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<https://ejournal.upi.edu/index.php/penjas/article/view/66731>DOI: <https://doi.org/10.17509/jpjo.v9i1.66731>**Functional Capacity Training for Improvement of VO₂ Max in Football Players:
Differences in The Effects of Circuit Training and Interval Training Models****Ummi Aisyah Nurhayati*, Baiq Nurul Hasnawati**

Universitas 'Aisyiyah Yogyakarta, Indonesia

Article Info*Article History :**Received January 2024**Revised February 2024**Accepted March 2024**Available online April 2024**Keywords :**Circuit training, Interval training, Maximal oxygen capacity***Abstract**

Football players should be in good physical condition to support their performance on the pitch. For example, the cardiorespiratory capacity (VO₂ max) needed to maintain endurance during the game. An increase in VO₂ max indicates 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. Interval training has an effect on the metabolic waste produced by the muscles during rest, which increases oxygen consumption during exercise and increases VO₂ max. The aim of this study was to determine the difference in the effect of circuit training and interval training on increasing VO₂ max in football players. For the research method, an experimental method was used with a quasi-experimental approach to pre and post test two grub design treatment, the sampling technique used total sampling, a sample of 44 people with a 3x a week training programme for 6 weeks. The research instrument used was the multi-stage fitness test and the data analysis used was the paired samples t-test. Results showed that there was an effect of circuit and interval training on increasing VO₂max in footballers ($P=0.00$ $P<0.05$), with a more significant effect in the circuit group.

INTRODUCTION

Football players need to be in a good physical condition to perform at their best in football matches. It is important for football players to have a good VO₂max. It is because the players are required to perform an extensive running to cover a large field (75 x 100 meters) during the match. Maximal oxygen volume (VO₂max) is an indicator of cardiorespiratory fitness that affects an athlete endurance during physical exertions. An increase in VO₂max indicates a 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 the exercise, with the average VO₂max utilization ranged from 70%-80% during a match (Silva et al., 2021). An increase in VO₂max indicates a greater endurance during the exercise and depends on how long an athlete can maintain working muscles (Chekhovskaya, 2023). In football players aged 13-19 years, the VO₂max 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 years had an average VO₂max 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 years had an average VO₂max of 36.74 mL/min/kg, classified as low. The results of research measuring the National Sports Success Index depicting the physical fitness in Indonesia showed that 1.08% were in the very good category, 4.07% were in the good category, 13.55% were in the moderate category, 43.90% were in the poor category, and 37.40% were in the very poor category (Nurhayati & Kristiana, 2021).

Footballers with low VO₂max values will have a low endurance, causing the athletes to get tired easily, allowing a decrease in their concentration, and not being able to focus when the game is taking place (Ren et al., 2022). A reduction in VO₂max can lower physical fitness, increasing the risk of injury. This is due to the 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 VO₂max,

based on research by Bazaba Kayilou et al. (2021), are ethnicity, age, environment, and the level of physical activity. In addition, an 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 performing physical activity as an important factor influencing the VO₂max (Zarwan & Hardiansyah, 2020). To increase VO₂max of football players, training or exercise efforts should be performed.

Increasing VO₂max can be achieved by improving the training quality for young players through planning and scheduling a regulated training, including the regulation of duration - intensity - recovery, with training methods adjusted to the age and personality of the player (FIFA, 2022). Meanwhile, according to the Malaysian Football Association in the research of Atan et al. (2021), the development of youth football should focus on the aerobic endurance to prevent fatigue through endurance trainings. In Indonesia, sports clubs usually have sports coaches who are in charge of organizing and supervising the athlete training process (Suharjana, 2015). However, according to the research conducted 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 VO₂max, resulting in a poor VO₂max ability for soccer players. Various training methods can be used to increase VO₂max, including interval training, fartlek, tabata, and circuit training (Kastrena & Revianny, 2023). The focus of this study was to compare the different effects of circuit training and interval training on VO₂max.

Circuit training is a workout program that includes multiple stations where players or athletes perform predetermined exercises. Circuit training leads to physiological changes in muscles through a repetitive and systematic exercise that improves the body maximum oxygen volume (VO₂max) (Fitriyansyah et al., 2021). The circuit training model used by the researchers was a modified model related to the form and intensity of the exercise. The exercises included jogging, squat trust, plyometric jump, running in place, sit-ups, and 5m shuttle. Campo et al. (2021) showed that circuit training had a beneficial effect on the cardiorespiratory endurance, where the VO₂max increased 6.3%, maximal aerobic speed or power increased 0.3%, and aerobic power

increased 2.6% after the training.

