CIRCUIT TRAINING IS MORE EFFECT THAN INTERVAL TRAINING ON INCREASING VO2 MAX IN FOOTBALL PLAYERS

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Abstract

Introduction: *Football players should be in good physical condition to support their performance on the field. This includes cardiorespiratory fitness (VO2 max), which needs to be maintained to be able to perform while playing. An increase in VO2 max is an indication of the ability of the heart and lungs to function optimally during exercise. Low endurance can cause football players to tire easily. Exercises that can be done to increase VO2 max are circuit training and interval training. Circuit training has a physiological effect on the muscles. They adapt and are automatically able to increase the maximum oxygen volume. Whereas interval training has an effect on metabolic waste from muscles at rest, resulting in increased oxygen consumption during exercise and an increase in VO2 max.* ***Research objective:*** *To know the difference in the effect of circuit training and interval training on the increase of the VO2 max in football players.* ***Methods:*** *Experimental with a quasi-experimental approach to pre- and post-test two grub design treatment, sampling technique using total sampling, a sample of 44 people with a training program 3x a week for 6 weeks. The research instrument used was a multi-stage fitness test. Data analysis used was descriptive statistical test, normality test, homogeneity test and hypothesis testing.* ***Results:*** *Hypothesis tests I and II using paired sample t-test showed that there was an effect of circuit training and interval training on the increase of VO2 max in football players (P=0.00 P<0.05). Hypothesis test III using independent samples t-test shows that circuit training has a greater effect than interval training on increasing VO2 max in footballers (P=0.00 P<0.05).* ***Conclusion:*** *Circuit training is more effective than interval training in increasing VO2max.* ***Suggestion:*** *Further analysis of other more varied exercises to increase VO2 max is expected in future research.*

Keywords*: Circuit training, interval training, maximal oxygen volume*

LATIHAN SIRKUIT LEBIH EFEKTIF DARIPADA LATIHAN INTERVAL DALAM MENINGKATKAN VO2 MAX PADA PEMAIN SEPAKBOLA

Abstrak

Pendahuluan: Pemain sepak bola harus memiliki kondisi fisik yang baik untuk menunjang performanya di lapangan. Hal ini termasuk kebugaran kardiorespirasi (VO2 max) yang perlu dijaga agar tetap prima saat bermain. Peningkatan VO2 max merupakan indikasi kemampuan jantung dan paru-paru untuk berfungsi secara optimal saat berolahraga. Daya tahan tubuh yang rendah dapat menyebabkan pemain sepak bola mudah lelah. Latihan yang dapat dilakukan untuk meningkatkan VO2 max adalah latihan sirkuit dan latihan interval. Latihan sirkuit memiliki pengaruh fisiologis terhadap otot. Otot beradaptasi dan secara otomatis mampu meningkatkan volume oksigen maksimal. Sedangkan latihan interval memiliki pengaruh terhadap sisa metabolisme dari otot saat istirahat sehingga mengakibatkan peningkatan konsumsi oksigen saat berolahraga dan peningkatan VO2 max. Tujuan penelitian: Mengetahui perbedaan pengaruh latihan sirkuit dan latihan interval terhadap peningkatan VO2 max pada pemain sepak bola. Metode: Eksperimen dengan pendekatan quasi eksperimen dengan rancangan perlakuan pre- and post-test two grub design, teknik pengambilan sampel menggunakan total sampling, sampel sebanyak 44 orang dengan program latihan 3x seminggu selama 6 minggu. Instrumen penelitian yang digunakan adalah tes kebugaran jasmani multistage. Analisis data yang digunakan adalah uji statistik deskriptif, uji normalitas, uji homogenitas dan uji hipotesis. Hasil: Uji hipotesis I dan II menggunakan paired sample t-test menunjukkan bahwa ada pengaruh latihan sirkuit dan latihan interval terhadap peningkatan VO2 max pada pemain sepakbola (P=0,00 P<0,05). Uji hipotesis III menggunakan independent samples t-test menunjukkan bahwa latihan sirkuit memiliki pengaruh yang lebih besar dibandingkan latihan interval terhadap peningkatan VO2 max pada pemain sepakbola (P=0,00 P<0,05). Kesimpulan: Latihan sirkuit lebih efektif dibandingkan latihan interval dalam

meningkatkan VO2 max. Saran: Penelitian selanjutnya diharapkan dapat melakukan analisis lebih lanjut terhadap latihan lain yang lebih bervariasi untuk meningkatkan VO2 max.

