Comparison of High-Intensity Interval Training and Moderate-Intensity Continuous Training on VO2max and Response Reaction Time in Basketball Referees

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Abstract

Introduction –Physical condition is an important aspect that a referee must have, because the decrease in physical condition mayresult in emotional instability, premature fatigue, decreased concentration and cause failure to focus in leading the match.

Objective –The aim ofthis study was to compare the effect of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on VO_2max and reaction time response in basketball referees.

Methods – A total of 20 men aged 18-21 years were enrolled in this study and given high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT).VO_2max was measured using multistage fitness test (MFT) and the response reaction time was measuredusingwhole body reaction time test type II. Measurementswere carried out twice in pretest and postest. Data were analyzed for Independent-Samples T-Test and Paired Samples Test using the Statistical Package for Social Science (SPSS).

Results –Mean value ofVO_2max on HIIT between pretest and posttest was 33.36±3.78 vs. 45.12±3.45 mL/kg/min (*p*-value=0.000). Mean value ofVO_2max at MICT between pretest and posttest was 34.26±6.69 vs. 40.50±5.04 mL/kg/min (*p*-value=0.000). Mean reaction time in HIIT between pretest and posttest was 0.33±0.08 vs. 0.28±0.08 second (*p*-value=0.001). Mean MICT reaction time between pretest and posttest was 0.30±0.04 vs. 0.29±0.04 second, (*p*-value=0.029)). Mean delta (Δ) VO_2max between HIIT vs. MICT was 11.76±2.27vs.6.24±2.49 mL/kg/min (*p*-value=0.000). Mean delta (Δ) reaction time between HIIT vs. MICT was –0.04±0.03 vs. –0.01±0.01 second (*p*-value=0.002).

Conclusion –Based on the study results, it can be concluded that HIIT and MICT increase VO_2max and response reaction time, but HIIT was more effective in increasing VO_2max and reaction time compared to MICT in basketball referees.

Keywords: *HIIT, MICT, VO_2maks, reaction time, basketball, referees*

Introduction

Basketball is growing rapidly, this is proven by the increasing number of tournaments and competitions at all levels and age groups. Starting from competition between elementary to collegestudents level, district level, until the national level. To create a good and orderly match, healthy leadership is required from the referee who leads the match. Basketball referee must meets the standards set by the refereeing commission. A basketball referee must pass the theoretical tests and physical fitness tests. In the physical fitness test, referees must be able to pass the beep test provided, for men it is 86 laps and for women it is 66 laps. Researchers

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observed that the referees' physical conditions were less than optimal, especially from Surabaya, Indonesia.

Physical condition is an important aspect for referees. One of the components in physical condition is VO_2. VO_2max is the maximum amount of oxygen used in millimeters, which the body can consume in millimeters per minute.[1]For basketball referees, having a good physical condition, especially in cardiovascular endurance, is an important aspect. The endurance function for the referee is to guard the match with a duration of 10 minutes by 4 quarters. If a referee has a high endurance level, the match will be well guarded. However, with a low level of endurance, they will quickly experience fatigue, which results in decrease ofphysical condition. This condition will cause unstable emotions, exhausted, lack of concentration, and unfocused during the match.[1] Concentration is an important part of refereeing activity. An activity can be well done if it is carried out with high concentration. Concentration helping the basketball referee shows his skills, especially during a match. Concentration is a state of one's consciousness fixed on an object within a certain time.[2] In basketball matches, the referee requires high concentration, In a basketball match, the referee requires high concentration, because decision making must be done quickly, correct, and acceptable.The performance of the referee describes the match, from the beginning to the end. Full concentration is needed every time leading a match so as not to harm both teams.

