International Journal of Human Movement and Sports Sciences 12(1): 210-221, 2024 http://www.hrpub.org
DOI: 10.13189/saj.2024.120122

Effects of Endurance Training Methods and Mental Toughness on VO_2max

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Received July 12, 2023; Revised November 26, 2023; Accepted December 18, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Mimi Haetami, Yusuf Hidayat, Andika Triansyah, Asep Sumpena, Reshandi Nugraha, Carsiwan, Alit Rahmat, Prisca Widiawati, Rozita Abdul Latif, Wahidah Tumijan, "Effects of Endurance Training Methods and Mental Toughness on VO_2max," International Journal of Human Movement and Sports Sciences, Vol. 12, No. 1, pp. 210-221, 2024. DOI: 10.13189/saj.2024.120122.*

(b): *Mimi Haetami, Yusuf Hidayat, Andika Triansyah, Asep Sumpena, Reshandi Nugraha, Carsiwan, Alit Rahmat, Prisca Widiawati, Rozita Abdul Latif, Wahidah Tumijan (2024). Effects of Endurance Training Methods and Mental Toughness on VO_2max. International Journal of Human Movement and Sports Sciences, 12(1), 210-221. DOI: 10.13189/saj.2024.120122.*

Abstract Research that examines the effect of a training combining physical and mental aspects simultaneously is still limited, especially the combination of Endurance Training Method (ET-Method) and Mental Toughness (MT). For this reason, this study aimed to examine the effect of the ET-Method (Tabata Training/TT-Method and Sprint Interval Training/SIT-Method) as the independent variable and MT (High-MT and Low-MT) as the moderator variable on VO_2max (the dependent variable). The study was conducted using a field experiment method and a 2x2 factorial design on 48 male university students. All participants were divided into four treatment groups using a random assignment. The training was carried out for eight weeks (24 meetings, 3 meetings per week). The data were collected using the Mental Toughness Questionnaire 48 (MTQ48) and the aerobic ability test, namely The 20m Multi Stage Fitness Test or Bleep Test with units of ml/kg/minute to measure an athlete VO_2max. Data analysis was performed using a two-factor analysis of variance technique. The results showed that the ET-Method and MT were effective to increase VO_2max, both independently and interactively. The TT-Method had a higher effect than the SIT-Method on VO_2max, while the VO_2max of participants having High-MT was higher than participants having Low- MT. TT-Method gave a higher effect than SIT-Method when combined with Low-MT. Conversely, SIT-Method was more effective than TT-Method when combined with High-MT. Coaches can use both types of ET-Method independently or in combination with MT as an alternative method to increase VO_2max.

Keywords Endurance Training, Mental Toughness, Sprint Interval Training, Tabata Training, VO_2max

1. Introduction

Physical abilities and mental skills are integral parts of every activity in human life, including in sport performance. Several studies have found that mental aspects play an important role in sport performance. Mental fatigue impairs endurance, movement skills, and decision-making abilities. Mental fatigue that interferes with sport ability is the mental fatigue that occurs during exercises carried out at submaximal intensity, while exercises performed at maximum and supramaximal intensity do not interfere with sport ability [1,2].

Participation in sports has been found to help improve social skills, self-esteem, self-confidence, self-control,

self-concept, and competence [3]. It can also help protect and improve mental health for children and adolescents [4]. Regular exercise can minimize symptoms of depression and anxiety disorders and is an important key to physical and mental health [5], including to improve the mood [6]. The effect of exercise on physical and mental health is determined by the intensity level of the exercise carried out. Moderate-intensity activity often leads to pleasure and a positive mood, while high-intensity activities can cause displeasure [7-10]. Based on the results of previous studies, participation in sports has a positive impact on mental health because it improves the overall quality of life [11,12]. However, to emphasize the effect of physical activity (exercise) with intensive training, especially associated with the role of mental skills on more measurable achievements, it is necessary to carry out further in-depth and broad studies.