***Kata kunci**:* Latihan sirkuit, latihan interval, volume oksigen maksimal

1. Introduction

Football players need to be in good physical condition to perform at their best in football matches. It is important for football players to have a good VO2 max. This is because of the extensive running that is required to cover a large field of 75 x 100 meters. Maximal oxygen volume (VO2 max) is an indicator of cardiorespiratory fitness that affects an athlete's endurance during physical exertion. An increase in VO2 max indicates greater endurance and depends on how long an athlete can energize functioning muscles (Rosenblat et al., 2022). Aerobic metabolism is the primary source of energy for endurance recovery during exercise, with the average utilization of VO2 max in the range of 70%-80% during a match (Silva et al., 2021). An increase in VO2 max indicates greater endurance during exercise and depends on how long an athlete can maintain working muscles (Chekhovskaya, 2023). In football players aged 13-19 years, the VO2 max category is considered to be very low if it is <32 mL/min/kg and is considered to be high if it is >48 mL/min/kg(Siregar et al., 2022).

A study conducted by Crouse et al., (2019) in Texas, United States, revealed that 472 subjects who were American-Style Football Athletes aged 18 had an average VO2 max value of 45 mL/min/kg, categorised as good. Research by Rosman & Anuar (2020) in a secondary school in Perak, Malaysia, showed that 20 football players under the age of 18 had an average VO2 max of 36.74 mL/min/kg, which was classified as low. The results of research measuring the National Sports Success Index, physical fitness in Indonesia are 1.08% in the very good category, 4.07% in the good category, 13.55% in the moderate category, 43.90% in the poor category and 37.40% in the very poor category (Nurhayati & Kristiana, 2021).

Footballers with low VO2 max values are going to have low endurance, which will cause the athletes to get tired easily and will allow for a decrease in concentration, not being able to focus when the game is taking place (Ren et al., 2022). A reduction in VO2 max can lower physical fitness, increasing the risk of injury. This is due to decreased nerve, musculoskeletal, and motor control performance caused by fatigue and decreased energy availability (Agustiyawan et al., 2021).
Factors that can cause a decrease in VO2 max based on research by Kayilou et al., (2021) is ethnicity, age, environment and level of physical activity. In addition, optimal cardiovascular function is necessary for the proper delivery of inhaled oxygen to the lungs, blood vessels and circulation throughout the body, and this function can be improved by physical activity, which is an important factor influencing VO2 max (Zarwan & Hardiansyah 2020). In order to increase VO2 max in football players, training or exercise efforts should be performed.

Increasing VO2 max based on the Federation International Football Association (FIFA) can be done by improving the quality of training for young players through planning and scheduling training for the regulation of training: duration - intensity - recovery with training methods must be adjusted to the age and personality of the player (FIFA, 2022). Meanwhile, the efforts made by the Malaysian Football Association in the research of Atana et al., (2021) are the development of youth football which is focused on aerobic endurance to prevent fatigue through endurance training. In Indonesia, sports clubs usually have sports coaches who are in charge of organizing and supervising the training process of athletes (Suharjana, 2015). However, according to research by Utomo (2019) sports science is still not fully spread throughout Indonesian cities, as evidenced by the fact that many coaches still do not know how to evaluate and use instruments to measure VO2 max, resulting in poor VO2 max ability for soccer players. Various kinds of exercises can be used to increase VO2 max in football, such as circuit training and interval training.