Interval training is a high-intensity physical exercise regimen that alternates between the exercise and recovery periods. Interval training is carried out with the intensity, repetition, and distance planning for the exercise. Rest periods between each set must be consistent (Mangine & Seay, 2022). Interval training aims to develop lactate eliminations, the maximum oxygen uptake, and the maximum aerobic capacity to enhance the physical performance capabilities of the body (Hov et al., 2023). Previous research by Bahtra et al. (2023) showed that VO₂max could increase during the interval training because of the recovery period between the exercise bouts. The rest period allows the athlete to be better prepared for the next load.

This research was conducted at the Sleman Football Association (Persatuan Sepak Bola Sleman/ PSS) Development Centre. PSS Development Centre is a youth coaching academy owned by the PSS Sleman. The age categories of players at the PSS Development Centre are under (U) 14, U16, U18, and U20. The researchers were conducting research on the U14-U16 age groups because, based on the results of observations and interviews with players, physiotherapists, and physical trainers at the PSS Development Centre club, 90% of the 43 U14-U16 players complained of getting tired easily during the training or competition. The data were supported by the results of the VO₂max measurements carried out in March 2023, showing that the VO₂max results of 16.7% of the players were in the very poor category, 54.2% of the players were in the poor category, and 29.2% of the players were in the sufficient category.

Based on the aforementioned data, the researchers saw a problem related to the VO₂max of the footballers at the PSS Development Centre. It might be because training programmes, such as the interval training and circuit training, to increase VO₂max had not been carried out. Therefore, the researcher was interested in providing circuit training and interval training exercises using the Multistage Fitness Test (MFT) measuring devices to increase VO₂max at the PSS Development Centre U14-U16 club. This would help improve their championship performance.

METHODS

This research followed an experimental approach with a quasi-experimental design. The experiment research was carried out to determine the symptoms or effects of the treatments or experiments. The research design employed the pretest-posttest control two-group design, comparing the treatments given to the first group (circuit training) and the second group (interval training).

Participants

The target population of this study were the footballers of the PSS Development Centre Club. While the affordable population were footballers at the PSS Development Centre Club aged 14-16 years.

Sampling Procedures

The purposive sampling was used. Samples from the population had to meet the following inclusion and exclusion criteria:

Inclusion criteria

- a. Male
- b. Age between 14-16 years
- c. Registered as an official player of the PSS Development Centre and actively training
- d. Having completed the informed consent form and be willing to participate in the study
- e. Having a VO₂max rating of adequate, less, to very less in the MFT/Beep test (<32 to 41)
- f. Not receiving an exercise programme to increase VO₂max

Exclusion criteria

- a. The subject became ill or injured during the data collection and was unable to continue.
- b. The subject withdrew from the study.

Drop out criteria

- a. Failure to return for a maximum of 3 consecutive visits during the study
- b. Not present at the time of the test

Number of samples

In determining the sample for this study, the total sampling was used. There were 44 samples aged 14-16 years who met the inclusion criteria.

Materials and Apparatus

The maximum oxygen volume was measured by the Multistage Fitness Test (MFT). The MFT is also known as the beep test, one of the precise methods to measure the maximal aerobic power or VO₂max (Pacholek, 2023). The MFT instrument is reliable and valid according to the research of Elfadey & Elsaidy (2012), with the reliability of 0.990 and validity of 0.995. Participants performed the MFT by running back and forth over a 20-metre distance, responding to a "beep" indicating the completion of each stage recorded in the VO₂max prediction table.

Instrument and Procedures

1. During the pre-test and post-test, the multi-stage fitness test was performed by using the following procedure:
2. The test was performed by running 20 metres.
3. There were 21 stages, each stage lasted for 1 minute.
4. The start was made by standing with both feet behind the start line. At the "Ready go!" signal, the subject ran towards the boundary until one or both feet crossed the boundary and waited for the sound.
5. When the subject did not hear the beep, the subject should not return and had to wait for the beep. Conversely, when the beep indicated that the subject had not reached the boundary line, the subject should accelerate until the boundary line was crossed and immediately resumed running in the opposite direction.
6. When the subject was unable to keep up with the rhythm of the beep twice in the succession, it indicated that the subject maximum strength was only at that level.

Training Protocols

1. Before performing the circuit training and interval training, the researchers firstly measured the HR rest and HR max to predict whether the HR was in line with the target intensity (10-70% max).
2. Warming up for 4 minutes
3. Circuit training procedure (Group 1)
4. Each subject completed 6 predetermined exercise stations, including jogging, squat trust, plyometric jump, running in place, sit-ups, and 5m shuttle.
5. A station was completed for 45 seconds to 1 minute, with a rest period of 15-20 seconds from each station for 15 repetitions.
6. Interval training procedure (Group 2)
7. The subject started with a 400m sprint for 80 seconds and returned to the starting point by jogging with a rest period of 3 minutes.