Improving physical abilities in exercise requires stages that are relevant to training principles and methodologies [13-15]. One of the main abilities that needs to be developed as an effort to improve physical abilities is endurance, which is placed in the general preparation stage in the training program [16-19]. Endurance is considered important because it is related to the main organ, namely the heart. Training endurance is the same as training the heart so that it is ready to work optimally to circulate blood throughout the body during strenuous activities [20]. In addition, endurance training also has an impact on the ability of the lungs to consume oxygen in a large capacity needed by the brain and other physiological functions [21,22].

The endurance level of an athlete is known as the maximum oxygen volume (VO_2max) [21-24]. Increasing VO_2max capacity means increasing the functional ability of the heart and lungs to consume oxygen when the body is working intensely for a certain period of time, so as to suppress fatigue during the exercise period [24,25]. Measurement of aerobic endurance can be done by measuring the value of maximum oxygen consumption, namely the largest amount of oxygen that can be used in a maximal exercise, using the physiological abilities of all limbs [24,25]. Before puberty, boys and girls have similar VO_2max values, but after that girls lag far behind. On average, teenage girls have VO_2max values between 15% to 25% lower than boys, although other opinions show a difference of 20% -37% [26]. Thus, it concludes that a good VO_2max is important to improve the performance or achievements of athletes.

To increase VO_2max capacity, training methods that are relevant to the goal, namely increasing endurance starting from low-intensity exercise to high-intensity exercise, are needed. Two training methods that have training characteristics to increase endurance are the Tabata Training Method (TT-Method) and the Sprint Interval Training-Method (SIT-Method) [27,28]. The TT-Method is included in high intensity category, or the supra aerobic cardio category, and has a short training duration (lasts for four minutes). This method was developed by Dr. Izumi Tabata from the National Institute of Fitness and Sports Tokyo [29]. The TT-Method is an exercise that combines intermittent training with high-intensity training to improve performance in sports [28,30,31]. The TT-Method is performed for four minutes in the form of interval training consisting of 8 forms of movement with a maximum of 20 seconds for each form; each exercise is followed by a 10-second rest [32,33]. The TT-Method can also be applied for 20 to 60 minutes [34]. The TT-Method cannot be applied too often. It is recommended to perform the TT-method once or twice a week, or three days a week [35].

The SIT-Method is an intermittent training method that involves a period of training followed by a recovery period, allowing the athlete to increase the intensity of the training workload. To be included in the high-intensity category, training must start from 85% VO_2max [36,37]. The SIT-Method involves one minute of intense exercise for 10 minutes [38,39], 4-6 sprints with a maximum of 30 seconds, rest between sets for four minutes, and a practice time of around 30 minutes per session [40,41]. High-intensity interval training is an effective training protocol to increase maximal aerobic capacity [42,43].

Several previous studies on the effectiveness of the TT-Method and SIT-Method on aerobic endurance, including systematic literature review articles published between 1996 to 2017 in PubMed and Scopus, found that variations of the TT-Method protocol seem to be an indicator of increasing aerobic endurance. It is similar to the traditional aerobic exercise, but it requires a shorter time [44-46]. The TT-Method consists of high-intensity interval training (HIIT) administered for over 8 weeks. The program aims to increase aerobic and anaerobic efficiency, strengthen the ligament and muscle systems, and increase resting metabolism, which will lead to a gradual reduction in body fat. The Tabata protocol used in this study consisted of 3 meetings in 1 week for a total of 24 meetings. It involved eight cycles consisting of two exercises. Each cycle started with a maximum intensity exercise lasting for 20 seconds, followed by an active rest for 10 seconds. The exercises used in this program targeted several large muscle groups and required minimal exercise equipment. The introduction of TT-Method, given at 3 meetings per week for 8 weeks, was hypothesized to be sufficient to observe improvements in health indicators, such as fat reduction, physical performance, and motor skill performance. This study used a priori sample size calculations to ensure the accuracy and adequacy of the sample size for proper interpretation of the results [32, 47, 48].