Circuit training is a workout program that includes multiple stations where players or athletes perform predetermined exercises. Circuit training is a fitness regimen that efficiently enhances strength, flexibility, and cardiovascular health in one session (Jes et al., 2021). Circuit training leads to physiological changes in muscles through a repetitive and systematic exercise that improves the body's maximum oxygen volume (VO2 max) (Fitriyansyah et al., 2021).

Interval training is a high-intensity physical exercise regimen that alternates between exercising and recovery periods. Interval training is carried out with intensity, repetition, and distance, by exercise planning. Rest periods between sets must be consistent (Mangine & Seay, 2022). Interval training aims to develop lactate elimination, maximum oxygen uptake, and maximum aerobic capacity to enhance the physical performance capabilities of the body (Hov et al., 2023).

Maximum oxygen volume is measured by the Multistage Fitness Test (MFT). The MFT also known as the beep test, is one of the precise methods to measure maximal aerobic power or VO2 max (Pacholek, 2023). Participants perform the MFT by running back and forth over a 20-metre distance, responding to a "beep" to indicate completion of each stage, which is recorded in the VO2 max prediction table.

2. Method

This study uses an experimental method with a quasi-experimental approach, specifically by conducting experiments to determine the effects of certain treatments or interventions. The study follows the research design of a "pretest-posttest control two-group design". A comparison was made between the treatments with the first group receiving circuit training and the second group receiving interval training. Before the treatment, the sample group will measure their VO2 max using the Multistage Fitness Test (MFT) and after the treatment, three times a week for six weeks, the sample's VO2 max will be measured again using the MFT. The results of the MFT measurements can be classified into five categories based on age between 14 and 19 years: very good (>48), good (42-47), moderate (38-41), poor (33-37) and very poor (<32).

The sample for this study consisted of 44 individuals between the ages of 14 and 16 years who were selected on the basis of pre-defined inclusion and exclusion criteria for total sampling. In this study, a frequency distribution was used as the analysis technique for managing data based on age, sex, body mass index (BMI), MFT pre- and post-test values. Data normality was then checked using the Shapiro-Wilk test with a criterion of p>0.005, indicating that data were normally distributed. The homogeneity of the data was tested for the population obtained from the same variant using the Levene's test. Hypothesis testing was carried out to determine the effect of circuit training and interval training using a paired sample t-test with a significance level of p<0,005. To compare the effects of circuit training and interval training, measurements were made using an independent sample t-test with a significance level of p<0,005.

3. Result

This study analyzed respondent characteristics including age, gender, body mass index (BMI), and pre/post MFT scores. A total of 44 male participants (100%) participated in the study. The most common age group in this study was 14 years of age, which comprised 45.5% (10 individuals) of the circuit training group and 40.9% (9 individuals) of the interval training group. All participants had a normal body mass index (BMI) in both the circuit training and interval training groups.

Table 1. Characteristics of the Circuit Training Group

Characteristics	Category	F	%
Age	14	10	45,5
	15	6	27,3
	16	6	27,3
Gender	Male	22	100
BMI	18,5-25,0 (Normal)	22	100

Table 2. Characteristics of the Interval Training Group

Characteristics	Category	F	%
Age	14	9	40,9
	15	7	31,8
	16	6	27,3
Gender	Male	22	100
BMI	18,5-25,0 (Normal)	22	100

The sample in the circuit training group had a mean pre-test score of 38.41 ± 1.709, categorized as sufficient, and a mean post-test score of 50.64 ± 2.300, categorized as very good. On the other hand, the interval training group had a mean pre-test score of 37.73 ± 2.313, categorized as sufficient. The mean post-test score was 48.50 ± 3.529, categorised as very good. Changes in the mean values obtained indicate an increase in VO2 max after circuit training with a mean increase of 12.22 and interval training with a mean increase of 10.77.