Physical condition has an important role for a referee, especially basketball referee. Therefore, it is necessary to improve the physical condition of a referee to support his performance when leading a match. The referee's physical condition can be improved through endurance training. Recently, research on the effects of high-intensity interval training (HIIT) has been widely studied. HIIT is a short-duration physical exercise consisting of several exercise cycles with high intensity interspersed with rest periods at lower intensity. Provide HIIT exercise for 2 weeks can improve physical condition abilities.[3] HIIT is an exercise with an intensity of 80 - 95% HRmax.[4] Likewise, moderate-intensity continuous training (MICT) has also been widely studied. MICT is an exercise with an intensity of 60-70% HRmax.[5] Several studies have stated that this exercise can increase endurance skills, however, MICT requires a longer period of time compared to HIIT.[6] Research about the comparison of HIIT and MICT effects on the increase inVO_2max and reaction time response in basketball referees is still unclear.

In Surabaya, 75% of basketball referees are dominated by referees from State University of Surabaya.[7] However, from the mean level of endurance for basketball referees who have a C license fromState University of Surabaya basketball referees mentioned in study that has been conducted, it was known only 30% from 15 referees who are able to meet the high endurance level.[8] To determine the improvement in physical condition and response time to basketball referees, research needs to be done through provide HIIT and MICT exercises. Based on the background mentioned before, the aim of this study was to compare between HIIT and MICT effects on the increase in VO_2max and reaction time response in basketball referees.

Material and Methods

Study Design

This study was conducted using Field Experiment with Two-Group Random Assignment Pretest–Posttest Design. Subjects were 20 men aged 18-21 years, normal Body Mass Index (BMI), normal blood pressure, normal resting heart rate (RHR), and divided randomly into two groups, namely the HIIT group (n=10, high-intensity interval training) and the MICT group (n=10, moderate-intensity continuous training). All procedur conducted in this study were under the approval of Research Ethics Committee of Health Faculty, Faculty of Medicine, Universitas Airlangga (22/EC/KEPK/FKUA/2020).

Anthropometric Measurement

Measurement of height was carried out using stadiometer (SECA, Chino, CA). Body weight wasmeasured using digital scale(OMRON HN-289., JAPAN). BMI was measured usingthe formula ofbody weight (kg) divided by the height in square meter (m2).[9,10] RHR was measured usingPulse Oximeter (PO 30 Pulse Oximeter, Beurer, Germany). Blood pressure was measured using digital tensimeter(OMRON Model HEM-7130 L, Omron Co., JAPAN) on the upper arm in three consecutive times with 1-2 minute intervals between the two measurements. At the time of measuring

blood pressure, the subjects were in a sitting position.

Exercise Protocol

HIIT intervention was carried out with an intensity of 85-95% HRmax, which was carried out at intervals of 25 minutes/training sessions with a frequency of 3x/ week for 4 weeks.[4] MICT was carried out with 60-70% HRmax intensity which is carried out continuously for 25 minutes/training session with a frequency of 3x/week for 4 weeks.[4,5] HIIT and MICT interventions were carried out in the morning at 07.00-09.00 a.m using treadmill (Pulsar 4.0 HP Cosmos Sports & Medical, Nussdorf-Traunstein, Germany).[11] Monitoring of exercise heart rate were carried out using Polar (Polar H10 Heart Rate Sensor, USA, Inc).

VO_2maks and Reaction Time Measurements

Measurement of VO_2max was carried out usingMultistage Fitness Test (MFT),[12]while the measurement of reaction time response was carried out usingwhole body reaction time test type II. Measurements ofVO_2max and reaction time response were carried out twice, in pretest and postest (after 4 weeks intervention).

Statistical Analysis

Data analysis performed usingstatistical Package for social science (SPSS) software version 21 (Chicago, IL, USA). Data were analyzed for distribution of normality usingthe Shapiro-Wilk Test. Data with normal distributionwere analyzed for mean difference usingIndependent-Samples T-Test dan Paired Samples Testwith level of signifficance ($p \geq 0.05$). All data were presented in mean± Standard Deviation (SD).

Results

The results of the analysis of subject characteristics including age, body height, body weight, body mass index (BMI), systolic and diastolic blood pressure, and resting heart rate are presented in Table 1 below.