Meanwhile, SIT-Method usually involves short periods of high-intensity sprinting followed by low-intensity rest or recovery periods. A common protocol for SIT-Method is the “4x4” method, which consists of four 20-second sprint intervals at maximal effort with 10 seconds of rest between each sprint, followed by a longer recovery period. This protocol is repeated for four to eight cycles. SIT-Method can be performed on various types of equipment, such as a

stationary bike or treadmill, and can be tailored to the individual fitness level. SIT-Method has been shown to increase VO2peak after 4 weeks of training [49]. Additionally, SIT-Method has been found to reduce sclerostin circulation and increase Wnt signaling in subcutaneous adipose tissue (scWAT). These specific indicators demonstrate the effectiveness of SIT in increasing aerobic capacity and modulating molecular adaptation in adipose tissue [50]. Similar results were found in other studies. It was proven that the SIT-Method could increase the aerobic capacity of participants aged 23.5 years, successfully improved fitness and cardiorespiratory health [38]. The SIT-Method was also shown to be effective at increasing VO_2max of 23 male participants who completed four weekly SIT sessions (8 × 20-s cycling at ∼170% of work rate at $\dot{V}O_2$max, 10-s recovery) over four weeks at high intensity, while at the group of participants doing low-intensity exercise, it was found to be ineffective [50].

According to the description of the focus of the problem, conceptual studies, and the empirical findings above, it is proven that the TT-Method and SIT-method are effective in increasing aerobic capacity. However, research examining the interaction of these training methods with MT is still limited, especially in terms of its function to increase VO_2max capacity. This research is important to improve the athlete performance. It cannot be separated from the role of simultaneous physical and mental abilities [51], especially with regard to MT. Various empirical findings show MT to be a predictor of success in matches [52,53], predicting skills in playing sports and increasing fitness and results in competitions [54]. However, research examining the combination of MT with other aspects of training, especially the physical aspect (ET-Method) is still limited. For this reason, this research is important and strategic in relation to the value of novelty and can contribute positively to improve the quality of training and sport achievements.

2. Materials and Methods

2.1. Method and Design

Table **1.** Factorial design 2 x 2 effect of ET-Method and MT on VO_2max

		Mental Toughness (MT) (B)	
		High-MT (B_1)	Low-MT (B_2)
ET-Method (A)	TT-Method (A_1)	EG1 (A_1B_1)	EG2 (A_1B_2)
	SIT-Method (A_2)	EG3 (A_2B_1)	EG4 (A_2B_2)

Note: EG1-4 = Experiment group 1-4

To carry out this research, a field experiment research method was used with a 2x2 factorial design. The study involved two independent variables, namely the Endurance Training Method / ET-Method (A) variable as an active independent variable (consisting of the TT-Method (A_1) and SIT-Method (A_1) categories) and Mental Toughness (MT) as an attribute independent (moderator) variable, consisting of High-Mental Toughness / High-MT (B_1) and Low-Mental Toughness /Low-MT (B_2) categories, and the VO_2max as the dependent variable (Table 1).

2.2. Participants

A total of 48 male university students aged 21-23 years (M_{years} = 21.11; SD_{years} = 2.64) from the Physical Education Study Program at Tanjungpura University were included in this study. Participants were divided into four treatment groups through the random assignment so that each treatment group consisted of 12 participants. The four treatment groups were the TT-Method and High-MT combination group (EG-1/A_1B_1), the TT-Method and Low-MT combination group (EG-2/A_1B_2), the SIT-Method and High-MT combination group (EG-3/A_2B_1), and the SIT-Method and Low-MT combination group (EG-4/A_2B_2). The inclusive characteristics of the participants included male students having low VO_2max and male students in the third and fifth semester.

2.3. Procedure

The experimental process was carried out for two months (eight weeks), from July to August 2022, for 24 meetings (three times a week; 60 minutes for each training session). The TT-Method and SIT-Method implementation protocols were carried out with almost the same characteristics, namely 90-100% intensity and dense density. The TT-Method form used eight exercise posts, consisting of push-ups, high knee jogging, squat-thrust, sit-ups, lunges, plank jacks, mountain climber, and squat jump exercises. While the SIT-Method was conducted by running a distance of 40 meters, 50 meters, and 100 meters. An assessment at the end of the experiment (post-test) was carried out one day after the experiment was finished. The success of the experimental process was measured using the VO_2max test.