Table 3. MFT Pre-test and Post-test Scores

	VO2 Max Value		
	Mean Pre-test	Mean Post-test	Difference
Circuit training	38,41	50,64	12,22
Interval training	37,73	48,50	10,77

Testing the normality of the data using the Shapiro-Wilk test shows that the normality test results in the circuit training group before being treated is 0.172 and after being treated is 0.153, which indicates that the data is normally distributed because p>0.05. Whereas in the interval training group, the pre-treatment value is 0.077 and the post-treatment value is 0.121, this is an indication that the data are normally distributed because p>0.05.

Table 4. Normality Test Result

	Circuit Training		Interval Training	
	Statistik	P	Statistik	p
Pre	0,937	0,172	0,920	0,077
Post	0,935	0,153	0,930	0,121

Levene's test was used to determine homogeneity. Before treatment, the homogeneity test produced a score of 0.095, indicating that the data is homogeneous (p value > 0.05). After treatment, the score was 0.428, indicating that the data is still homogeneous (p value > 0.05).

Table 5. Homogeneity Test Result

	Statistics	P
Pre-test	2,918	0,095
Post-test	0,642	0,428

Hypothesis testing to determine the effect of circuit training on increasing VO2 max in soccer players using a paired sample t-test, where p = 0.000, this shows that p <0.05 so Ha data is accepted and Ho is rejected. Concluded that there is an effect of giving circuit training on increasing VO2 max soccer players.

Table 6. Circuit Training Hypothesis Test

Treatment Group	N	Mean ± SD	p
Pre-test	22	38,41±1,709	0,000
Post-test	22	50,64±2,300	

This study used hypothesis testing to evaluate the effect of interval training on increasing VO2 max in soccer players using a paired samples t-test. The results obtained indicate that p = 0.000, indicating p <0.05 and accepting Ha while rejecting Ho. In conclusion, this study found a statistically significant effect of providing interval training on increasing the VO2 max of soccer players.

Table 6. Interval Training Hypothesis Test

Treatment Group	N	Mean ± SD	P
Pre-test	22	37,73±2,313	0,000
Post-test	22	48,50±3,529	

The study employed the Independent Sample T-Test to ascertain the difference and effectiveness of circuit training and interval training on improving the VO2 max of soccer players. The results obtained from the test showed that p = 0.02, thereby indicating a significant difference between circuit training and interval training, since p <0.05.

Table 7. Hypothesis Test of Differences in Effect of Circuit Training and Interval Training

Kelompok Perlakuan	N	Mean ± SD	p
Circuit training	22	50,64±2,300	0,02
Interval training	22	48,50±3,529	

4. DISCUSSION

a. Characteristics Based on Gender

The research sample in this study consists entirely of males. Traditionally, football is a male-dominated sport with comparatively fewer female players. One of the factors that can

influence VO2 max is gender. Men have greater aerobic capacity than women, which can be attributed to differences in body composition and size. Furthermore, women typically have higher body fat levels, resulting in a relatively lower VO2 max. VO2 max values also vary depending on the haemoglobin concentration difference between males and females. Men's higher haemoglobin levels result in a greater blood-carrying capacity and oxygen supply during exercise, thereby enhancing men's aerobic capacity.

According to research by Nuarti et al., (2019) haemoglobin concentration is closely related to oxygen binding, which is necessary for the process of energy metabolism that enables optimal energy production in men. The normal hemoglobin levels in adult males range from 13.5-18.0 g%, whereas in females, it ranges from 11.5-16.5 g%. Santisteban et al., (2022) research supports the notion that the average volume of body water in women is lower than in men, which can affect physical fitness. This is because water, which functions as a catalyst, cannot deliver oxygen from the lungs to the rest of the body. Dominelli et al., (2018) study explained that women typically have smaller lungs and airways, which are 20-30% smaller than those of men who are of the same height and age. The reduced size of women's airways leads to greater resistive forces, which heighten the breathing workload at a given ventilation rate. This decreases women's capacity to increase VO2 max compared to men (Lomauro & Aliverti, 2018).

b. Characteristics Based on Age

Based on the results of the descriptive analysis, it can be seen that the dominant age in the circuit training treatment group was 14 years, 10 people (45.5%), while the interval training treatment group was dominated by individuals of age 14, with 9 people (40.9%). Age grouping in football is based on age levels in the coaching process, namely 1) 5-8 years (beginners), 2) 9-12 years (basic), 3) 13-14 years (intermediate), 4) 15-30 years (advanced). Football training is based on a basic programme of physical, technical, tactical and mental training, especially at a young age.

