

# The Effects of Circuit and Fartlek Exercise Method and Peak Expiratory Flow on $VO_2\text{max}$

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**Abstract—objective:** (1) Differences between the effects of circuit and fartlek training method on  $VO_2\text{Max}$ ; (2) Differences between the effects of high and low peak expiratory flow on  $VO_2\text{Max}$ ; and (3) The interactions between circuit, fartlek exercise methods and peak expiratory flow (high and low) on  $VO_2\text{Max}$ . 2 x 2 factorial method. Peak expiratory flow instruments: *peak flow meter* and  $VO_2\text{Max}$ : *multistage fitness test*. ANAVA data analysis  $\alpha = 0.05$ . Results. (1) There is a significant difference between the effects of circuit and fartlek exercise methods on  $VO_2\text{Max}$ ,  $p$  value =  $0.022 < 0.05$ , which show that circuit training method is objectively better than fartlek training method. (2) There is a significant difference between the effects of high and low peak expiratory flow on  $VO_2\text{Max}$ ,  $p$  value =  $0.000 < 0.05$ , students with high expiratory volume achieve higher value than those with low expiratory volume. (3) There is a significant interaction between circuit and fartlek training method and (high and low) peak expiratory flow on  $VO_2\text{Max}$ ,  $p$  value =  $0.000 < 0.05$

**Keywords—***circuit training method, fartlek,  $VO_2\text{Max}$*

## I. INTRODUCTION

The basic techniques that soccer students need to have includes kicking, stopping, dribbling, heading, tackling, throw-in, and goal keeping. Sports achievements require a variety of complex motion skills. A student generally encounters movements that include sprinting, stopping abruptly and immediately moving again, jumping, reaching out, twisting quickly, and doing wide strides without ever losing bodily balance. These movements listed above are done repeatedly over a long period of time during the match and as a result, the students tend to experience fatigue which will directly affect the performance of their heart, lungs, blood circulation, breathing, muscle work, and joints of the body [1].

In addition to some of the techniques above, one important factor of one's achievements in sports is their physical condition. A person's physical ability is one of the most important factors in obtaining sports achievement. Sporting achievements cannot be separated from the elements of tactics, techniques and the quality of physical condition. Students really depend on strength, endurance, flexibility, speed, agility, and good motion coordination. These qualities are required of players to be able to move and react well during the match.

Aerobic ability is a very important characteristic a soccer student must have in order to prepare and maintain their prime physical condition. Soccer students are required to have good physical condition because they are required to play or compete for 2 (two) rounds (2 x 45 minutes). Sometimes if the match uses the knockout system, they must also undergo an additional time of 2 x 15 minutes. Soccer is a team game consisting of eleven students per team with 45x2 minute match time. This means that soccer students must be in good physical condition during a match. Physical endurance is the key in aerobic sports, i.e. soccer. Physical condition is related to strength, energy, agility, dexterity or body movement skills, all of which are necessary in soccer [2].

Endurance is a very important physical factor which determines a student's achievement. Good endurance enables the student to maximize the application of techniques and tactics, hence with excellent endurance students will be able to excel with ease. The main factor in the success of training for a match is the endurance of the athlete, because a person with great endurance will be able to complete their objectives optimally. Good physical endurance is defined as the ability of a student to meet oxygen consumption characterized by the maximum oxygen volume level ( $VO_2\text{Max}$ ).  $VO_2\text{Max}$  is the maximum amount of oxygen in milliliters that can be consumed in one minute per kilogram of body weight. People with great fitness have higher  $VO_2\text{Max}$  values and can perform stronger activities than those with low fitness [3].

Oxygen concentration or  $VO_2\text{Max}$  and cardiac function can increase consistently if large muscles exercises are done regularly, such as walking, jogging, cycling, swimming, circuit training, cross-country exercises, interval training, intermittent running exercises, etc. Maximum oxygen volume or  $VO_2\text{Max}$  is a measurement carried out to determine the heart's endurance and it is also a major factor of physical fitness.