2.4. Instrument

There are two instruments used in this study, namely the Mental Toughness Questionnaire 48 (MTQ48) and the aerobic ability test named The 20m Multi Stage Fitness Test (MSFT). MTQ48 was adapted from Clough, Earle, & Sewell [55], containing 48 items elaborated from 4 (four) dimensions, namely the dimensions of control, commitment, challenge, and self-confidence. The results of the reliability test analysis found a reliability coefficient index of 0.87. The instrument adaptation process referred

to the transcultural translation procedure as recommended by Núñez, et al. [56]. The VO_2max ability was measured using the MSFT test, a maximal running aerobic fitness test, also known as the 20-meter shuttle run test or bleep test, because it requires participants to run continuously between two lines, 20 meters apart, in time to record a beep. The results of content validity analysis using the AIKEN formulation found a content validity coefficient index of 0.89 [57].

2.5. Data Analysis

Using IBM SPSS Statistics 20, the two-way ANOVA technique was used to analyse all of the acruired data. The analysis process was carried out through the following stages: (1) descriptive statistical analysis, (2) assumption test, including (a) normality test using the Kolmogorov Smirnov formula, if the p-value > 0.05, the data are normally distributed, and (b) homogeneity test, carried out to determine the similarity of variance or to test that the data obtained come from a homogeneous population. The homogeneity test was carried out using the Box's Test of Equality of Covariance Matrices. If the p-value > 0.05, the variance data is homogeneous. (3) The hypothesis test used a two-way ANOVA to test the main effect, interaction effect, and simple effect [58].

3. Results

3.1. Descriptive Statistics

The results of the 20m Multi Stage Fitness Test's VO_2max measurement are included in Table 2 along with descriptive statistics (mean and standard deviation).

3.2. Assumption of Equal Covariance Matrices Test

The Kolmogorov-Smirnov analytic method was used to do the test for the normality assumption. The distribution of data from a group is said to be normal if it has a p-value > 0.05. On the other hand, the distribution of data is declared not-normal if the value of p < 0.05. The results of the analysis found that all data distribution in the four treatment groups had a p-value > 0.05. This means that the distribution of data was normally distributed. For the homogeneity, the assumption test was carried out using Levene's test of equality of error variance. The results of the analysis obtained the F test value (3,44) of 1.80 and statistically not significant at p = 0.16 > 0.05. This means that the null hypothesis was accepted or had the same variance (homogeneous).

Table 2. Statistical Description of the Effect of ET-Method and MT on VO_2max

Dependent Variable	Mental Toughness (MT)	Endurance Training Method (ET-Method)	Mean (ml/kg/minute)	SD	N
VO_2Max	High-MT	TT-Method	44.00	4.13	12
		SIT-Method	42.45	7.67	11
		Total	43.23	5.99	23
	Low-MT	TT-Method	44.38	6.38	13
		SIT-Method	34.67	4.48	12
		Total	39.53	7.36	25
	Total	TT-Method	44.19	5.32	25
		SIT-Method	38.56	7.25	23
		Total	41.38	6.90	48

Note: ml = mililiter; kg = kilogram

Table 3. Results of The Main Effect and Interaction Effect Analysis of ET-Method and MT on VO_2max

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	VO_2Max	753.20[a]	3	251.07	7.43	.00
Intercept	VO_2Max	81890.21	1	81890.21	2423.98	.00
MT	VO_2Max	163.85	1	163.85	4.85	.03*
ET-Method	VO_2Max	379.27	1	379.27	11.23	.00**
MT * ET-Method	VO_2Max	199.67	1	199.67	5.91	.02*
Error	VO_2Max	1486.47	44	33.78		
Total	VO_2Max	84576.00	48			
Corrected Total	VO_2Max	2239.67	47			

Note: *p < 0,05*; p < 0,01**; ET-Method = Endurance training method; MT = Mental toughness;

3.3. Hypothesis Testing

Hypothesis testing was carried out to test the effect of the independent variables (ET-Method and MT) and the interaction of ET-Method with MT. Table 3 presents the results of the analysis.

Based on the analysis results shown in Table 3, it was found that MT had a significant effect on VO_2max ($F(1,48) = 4.85$, $p = 0.03 < 0.05$ (58%), likewise for the ET-Method ($F(1,48) = 11.23$, $p = 0.00 < 0.01$ (91%)). There was also an interaction effect between MT and ET-Method ($F(1,48) = 5.91$, $p = 0.02 < 0.05$ (66%)). The results of the main effect and interaction effect test analysis are presented in Table 4 and 5.