8. The training continued with a 3 minute rest on each lap and the completion of the distance in 20 repetitions.
9. Cooling down for 4 minutes
10. Performing the exercise 3 times a week for 6 weeks

Design or Data Analysis

In this study, a frequency distribution was used as the analysis technique for managing data based on age, sex, body mass index (BMI), and MFT pre- and post-test values. To compare the effects of the circuit training and interval training, measurements were made using an independent sample t-test with a significance level of $p < 0,005$.

Ethics

This study have been approved by the Ethical Committee of Faculty of Medicine, 'Aisyiyah Yogyakarta University/PSS Development Center No. 2797/KEP-UNISA/IV/2023 and has obtained permission from the Research and Development Unit of Faculty of Medicine, 'Aisyiyah Yogyakarta University.

RESULT

This study analyzed the 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, 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. The characteristics of the samples are shown in Table 1.

Paired samples t-test was conducted to determine the effect of the circuit training and interval training on the increase of VO₂max of football players. The results of the hypothesis test are shown in Table 2.

The hypothesis testing based on Table 2, using paired samples t-test, obtained $p = 0.000$, showing that $p < 0.05$. It concludes that there is an effect of providing the circuit training and interval training on the increased

VO2max of football players. The samples in the circuit training group had a pre-test mean score of 38.41 ± 1.709 , categorized as sufficient, and a post-test mean score of 50.64 ± 2.300 , categorized as very good. On the other hand, the interval training group had a pre-test mean score of 37.73 ± 2.313 , categorized as sufficient, and the post-test mean score of 48.50 ± 3.529 , categorised as very good. Changes in the mean values indicate an increase of VO2max after the circuit training, with a mean increase of 12.22, and interval training, with a mean increase of 10.77 (Table 2).

DISCUSSION

Characteristics based on Gender

The research sample in this study consisted entirely of males. Traditionally, football is a male-dominated sport with comparatively fewer female players. One of the factors influencing VO2max is gender. Men have a greater aerobic capacity than women, which can be attributed to differences in body composition and size. Furthermore, women typically have a higher body fat levels, resulting in a relatively lower VO2max.

Table 1. Characteristics of of the Circuit Training and Interval Training Groups

Characteristics	Circuit Training			Interval Training		
	Category	F	%	Category	F	%
Age	14	10	45,5	14	9	40,9
	15	6	27,3	15	7	31,8
	16	6	27,3	16	6	27,3
Gender	Male	22	100	Male	22	100
BMI	18,5-25,0 (Normal)	22	100	18,5-25,0 (Normal)	22	100

Table 2. MFT Pre-Test and Post-Test Scores

	VO ₂ max Value			
	Mean± SD Pre-test	Mean± SD Post-test	Difference	<i>p</i>
Circuit training	38,41±1,709	50,64±2,300	12,22	0,00
Interval training	37,73±2,313	48,50±3,529	10,77	0,00

Table 3. Hypothesis Test of Effect Differences of Circuit Training and Interval Training

Groups	N	Mean ± SD	<i>p</i>
Circuit training	22	50,64±2,300	0,02
Interval training	22	48,50±3,529	

The independent sample t-test was used to determine the difference of the effect of the circuit training and the interval training on increasing the VO2max of football players. The results of the hypothesis test are shown in Table 3.

Based on Table 3, the independent sample t-test test obtained $p = 0.02$, showing that $p < 0.05$. It concludes that there is a significant difference between the circuit training and the interval training.

VO2max values also vary depending on the haemoglobin concentration difference between males and females. Male higher haemoglobin levels result in a greater blood-carrying capacity and oxygen supply during the exercise, thereby enhancing the man aerobic capacity (Santisteban et al., 2022).

According to the research conducted by Nuarti et al. (2019), the haemoglobin concentration is closely related to the oxygen binding, which is necessary for

the energy metabolism process that enables the 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%. The 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 the physical fitness. It is because water, which functions as a catalyst, cannot deliver the oxygen from the lungs to the rest of the body. The reduced size of woman airways leads to greater resistive forces, which heighten the breathing workload at a given ventilation rate. It decreases the woman capacity to increase the VO₂max compared to men (Lomauro & Aliverti, 2018).

Characteristics based on Age

Based on the results of the descriptive analysis, 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 years, 9 people (40.9%). The 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), and 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 VO₂max develops at a faster rate at the ages of 13 to 19 years due to higher levels of growth hormone, compared to individuals over 19 year old. As outlined in the Carayanni et al. (2022) study, the growth and hormonal changes that occur during puberty significantly influence the VO₂max 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, VO₂max levels may only be increased by an intense aerobic exercise that alters aerobic factors.

Furthermore, according to the research conducted by Sari & Setiari (2020), the muscle mass of male teenagers increases differently from the female teenagers. The increase of the 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.