Tabel 1. Characteristics of the subjects

Variable	n	HIIT Mean±SD	MICT Mean±SD	Independent-Samples T-Test *p-values*
Age (year)	10	19.10±0.88	18.90±0.88	0.616
BH (m)	10	1.66±0.07	1.64±0.03	0.485
BW (kg)	10	56.08±10.96	62.69±9.77	0.172
BMI (kg/m^2)	10	20.43±3.39	22.97±3.13	0.098
RHR (bpm)	10	80.20±5.81	78.30±4.78	0.435
SBP (mmHg)	10	113.20±12.03	115.70±7.02	0.578
DBP (mmHg)	10	72.70±6.68	75.20±7.91	0.455

Note: BH: body height; BW: body weight; BMI: body mass index; RHR: resting heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; HIIT: high-intensity interval training; MICT: moderate-intensity continuous training.

Based on Table 1,the Independent-Samples T-Test results showed that the mean data on the characteristics of the subjects did not show significant differences in all parameters between the HIIT and MICT groups ($p \geq 0.05$). The results of VO_2max analysis and response time between pretest and posttest in the HIIT and MICT groups are presented in Fig. 1 and Fig. 2.

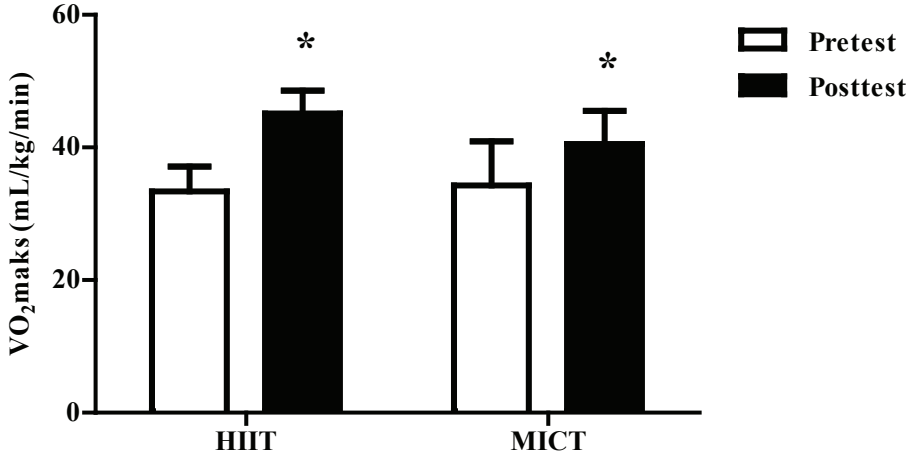

Figure 1. Mean VO_2maks betweenPretest andPosttest in the HIIT group and the MICT group

Note:HIIT: high-intensity interval training; MICT: moderate-intensity continuous training. *Significant difference vs pretest ($p \leq 0.05$).

The results of the Paired Samples Test in the HIIT group showed that there was a significant difference in the mean of VO_2max between pretest and posttest (33.36±3.78 vs. 45.12±3.45 mL/kg/min, (*p*-value=0.000)) (Figure 1). The results of the Paired Samples Test in the MICT group also showed a significant difference in mean VO_2max between pretest and posttest (34.26±6.69 vs. 40.50±5.04 mL/kg/min, (*p*-value=0.000)) (Figure 1).