Based on the result of the pairwise comparisons test (Table 4), it is proven that (1) High-MT had a more significant effect than Low-MT on VO_2max ($t_{count} = 10.56 > t_{table} = 2.02$); (2) TT-Method had a more significant effect than SIT-Method on VO_2max ($t_{count} = 16.07 > t_{table} = 2.02$).

The outcomes of the test of pair interaction between the MT and ET-Method (Table 5) show: (1) the High-MT/ SIT-Method combination gave a higher interaction effect than the Low-MT/SIT-Method combination ($t_{count} = 4.55 > t_{table} = 2.02$), but it did not give a different interaction effect when combined with the TT-Method ($t_{count} = -0.23 < t_{table} = 2.02$). In other words, High-MT had a higher effect than Low-MT on VO_2max in the SIT-Method condition or when combined with the SIT-Method. (2) The TT-Method/ Low-MT combination gave a higher interaction effect than the SIT-Method/Low-MT combination ($t_{count} = 5.92 > t_{table} = 2.02$), but it did not give a different interaction effect when combined with High-MT ($t_{count} = 0.90 < t_{table} = 2.02$). In other words, the TT-Method had a higher and significant effect than the SIT-Method on VO_2max in Low-MT conditions or when combined with Low-MT.

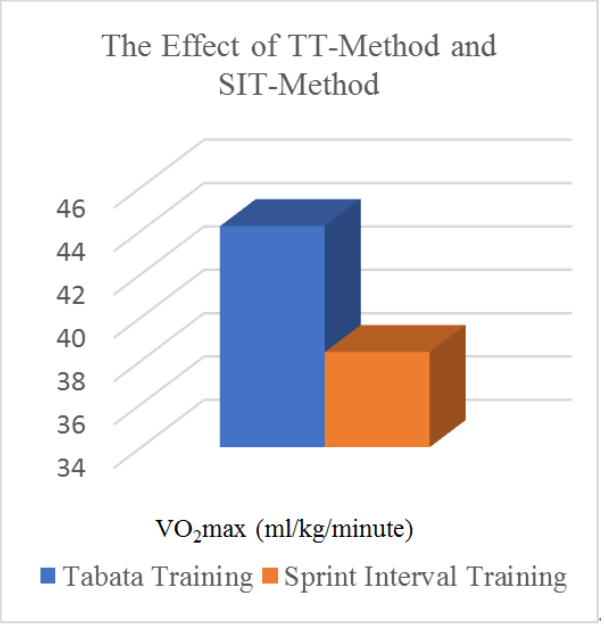

Figure 1. Effects of TT-Method and SIT-Method on VO_2max

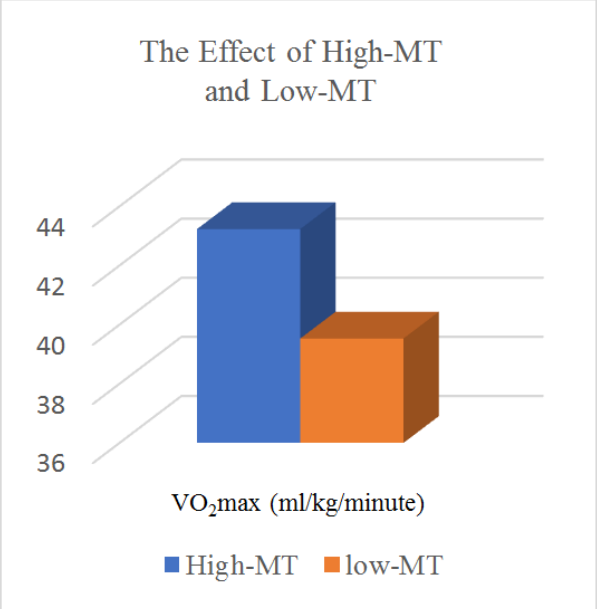

Figure 2. Effects of High-MT and Low-MT on VO_2max

Table 4. The Results of the Independent Variable Categories Pairwise Comparison Analysis on VO_2max

Pairwise Comparison			Mean			SEM			Mean Difference	t_{count}	t_{table}	Conclusion
High-MT	:	Low-MT	43.23	:	39.53	1.21	:	1.16	3.70 (-3.70)	10.56	2.02	Significant
TT-Method	:	SIT-Method	44.19	:	38.56	1.16	:	1.21	5.63 (-5.63)	16.07	2.02	Significant

Note: SEM = St andard error measurement; High-MT = High-Mental Toughness; Low-MT = Low-Mental Toughness; TT-Method = Tabata Training-Method; SIT-Method = Sprint Interval Training-Method.