Endurance is one's ability to perform actions with his body over a long period of time and with moderate to fast tempo without experiencing pain and heavy fatigue. Endurance is important for daily activities, if a person has good endurance, their activities would not cause severe fatigue. Endurance is closely related to breathing, heart, and blood circulation. The exercise for respiratory, heart, and blood circulation endurance is called secondary ergosystem, which a person is trained for after going through primary ergosystem enhancement. Secondary ergosystem

enhancement exercises should be performed for a long period of time. Endurance and lung exercises is done by increasing intensity.

Exercises that improve  $VO_2Max$  are very diverse, they include circuit training with several variations of exercise items and fartlek training. Physiologically, circuit training can improve the heart and lung, where the system facilitates blood circulation from and to the heart as well as circulating blood to the brain and the whole body enabling the metabolism of the body to run smoothly while doing sports (physical activity) or exercise. As for circuit training, it is a variation exercise with some items or posts given with short or no rest breaks. The exercises aim to improve  $VO_2Max$  in order to improve physical conditions, it includes doing push ups, squats, sit ups, dips, alternating squats, back ups, and combinations. *The results of the study stated that the circuit training had significantly improved the speed, leg power, arm power and agility of the subjects*” [4]. Circuit training of 1:1 ratio and 1:2 ratio is used to increase the maximum oxygen volume ( $VO_2Max$ ) in students of Putra Ngaliyan Semarang central soccer training. Circuit training 1:1 ratio is better for increasing  $VO_2Max$ ” [5].

Other methods could be done by trying other exercises, which is a combination of aerobic and anaerobic exercises such as fartlek exercise. Based on observations made by the researchers, people who engage in fartlek exercise feel challenged because after jogging with slow and continuous rhythm, they try other alternative fartlek exercise by combining sprint-road-jogging to their routine. Fartlek or speed play exercise was created by Gotta Roamer from Sweden. Fartlek is an endurance training system whose aim is to build, restore or maintain a person’s body condition in order to be well-adapted for all kinds of sports, especially sports that require endurance. The principle of fartlek exercise is to run with variations, this means that we could set the desired running speed during the exercise in accordance with the preference and the condition/ability of students. For example, training begins slowly and then intensifies as the student continues at a short distance [6].

Both exercises were originally designed to increase  $VO_2Max$ , but were further developed to improve body composition. The exercise program offered is expected to be a motivation for students to improve  $VO_2Max$ , so students could have a good level of fitness, a proportionate body, strong bones, flexible joints and strong muscles. Appropriate exercise should apply the basic principles of exercise in order to achieve maximum physical performance of an individual.

PEF is the maximum expiratory peak flow speed one can reach, it is expressed in liters per minute (L/min) or liters per second (L/sec). PEF or peak expiratory flow is one of the most commonly used parameters in lung testing and can be used to determine the peak current flow rate of one's expiration. The peak expiratory flow describes the state of the airway and the maximum airflow achieved at expiration by maximum forced effort from the total lung capacity (Dermawan et al., 2013). The peak expiratory flow is used to evaluate the effects of various factors such as drug therapy, exposure to air pollution, and caliber of the airway [7].

Based on the observations of researchers on U-14 soccer team of SSB Baturetno, the  $VO_2Max$  endurance training program offers very minimal variation of exercise model

used in the training, compared to the model of technique, tactics, and other exercises. The model of  $VO_2Max$  endurance training program in SSB Baturetno consists of small sided games exercise model, and all training programs are only incidental in use. Meanwhile, for the  $VO_2Max$  training program, there are many variations of available trainings such as circuit and fartlek. The outline of the exercise is pyramidal in shape which is based on the physical and mental technique and tactic. Therefore, the physical aspect is very influential in the student’s performance in gaining an achievement. If refers to the ratio of match percentage that have been undertaken, SSB Baturetno always experience fatigue when entering the second round. Based on this, the researchers are interested in conducting a research titled “The influence of circuit training, fartlek exercise and peak expiration flow to the increase of  $VO_2Max$  of U-14 soccer students in SSB Baturetno”.