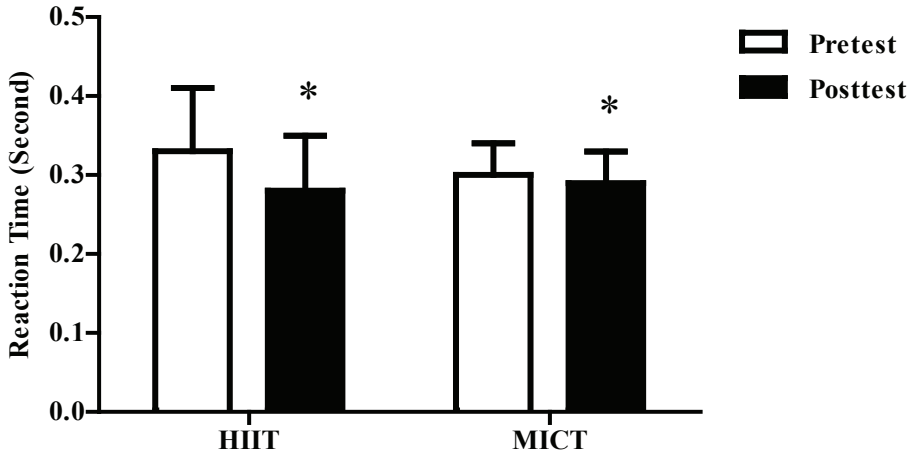

Figure2. MeanReaction Timebetween Pretest and Posttest in the HIIT group and the MICT group

Note:HIIT: high-intensity interval training; MICT: moderate-intensity continuous training. *Significant difefrence vs pretest ($p \leq 0.05$).

The results of the Paired Samples Test in the HIIT group showed that there was a significant difference in the mean reaction time between the pretest and posttest (0.33±0.08 vs. 0.28±0.08 second, (*p*-value=0.001)) (Figure 2). The results of the Paired Samples Test in the MICT group also showed a significant difference in the mean reaction time between pretest and posttest (0.30±0.04 vs. 0.29±0.04 second, (*p*-value=0.029)) (Figure 2).

Table 2. The results of the analysis of VO_2max andReaction Timebetween Pretest HIIT vs MICT, Posttest HIIT vs MICT andDelta (Δ)HIIT vs MICT

Group	Variable	Time	Mean±SD (n=10)	Independent-Samples T Test p-values
HIIT	VO2max (mL/kg/min)	Pretest	33.36±3.78	0.716
MICT			34.26±6.69	
HIIT		Posttest	45.12±3.45*	0.028
MICT			40.50±5.04	
HIIT	Reaction Time (second)	Pretest	0.33±0.08	0.419
MICT			0.30±0.04	
HIIT		Posttest	0.28±0.08	0.754
MICT			0.29±0.04	
HIIT	VO2max (mL/kg/min)	Delta (Δ)	11.76±2.27*	0.000
MICT			6.24±2.49	
HIIT	Reaction Time (second)	Delta (Δ)	–0.04±0.03*	0.002
MICT			–0.01±0.01	

Note: HIIT: high-intensity interval training; MICT: moderate-intensity continuous training. *Significant difference vs moderate-intensity continuous training (MICT) ($p \leq 0.05$).

Based on the results of the Independent-Samples T-Test, it shows that there was no significant difference in the mean of VO_2max between the HIIT vs MICT pretest ($p \geq 0.05$), while the mean of VO_2max between the posttest HIIT vs MICT showed a significant difference ($p \leq 0.05$). The results of the Independent-Samples T Test between pretest HIIT vs MICT and posttest HIIT vs MICT showed no significant difference ($p \geq 0.05$). The results of the Independent-Samples T-Test showed that there was a significant difference in the mean delta (Δ) of VO_2max and reaction time between HIIT vs MICT ($p \leq 0.05$).

Discussion

Twentymen participated in this study and were divided into two groups, namely the HIIT group (n=10, high-intensity interval training) and the MICT group (n=10, moderate-intensity continuous training). The characteristics of the subjects of this study were men aged 18–21 years who had Body Mass Index (BMI) of 19–23 kg/m². Based on the results of the Independent-Samples T-Test analysis, the data on the characteristics of the subjects showed no significant difference in all parameters between the HIIT and MICT groups ($p \geq 0.05$). Therefore, if there is an increase in VO_2max and reaction time, it is not due to the characteristics

of the subject but it is probably due to the influence of interventions from high-intensity interval training and moderate-intensity continuous training.