Table 5. Results form the Comparison Analysis of the Pair Interaction on VO_2max between the ET-Method and MT Categories

Pairwise Comparison			Mean			SEM	Mean Difference	t_{count}	t_{table}	Conclusion
High-MT/TT-Method	:	**Low-MT**/TT-Method	44.00	:	44.38	1.68	-0.38 (0.38)	-0.23	2.02	Not significant
High-MT/SIT-Method	:	**Low-MT**/SIT-Method	42.45	:	34.67	1.75	7.78 (-7.78)	4.55	2.02	Significant
TT-Method/High-MT	:	**SIT-Method** /High-MT	44.00	:	42.45	1.61	1.55 (-1.55)	0.90	2.02	Not significant
TT-Method/Low-MT	:	**SIT- Method** /Low-MT	44.38	:	34.67	1.68	9.71 (-9.71)	5.92	2.02	Significant

Note: High-MT = High-Mental Toughness; Low-MT = Low-Mental Toughness; TT-Method = Tabata Training-Method; SIT-Method = Sprint Interval Training-Method; SEM = Standard Error Measurement

4. Discussion

This study aimed to investigate the independent and interactive effects of the ET-Method and MT on VO_2max. To achieve this goal, a field experiment was carried out using a 2x2 factorial design, consisting of four combinations of treatment groups, namely the TT-Method and High-MT (EG-1/A_1B_1) combination group, the TT-Method and Low-MT combination group (EG-2/A_1B_2), the SIT-Method and High-MT combination group (EG-3/A_2B_1), and the SIT-Method and Low-MT combination group (EG-4/A_2B_2). In general, the results of the analysis show that the ET-Method and MT were effective in increasing VO_2Max, both independently and in combination. The effect of the TT-Method was higher than the SIT-Method on VO_2max. Participants who had High-MT gained higher VO_2max compared to participants who had Low-MT. TT-Method had a higher effect than the SIT-Method on VO_2max when combined with Low-MT. Conversely, the SIT-Method had a more effective effect than the TT-Method when combined with High-MT.

The results of the analysis found that the ET-Method had a significant effect on VO_2max and the TT-Method (M = 44.19) proved to be more effective at increasing VO_2max than the SIT-Method (M = 38.56). The study's findings are consistent with some of the findings of earlier investigations. It was found that the TT-Method carried out for 12 weeks with high intensity (90% maximal heart rate/MHR) succeeded in increasing physical fitness, including endurance, and improving performance in sports [59,60]. The TT-Method is one of the most effective endurance training methods [28]. It trains the body to be more efficient in producing and using energy from the anaerobic energy system [61,62]. The exercise is performed for 20 seconds at high intensity with a 10 second rest and performed with repetitions of up to eight times so that a total time of four minutes can increase aerobic capacity [46, 63,64].

The same results were found in the SIT-Method. It is proven to be effective in increasing the function of the brachial artery as an indicator of the vascular system and the mobilization and circulation function of cells, which can contribute to endothelial repair [39,65-68]. The SIT-Method is proven to have a differential effect on blood vessels that contributes to cardio-respiratory fitness [65,69,70]. Peripheral adaptation is known to increase the oxidative potential of muscles after performing the SIT-Method [40,45,50]. The SIT-Method, which involves a maximum intensity of 30 seconds, has been proven successful in significantly increasing the oxidative capacity of skeletal muscles, maximizing oxygen uptake and endurance performance, and improving cardiorespiratory fitness which ultimately has implications for the health development more broadly [38].

