigue, while still maintaining high intensity. The 400-meter sprints stimulate both the aerobic and anaerobic systems simultaneously, while the shorter 200-meter distance allows the athlete to maintain high intensity, while also improving energy recovery efficiency during the intervals.

The 2-minute interval was selected so that the body could recover part of its energy capacity without fully exiting the high-intensity training zone. This aligns with the basic

principle of interval training, which is to utilize recovery time as active rest to maintain the overall effectiveness of the workout (Parmar et al., 2021). With a total distance of 2.4 km, this method is designed to create a balance between volume and intensity. The intensity principle of 80-90% ensures that each repetition is performed near the athlete's maximum capacity, creating physiological stress on the cardiovascular system and (Ramadan & Sidik, 2019). The result is improved ability to transport and utilize oxygen efficiently, as well as metabolic adaptations that support VO2max endurance (Pelamonia et al., 2024b).

In the context of pencak silat, this method is relevant because it can enhance physical performance, particularly in terms of speed, endurance, and rapid energy recovery between attacks or rounds. Therefore, tabata training becomes an effective method for improving VO2max endurance.

CONCLUSION

Based on the discussion, it can be concluded that both training methods, Tabata training and interval training, are equally effective in improving athletes' VO2max endurance. Tabata training, which adopts a HIIT program with special periodization, has a greater impact due to the training structure of 65-85% intensity in a short period (1 minute of work followed by 20 seconds of recovery for 4 sets). This approach maximizes physiological adaptations in the cardiovascular and respiratory systems. On the other hand, interval training, which uses 400-meter and 200-meter sprints with 80-90% intensity and 2-minute intervals, is also effective in improving both aerobic and anaerobic endurance. This method emphasizes the combination of a total distance of 2.4 kilometers and high intensity to create metabolic adaptations that support physical performance. Although both methods produce significant results, Tabata training shows an advantage in providing a greater increase in VO2 max endurance of athlete PPLOP pencak silat Jawa Tengah, making it a more optimal method for athletes to prepare for long rounds in pencak silat competitions. However, interval training remains a good alternative for progressively improving endurance.

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