Functional and structural changes occur in the human body as one ages, including cardiorespiratory changes. The VO2 max develops at a faster rate between the ages of 13 to 19 years due to higher levels of growth hormone, compared to individuals over 19 years of age. As outlined in Carayanni et al., (2022) study, the growth and hormonal changes that occur during puberty significantly influence VO2 max development, along with other physical fitness parameters. These findings suggest that puberty in males is associated with an improvement in both heart and circulatory system abilities. Consequently, VO2 max levels may only be increased by intense aerobic exercise that alters aerobic factors.

Furthermore, according to research by Sari & Setiarini (2020), the muscle mass of male teenagers increases differently from that of female teenagers. The increase in muscle strength in male adolescents occurs around the age of 13. In male adolescent athletes, the increase in muscle mass also contributes more to body weight. A high level of muscle mass will also lead to high VO2 max values.

c. Characteristics Based on Body Mass Index

There is a correlation between body mass index (BMI) and VO2 max. BMI is a measurement used to ascertain body composition, where weight and height are contributing factors. All participants in the circuit training and interval training groups were found to have a normal BMI in this study.

Based on the analysis, it was found that BMI status has a strong link with physical fitness as determined by VO2 max, indicating that individuals with normal BMI status are more physically fit than those with an obese BMI status. Research conducted by Bryantara (2016) found that individuals with normal BMI have a 13.20 times greater chance of being fit compared

to obese individuals. Trioclarise et al., (2022) described that excess body mass index or obesity leads to the accumulation of fat in various organs, including cardiovascular organs such as the heart and blood vessels. Excessive body fat can hinder cardiorespiratory function during physical exercise and add to its burden. The musculoskeletal system is unable to get adequate oxygen during exercise because of the disproportionate accumulation of fat. Running requires more oxygen (O2) when you are overweight. If you are overweight, the amount of oxygen will decrease quickly. This will cause you to tire more quickly (Nurhayati et al., 2022). It can be concluded that football players having a normal BMI will accelerate the process of increasing VO2 max.

d. Effect of Circuit Training to Increase VO2 Max

The circuit training hypothesis was tested by processing the VO2 max value before and after treatment in the circuit training group. The results of the paired samples t-test show that $p = 0.00$, which means that $p < 0.05$ and therefore the Ha data is accepted and Ho is rejected. It is concluded that giving circuit training to soccer players has a positive effect on increasing the VO2 max. Before the treatment, the VO2 max results obtained through the multistage fitness test/beep test were in the adequate category with a mean of 38.41. After the treatment, the VO2 max results improved significantly, with a mean of 50.64 indicating the very good category.

Circuit training increases cardiovascular endurance by strengthening the respiratory system, which has significant benefits for maintaining cardiorespiratory fitness. Furthermore, the exercise involves three variables, namely intensity, repetition and duration, and can therefore increase VO2 max. Circuit training involves almost all elements of physical fitness, performed simultaneously at high speed in a relatively short period of time.