However, when these two training methods were compared, it was found that the TT-Method was more effective at increasing VO_2max than the SIT-Method. As an intermittent training method [71,72], the TT-Method is understood as an endurance training method carried out regularly in one period. The training process is divided into several parts with a short time (training, pause, and training again). The TT-Method is considered one of the High-Intensity Intermittent Training (HIIT) whose training characteristics vary in terms of exercise form, intensity, duration, and rest. HIIT is a submaximal effort generally performed at an intensity that results in > 80% (generally 85-95%) of MHR [73]. HIIT usually involves a short high-intensity effort followed by a short rest or recovery and to do so, it usually takes less than 30 minutes [74].

In contrast, the SIT-Method is characterized by efforts made at an intensity equal to or greater than the speed that will produce VO_2max, including with supramaximal effort [73]. Whereas in the TT-Method training protocol, the intensity of the training is consistent (170% VO_2max) from the first to the last training session, such as 20 seconds of training time and 10 seconds of rest time, conducted for eight repetitions. The amount of time between practice time and rest time is four minutes. In terms of the ratio between training and recovery, the TT-Method differs from the SIT-Method. SIT-Method is a protocol that includes a work duration of 10-60 seconds, maximal intensity, "supramaximal", volume ≥ 12 repetitions, and recovery ≥

5 times the duration of work [45]. It is also a training method that has all-out intensity, supramaximal, maximal ≥ VO_2max, 30 second duration of work, four minutes of rest, and three-five minute rest intervals [38].

The duration of work in the two ET-Methods is related to the energy system in the human body which functions to make the human body move, which comes from food by first converting it into adenosine triphosphate (ATP), a form of chemical energy that can be directly used for all cellular functions. The body stores small amounts of ATP in muscles, but most of it is synthesized from the food we eat. Because the body does not store large amounts of ATP and requires a continuous supply, it must be continuously resynthesized. It occurs in several ways using one of three energy systems, namely phosphagen (direct source), anaerobic (slightly slow, using carbohydrates), and aerobic (slow, using carbohydrates or fats).

In the TT-Method, because the action duration is 20 seconds (< 30 seconds), it uses a phosphagen energy system, where creatine phosphate is used to reconstitute ATP after it is broken down to release its energy. The total amount of CP and ATP is stored in the small muscles so that the energy available for muscle contraction is limited. However, it is available instantly and is especially important at the start of the activity, as well as during short periods of high-intensity activity that lasts for 1 to 30 seconds. While the energy system used in the SIT-Method is the Glycolytic System, where anaerobic glycolysis can produce ATP quickly enough to be used during activities that require large bursts of energy over a rather long period of time (maximum 30 seconds to three minutes, or during endurance activities). Before a stable state is reached, if forced to work with insufficient rest periods, a large amount of lactic acid accumulates in the muscles causing fatigue, which eventually results in the cessation of physical activity [75]. Therefore, increasing the aerobic and anaerobic energy release system using the TT-Method is more effective than the SIT-Method, because the training method used will depend on the aerobic and anaerobic energy release system to re-synthesize ATP used during certain sports.

Based on the results of a comparative analysis between High-MT and Low-MT, it is proven that there was a difference in the effect of High-MT and Low-MT conditions on Vo_2max. Participants who had High-MT (Mean = 43.23) gained a higher and more significant effect on VO_2max than participants who had Low-MT (Mean = 39.53). Good endurance ability requires the integration of several physiological and psychological systems. A long-term combined physical and mental training correlates with the improved performance in physical activities [76-78]. Performance limitations also depend on various factors, including the type of training, environment, external influences, individual training status, and a number of mental factors [79]. In athletes who require high endurance, mental toughness can be influenced by the age of training and the athlete rating [80,81]. Athletes can experience higher MT levels because they have a greater ability to endure pain through the body endocrine system [82,83], so that it can accept this form of exercise with high-intensity loads well. This is also a conjecture that strengthens the difference in the effect of High-MT and Low-MT conditions on VO_2max.