## II. RESULTS

Hypothesis testing are presented as follows: (a) Differences between influence of circuit training methods and fartlek on the increase of  $VO_2Max$  in soccer student; (b) Differences between influence of high and low peak expiratory flow on  $VO_2Max$  increase in soccer student; and (d) Interaction between circuit training methods and fartlek as well as high and low peak expiratory flow on the increase in  $VO_2Max$  of soccer students.

TABLE I. DESCRIPTIVE STATISTIC OF *PRETEST* DAN *POSTTEST* OF SOCCER STUDENTS’  $VO_2MAX$

Peak Expiratory Flow	Statistics	<i>Pretest</i>	<i>Posttest</i>
High (A1B1)	Total	201.00	239.95
	Mean	40.2000	47.9900
	SD	2.84143	1.21470
Low (A1B2)	Total	189.85	195.20
	Mean	37.9700	39.0400
	SD	1.85796	1.11714
High (A2B1)	Total	199.60	206.55
	Mean	39.9200	41.3100
	SD	2.48661	1.37859
Low (A2B2)	Total	190.30	215.30
	Mean	38.0600	43.0600
	SD	1.84167	.93434

Data normality test used in this research is the Komogorov Smirnov method. The results of the data normality test performed on each group of analysis is done with software program of SPSS version 20.0 for windows with a significance level of 5% or 0.05. The data summary is presented in the table below:

TABLE II. NORMALITY TEST

Data	p	Note
Pretest A1B1	0.948	Normal
Posttest A1B1	0.973	Normal
Pretest A2B1	0.976	Normal
Posttest A2B1	0.999	Normal
Pretest A1B2	0.623	Normal
Posttest A1B2	0.950	Normal
Pretest A2B2	0.954	Normal
Posttest A2B2	0.918	Normal

Based on statistical analysis of normality test that has been done by using Kolmogorov Smirnov Z test, all pretest and posttest data are obtained from significance value of data normality test  $p > 0.05$ , which means data is normally distributed.

Homogeneity test is done to test whether the equations of several samples are homogeneous or not. The homogeneity test was conducted to test the similarity in variance between pretest and posttest. Homogeneity test used in this research is the Levene Test. Results of the test are shown in the table below:

TABLE III. HOMOGENITY TEST

Group	Levene Statistic	Note
Pretest	0.132	Homogeneous
Posttest	0.115	Homogeneous

The statistical analysis of the homogeneity test using the Levene Test resulted in a significance value of  $p \geq 0.05$  from the pretest-posttest. The result shows that the data group has a homogeneous variant. Therefore the population variant is homogeneous.

The research hypothesis test is conducted on the basis of data analysis results and an interpretation of ANAVA two-way analysis. The test results are shown in the table below:

TABLE IV. ANAVA TEST

Source	Type III Sum of Squares	F	Sig.
Training Method	8.844	6.436	0.022
Peak Expiratory Flow	64.800	47.153	0.000
Training Method * Peak Expiratory Flow	14.113	104.139	0.000

From ANAVA test results, it can be observed that the significance value of  $p$  is 0.022. Since the significance value of  $p$  is  $0.022 < 0.05$ , it means that  $H_0$  is rejected. Thus, there are significant differences in the effect of circuit training and fartlek methods on the  $VO_2Max$  improvement of U-14 soccer students in SSB Baturetno. Based on the results of the analysis, it turns out that this method of circuit training is better compared to the fartlek exercise method with the difference in posttest average value of 1.33. Therefore, it can

be concluded that circuit training method is better for the  $VO_2Max$  improvement of U-14 soccer students in SSB Baturetno compared to fartlek exercise method.

From ANAVA test results, it is observed that the significance value of  $p$  is 0.000. Since the significance value of  $p$  is  $0.000 < 0.05$ , it means that  $H_0$  is rejected. Based on this finding, it implies that there are difference in significant effects on the  $VO_2Max$  improvement of students with high and low peak expiratory flow. Based on the results of this analysis, students with high peak expiratory flow capability score higher mean  $VO_2Max$  value than students with low peak expiratory flow with a mean difference of posttest's  $VO_2Max$  of 3.6.