Maximum oxygen volume (VO_2max) is defined as the maximum capacity of the body to take in, transport, and use oxygen during exercise.[13] Referees with high VO_2max can perform activities optimally compared to referees with low VO_2max.[14] When leading a match, the referee requires physical components such as endurance and reaction time to support the match, so that it is well guarded. Based on the pretest VO_2max results in this study, it shows that mean VO_2max in HIITis 33.36±3.78 mL/kg/min, while VO_2max with a good category for men should be at 42 mL/kg/min. This VO_2max result was probably due to the exercise program once a week that have done by the subjects, so that they had VO_2max which was still lacking in refereeing standards. The dose of practice to meets the target of developing skills and abilities requires a minimum frequency of practice at least three to five times a week.[15,16]

After the subjects were given high-intensity interval training (HIIT) intervention for 4 weeks with a frequency of 3x/week, there was an increase in the mean VO_2max value to 45.12±3.45 mL/kg/min. There was an increase in VO_2max by 35.25% from the pretest value. Based on the results of the Paired Samples Test in the HIIT group, it showed that there was a significant difference in the mean of VO_2max between the pretest and posttest (33.36±3.78 vs. 45.12±3.45 mL/kg/min, (*p*-value=0.000)) (Figure 1). These results are in line with the study conducted by Bacon *et al*.[17] concludes that high-intensity interval training increases VO_2max in young adults. HIIT can increase VO_2 max, the Cardiorespiratory Fitness Standard index. In addition, HIIT can increase the lactate threshold, that limits the domain of moderate and high exercise intensity. HIIT creates a high degree of efficiency in the circulatory and respiratory systems in carrying oxygen to working muscles. The more oxygen that can be inhaled and used, result in longer ability to work (exercise) and prevent premature fatigue.[18]

Reaction time is a measure of the response to a stimulus.[19]The ability to move quickly after receiving stimuli (can be in the form of hearing, sight, etc.) can be used to reach the optimal speed of reaction movement as an initial movement that can support further fast movements.[20] When in charge of leading a match, it requires a physical condition component such as reaction time to support faster movements in decision making in an event. Based on the pretest result, it showed that the meanof the reaction time was 0.33±0.08 seconds. The mean value at the pretest was still in the sufficient category, while to reach the good category must be in the range of 0.20-0.30 seconds. After 4 weeks of HIIT intervention with a frequency of 3x/week, there was an increase in the mean reaction time by 0.28±0.08 seconds. This value has met the good category. The increase in the reaction time variable was 15.05%. The results of the Paired Samples Test in the HIIT group showed that there was a significant difference in the mean reaction time between the pretest and posttest (0.33±0.08 vs. 0.28±0.08 mL/kg/min, (*p*-value=0.001)) (Figure 2).

Based on the study results, the mean of pretest VO_2max in the moderate-intensity continuous training (MICT) group was 34.26±6.69 mL/kg/min, while VO_2max with a good category for men should be at 42 mL/kg/min. After 4 weeks of HIIT intervention with a frequency of 3x/week, the mean VO_2max value increased to 40.50±5.04 mL/kg/min. Based on the pretest and posttest data, it can be seen that there was an increase in VO_2max by 18.21% from the pretest results. The results of the Paired Samples Test in the MICT group showed a significant difference in the mean of VO_2max between pretest and posttest (34.26±6.69 vs. 40.50±5.04 mL / kg / min, (*p*-value=0.000)) (Figure 1).

The mean of pretest reaction time in the MICT group was 0.30±0.04 seconds. These result was included in the good category, in the range of 0.20-0.30 seconds. After 4 weeks of HIIT intervention with a frequency of 3x/week, the mean reaction time increased by 0.29±0.04 seconds. There was an increase by 3% from the pretest results. Based on the results of the Paired Samples Test analysis in the MICT group, there was a significant difference in the mean reaction time between pretest and posttest (0.30±0.04 vs. 0.29±0.04 mL/kg/min, (*p*-value=0.029)) (Figure 2).