The results of the analysis also found that the ET-Method and MT had an interaction effect on VO_2max. TT-Method had a higher effect than SIT-Method on VO_2Max when combined with Low-MT. SIT-Method was more effective than TT-Method when combined with High-MT. Participants who had Low-MT got the best ability in the TT-Method treatment and low results in the SIT-Method. Furthermore, participants who had High-MT got higher results in the SIT-Method treatment. These results explain, among other things, that participants who have High-MT have the ability to withstand pain and/or are able to accept the training load given better. The role of mental aspects in improving achievement is an important part and has been proven a lot through previous research. The ability to accept criticism and control to hold back anger during training and matches is an important key for an athlete to be able to show the best performance he has and this has a positive correlation [84,85]. To achieve a good performance, three components are needed to support the athlete achievement, namely physical ability for competition, movement skills, and mental maturity to compete [86,87]. The determinant that can be the difference between the good and bad performance lies in the psychological ability to accept the pressure that comes on him, both during training and matches. The mental aspect must receive the same portion of training as physical training and tactics so that the best performances can be shown.

In principle, the TT-Method is a combination of high-intensity interval training. The characteristics of the TT-Method include increasing the amount of training volume (in repetitions and sets), adjusting the intensity in a high percentage (%) to the athlete ability level, and specifying rest duration of 10 seconds for each repetition. The TT-Method can be carried out in two ways, namely light loading intensity and high execution intensity with the pulse rate indicator rising. With a pulse of 170x/minute, it is included in the high category and the heavy loading intensity with maximum effort. The TT-Method is an endurance training method whose goal is to increase strength ability quickly and be maintained for a long time and to develop speed endurance, strength endurance, and power. In addition, the Tabata-method can burn fat, increase metabolism during exercise, increase metabolism after exercise, fast, and short training, improve the aerobic system, and increase MT and mental strength; the method is versatile and can choose a variety of activities [71,88]. With a lot of training volume compared to the SIT-Method, which is less and interspersed with frequent rest, the MT required by athletes does not need to be as high as when doing the SIT-Method.

The SIT-Method is characterized by repetitive and brief (4-6 x < 30 seconds) training with intermittent supramaximal intensity (> 90% VO_2max), punctuated by periods (4.5 minutes) of active or passive recovery [89,90]. Research has consistently shown the SIT-Method to be a powerful training stimulus that elicits a number of beneficial central and peripheral physiological adaptations characterized by improved indicators of health, fitness, and performance [91], even though the SIT-Method involves a total volume of training which is much lower [89,92] compared to the TT-Method. Indices of improvement of aerobic fitness (such as maximal oxygen uptake, muscle oxidative capacity, ventilator, lactate threshold, time-trial, and time-to-exhaustion performance) and sprint performance (such as peak anaerobic power, mean power, peak aerobic power (Watt)) have been shown to increase significantly after 2–6 weeks of the SIT-Method [89,93,94]. As a result, the SIT-Method is endorsed as a time-saving alternative intervention for achieving fitness and health benefits through exercise [95-97]. Although the SIT-Method is strongly supported by athletes, the general population is intimidated by feeling unwell and burdensome protocols [98]. It causes the athlete MT to be high as it has four MT dimensions, namely control, commitment, challenge, and self-confidence [55], causing intimidation of bad feelings and heavy protocols to become a challenge requiring a consistent commitment. Therefore, MT is a psychological aspect or skill that needs intervention using certain psychological strategies, such as self-talk and mental imagery [99].

The result of this research implies that coaches can develop physical training programs, especially to develop better endurance, by combining each level or category of endurance training methods (TT-Method and SIT-Method) with MT (high-MT and low-MT). Similar with other studies, one of the main limitations of this research is that it only involved one dependent variable. In fact, the results and contribution will be better if the influence on sport performance and psychological aspects is also examined.

5. Conclusions

There are three main conclusions of the research. First, both endurance training methods (TT-Method and SIT-Method) can be used as an alternative training method to develop endurance. Second, mental toughness becomes a moderator variable that can be combined with both forms of the ET-Method. Third, for better results, the High-MT is combined with the SIT-Method, while the Low-MT is combined with the TT-Method. In accordance with the three conclusions of this research, coaches can use these two types of endurance training in the training process as an alternative training method to increase VO_2max, either partially or in combination with both MT levels.

Acknowledgments

The authors would like to express their gratitude to everyone who contributed to this study, particularly the students, colleagues, and Tanjungpura University's Faculty of Teacher Training and Education, which provided funding for the study.

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