Characteristics based on Body Mass Index

There is a correlation between body mass index (BMI) and VO₂max. BMI is a measurement used to ascertain body compositions, 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 had a strong link with physical fitness as determined by VO₂max, indicating that individuals with normal BMI status are more physically fit than those with an obese BMI status. Trioclarise et al. (2022) describe that an 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. The excessive body fat can hinder cardiorespiratory functions during physical exercises and add to its burden. The musculoskeletal system is unable to get an adequate oxygen during the 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 get tired more quickly (Nurhayati et al., 2022). It concludes that football players having a normal BMI will accelerate the process of increasing VO₂max.

Effects of Circuit Training on Increasing VO₂max

The circuit training hypothesis was tested by processing the VO₂max values before and after treatments in the circuit training group. The results of the paired samples t-test show that $p = 0.00$, meaning that $p < 0.05$ and therefore the H_a was accepted and H_o was rejected. It concludes that giving a circuit training to soccer players has a positive effect on increasing the VO₂max. Before the treatment, the VO₂max results obtained through the multistage fitness test/beep test were in the adequate category with a mean of 38.41. After the treatment, the VO₂max 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 VO₂max. Circuit training involves almost all elements of physical fitness, performed sim-

ultaneously at a high speed in a relatively short period of time.

Venkatachalapathy (2021) research suggests that circuit training can enhance VO₂max since it is a training model that combines strength, power, speed, and endurance trainings. 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 throughout the body. Research of Fitriyansyah et al. (2021) explains that a systematic and repetitive circuit training can have a physiological effect on muscles since they experience physiological adaptations resulting from the continuous training load, ultimately improving the VO₂max.

Effects of Interval Training on Increasing VO₂max

The hypothesis of interval training was tested by processing the VO₂max values before and after the treatments in Group 2 using the paired samples t-test. The results showed $p = 0.00$, meaning that $p < 0.05$. Therefore, the H_a was accepted and H_o was rejected. It concludes that there is a significant effect of the interval training on increasing the VO₂max of soccer players. VO₂max measurements using a multi-stage fitness test/ beep test showed that the VO₂max results before the treatment were in an adequate category with a mean of 37.73. After the treatment, the VO₂max 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 the 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 flows throughout the body. Heart rate efficiency is demonstrated by a reduction in the pulse rate.

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

Supported by Wiswadewa et al. (2017) research,

the body compensates for the need for oxygen during a high-intensity exercise by increasing the heart rate, dilating coronary arteries, increasing the stroke volume, and strengthening heart contractions, resulting in an increase in the stroke volume. The body that undergoes an increase in VO₂max undergoes adaptations to heart contractions during the exercise. With an increase in the heart pump efficiency after receiving a continuous and physiological training load, the heart muscle undergoes adaptations, resulting in an increased strength of heart contractions when pumping the blood. This increase helps ensure that sufficient oxygen is supplied throughout the body during the exercise.

The Efficacy of Circuit Training and Interval Training on Increasing VO₂max

Hypothesis testing to compare the difference of the effect of the circuit training and interval training employed the independent sample t-test. The test obtained a value of $p = 0,01$, indicating that $p < 0.05$. It concludes that there is a significant difference between the circuit training and interval training with a more significant increase of VO₂max in the circuit training group.

The research conducted by Balasingh & Night (2018) explains that circuit training exercises have been shown to be effective in developing the cardiovascular fitness due to the way the exercises are structured and consist of a series exercises or stations completed sequentially with a minimal rest allowing athletes or trainers to add exercise variations. In the study conducted 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.

Circuit training interventions are effective in improving cardiorespiratory fitness, as there is a significant and large pre-post effect on VO₂max. VO₂max is affected by the maximal stroke volume, cardiac outputs, and peripheral factors (enhanced capillaries, enhanced muscle buffers or enhanced activity of metabolizing enzymes). A significant increase in VO₂max, accompanied by an increase in the maximal stroke volume and cardiac output, is the main response of the cardiovascular system to the resistance circuit training (Campo et al., 2021).

CONCLUSION

The results of the research conducted show that the circuit training and interval training are indeed effective training models for increasing VO₂max. The results of this study are in line with the objectives of the two training models. There was a 17.04% effect of circuit training on the post-treatment VO₂max increase in football players, while the interval training had a 10.36% effect on the post-treatment VO₂max increase in football players. The circuit training showed better results than the interval training model in increasing VO₂max of football players. The circuit training model facilitates a focus on exercises consisting of several stations, such as jogging, squat trust, plyometric jump, running in place, sit-ups, and 5m shuttle. The aim is to strengthen the respiratory muscles, which have a great benefit in maintaining the cardiopulmonary fitness and incorporate three variables in its training, namely intensity, repetition, and duration, to increase VO₂max of football players.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

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