Based on the posttest results of VO_2max in the HIIT group, there was an increase by 35.25%, while the MICT group increased by 18.21% from the pretest, meaning that there was a greater increase in the HIIT

group than in the MICT group. This results showed that the high intensity interval training and moderate intensity continuous training carried out for 4 weeks with a frequency of 3x/week progressively and programmatically affect cardiovascular development due to the adaptation process during exercise. In the process of training, the body needs oxygen to produce energy. Apart from oxygen, metabolism in the body can also affect muscle contraction. The body's ability to produce energy occurs through anaerobic (without O_2) and aerobic (with O_2) processes. The oxygen demand in the body due to the intensity of movement causes the body to stabilize with an increase in the cardiovascular system, namely an increase in heart rate, dilation of coronary arteries, an increase in stroke volume, and an increase in heart muscle contraction.[21] The value of increase in ability depends on the dose of exercise given. Improvement in the exercise level usually occurs through the formation stage.[22]

Based on the results of the Independent-Samples T-Test, it showed that there was no significant difference in the mean of VO_2max between pretest HIIT vs MICT ($p \geq 0.05$), while the mean of VO_2max between posttest HIIT vs MICT showed a significant difference ($p \leq 0.05$). This difference was due to the HIIT training method of giving weights with an intensity of 80-90% HRmax which is interspersed with active recovery during the training process, causing a maximum heart work process compared to the MICT method which uses an intensity of 60-70% HRmax without active recovery during training. Therefore, HIIT is more effective in increasing VO_2max than MICT.

This two training methods have different training patterns. HIIT uses an interval training pattern (with active recovery), while MICT uses continuous pattern (continuous without active recovery). Both of these training methods have a physiological effect on the cardiovascular system by adapting the heart muscle to a given exercise. During exercise, there is an increase in the cardiorespiratory system, such as an increase in oxygen demand in active muscles, an increase in the strength of the respiratory muscles (inspiratory and expiratory muscles), which are closely related to an increase in energy metabolism in the mitochondria. The contracted muscle cells need a lot of Adenosine triphosphate (ATP) supply, so that muscles used in training need more oxygen and produce carbon dioxide. Increase in cardiovascular also occurs due to an increase in heart rate during exercise, and will further increase stroke volume. As a result, these will increase the cardiac output, namely the volume of blood released by the two ventricles per minute. This increase is accompanied by vasodilatation of the blood vessels to carry oxygen to the active muscles. Exercise causes an increase in stroke volume so that resulting in a decrease in pulse rate while cardiac output remains,this mechanism is due to the efficiency of the heart muscle in supplying blood throughout the body. The efficiency of the heart rate is indicated by a decrease in pulse rate.[21]

The posttest reaction time results in the HIIT group increased by 15.05% and the MICT group increased by 3% from the pretest results, which means that there was a greater increase in reaction time in the HIIT group than in the MICT group. Based on the results of the Independent-Samples T-Test between pretest HIIT vs MICT and posttest HIIT vs MICT, there were no significant differences ($p \geq 0.05$). However, based on the mean value of improvement, the HIIT group had a higher increase in reaction time compared to MICT.

In both training methods, there are almost the same movement patterns. HIIT, which combines alternating sprint and jogging exercises, automatically trains the lower limb speed components, so that training for a certain period of time increases general speed. Speed increases because HIIT is a repetitive and continuous activity in a short time interspersed with intervals such as walking/jogging, while the MICT training pattern uses the same running speed every training period, so that causes the participants to become bored and less enthusiastic.[21] This is the cause of the difference in reaction time in the two groups.

Conclusion

Based on the results of the study, it can be concluded that HIIT and MICT performed 25 minutes/training session with a frequency of 3x/week for 4 weeks, significantly increased VO_2max and reaction time response, but HIIT was more effective in increasing VO_2max and reaction time response compared to MICT. Therefore, it is recommended that high-intensity interval training be applied to the preparation of an exercise program to improve the physical condition of

basketball referees. Based on the results of this study, it is recommended that further research be conducted by comparing high-intensity interval training carried out using a treadmill and ergocycle for 25 minutes/training sessions with a frequency of 3x/week for 4 weeks to see the effectiveness of increasing VO_2max and reaction time response.

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