Venkatachalapathy (2021) research suggests that circuit training can enhance VO2 max since it is a training model that combines strength, power, speed, and endurance training. Bahasyah et al., (2021) research explains that circuit training smoothens the process of blood conduction and return to the heart, thus leading to metabolic processes taking place throughout the body. Research of Fitriyansyah et al., (2021) explains that systematic and repetitive circuit training can have a physiological effect on muscles since they experience physiological adaptation resulting from the continuous training load, ultimately improving VO2 max.

e. Effect of Interval Training to Increase VO2 Max

The hypothesis of interval training was tested by processing the values of VO2 max before and after the treatment in group 2 with the paired samples t-test. The results showed $p = 0.00$, which means that $p < 0.05$ and therefore the data of Ha are accepted and Ho is rejected. It can be concluded that there is a significant effect of interval training on increasing the VO2 max of soccer players. VO2 max measurements using a multi-stage fitness test / beep test showed that before treatment, VO2 max results were in an adequate category with a mean of 37.73, and after treatment, VO2 max results were in a very good category with a mean of 48.50.

Interval training is a series of strenuous exercises performed repeatedly, interspersed with periods of rest and light exercise. Carrying out interval training can cause an increase in stroke volume, resulting in a transient decline in heart rate and a constant state in cardiac output levels. This enhances the efficiency of the heart muscle in delivering blood flow throughout the body. Heart rate efficiency is demonstrated by a reduction in pulse rate.

According to Khair et al., (2023) alternating low-intensity interval training with high-intensity intervals can assist in eliminating muscle metabolism when the body undertakes high-intensity interval training during periods of rest. Alternating exercise periods can increase the volume of oxygen consumed by the body during workouts. The oxygen going to active muscles breaks down lactic acid and turns it into energy.

Supported by research Wiswadewa et al., (2017) the body compensates for the need for oxygen during high-intensity exercise by increasing heart rate, dilating coronary arteries, increasing stroke volume, and strengthening heart contractions, resulting in an increase in stroke volume. The body that undergoes an increase in VO2 max undergoes adaptations to heart contractions during exercise. With an increase in the efficiency of the heart pump after receiving a continuous and physiological training load, the heart muscle undergoes adaptations, resulting in an increased strength of heart contractions when pumping blood. This increase helps ensure that sufficient oxygen is supplied throughout the body during exercise.

f. Circuit Training is More Effective than Interval Training to Increase VO2 Max

Hypothesis testing to compare the difference in the effect of circuit training and interval training with the independent sample t-test, where a value of p = 0,01 is obtained, this indicates that p <0.05 so it is concluded that there is a significant difference between circuit training and interval training with a more significant increase in VO2 max in the circuit training group. Based on these results, it can be seen that the circuit training method is better at increasing VO2 max compared to the interval training method because the circuit training method is a training method that contains all elements of fitness, including agility, endurance, strength, speed and other elements so as to increase various components of physical condition in a short time. In addition, because the circuit training method has more movement variations compared to the interval training method. With so many variations of these movements, athletes don't get bored quickly in doing exercises.

Research conducted by Balasingh & Night (2018) explains that circuit training exercises have been shown to be effective in developing cardiovascular fitness due to the way the exercises are structured and consist of a series exercises or stations that are completed sequentially with minimal rest which allows athletes or trainers to make exercises by adding exercise variations. In the study by Atmojo & Jayadi (2018) the interval training group did exercises with recovery in each set, while in the circuit training group, the rest or recovery time was during the movement from post to post. Exercise allows the use of oxygen per minute to reach the maximum target, and cardiorespiratory endurance functions optimally when the activity is performed for a long time with minimal recovery and significant fatigue. (Karyono et al., 2020).

According to research Yunus & Raharjo (2022) circuit training is able to grow muscle fibres faster, so they can increase muscle contractions faster than interval training. The muscle fibres are designed to produce strong explosive force. This makes the recovery process after exercise more effective. Circuit training has a greater effect than interval training on increasing VO2 max in footballers.

5. CONCLUSION

a) There is an effect of circuit training on the increase of the VO2 max of the football players after the treatment of 17.04%.
b) There is an effect of interval training on the increase in the VO2 max of football players after they have been given a treatment of 10.36%.
c) There is a difference in effect between circuit and interval training, with circuit training increasing VO2 max more significantly.

Saran

From the results of this research, this exercise should continue to be applied to respondents regularly so that qudriceps muscle strength continues to be maintained so that functional abilities are maintained well.

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