From ANAVA test results, it can be observed that the significance value of  $p$  is 0.000. Since the significance value of  $p$  is  $0.000 < 0.05$ , it means that  $H_0$  is rejected, so the hypothesis stating that there is a significant interaction between the circuit training method and fartlek and peak expiratory flow (high and low) to the  $VO_2Max$  increase of U-14 soccer students in SSB Baturetno, has been proven.

Diagram of interaction result between circuit training method and fartlek and peak expiratory flow (high and low) to the  $VO_2Max$  increase of U-14 soccer students in SSB Baturetno can be seen in Figure:

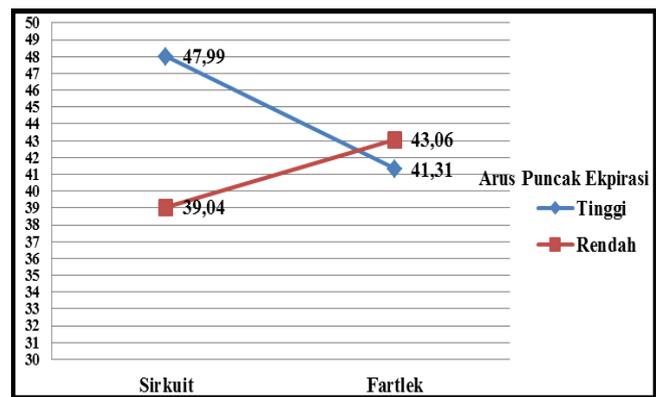


Fig. 1. Interaction between Practice Methods and Peak Expiratory Flow

The results of paired variance analysis with Tukey's advanced test show that there are significantly different pairs, namely: (1) A1B1-A2B1, (2) A1B1-A1B2, (3) A1B1-A2B2, (4) A2B1-A1B2, (5) A1B2-A2B2, with an additional pair with no difference: (1) A1B1-A2B2 and (2) A2B2-A2B1.

*A. Effect of differences between circuit training methods and fartlek on  $VO_2Max$  increase in soccer students*

Based on the hypothesis testings, it was discovered that there is a significant difference between the effect of circuit training and fartlek methods on the  $VO_2Max$  improvement of U-14 soccer students in SSB Baturetno. Circuit training method is better compared to fartlek exercise method on the  $VO_2Max$  improvement of U-14 soccer students in SSB Baturetno. Circuit training method has become a solution to increase ones maximum oxygen volume ( $VO_2Max$ ). The selection of training load type on circuit training needs to be adjusted for the purpose of circuit training to be achieved. Circuit training is a training system which helps to improve full body fitness, e.g. power, endurance, strength, agility, speed, and other physical factors [8]. Circuit training is used

to improve endurance of soccer students because circuit training is of very high intensity. It is based on the stamina work on high intensity of anaerobic level, so the oxygen supply or intake is not enough to provide enough energy for the muscles, because oxygen supply is not enough, the anaerobic work always makes the students to run out of oxygen (oxygen-debt). On this basis the students need to be trained on gradually higher intensity so their ability to endure tiredness also increases [8].

It is supported by a research conducted by Sonchan, Moungramee, & Sootmongkol (2017) that: This research aims to examine the effects of circuit training program on muscle strength, agility, anaerobic performance and cardiovascular endurance. This research result shows that circuit training program build up muscle strength, agility, anaerobic capacity and cardiovascular endurance of research subjects. This program can be used as a guidance to choose a training set to increase physical fitness [9].

*Circuit training (CT) appears to have multiple benefits on health and fitness, as various studies have shown that it may elicit significant increases in aerobic capacity, muscular strength, muscular endurance, lean body weight, and significant decreases in resting diastolic blood pressure and body fat [19]-[26]. The effect of CT on some other CVD risk factors such as fasting blood glucose, and blood lipids but lipoproteins remain under-investigated [10].*

*As studies about the cardiovascular components for 4 male students is carried out through the circuit training on them. The circuit training employed the quasi experimental method that involved 2 groups namely the control group that did not receive the circuit training and treatment group that received 10-week circuit training. The result of the study revealed that there is a positive change towards the group of students that received the 10 weeks of treatment [11].*

Fartlek training is a running activity like hollow sprint which is done by walking, jogging, sprint, and continuous walking. The principle of fartlek training is running in several variations this means we could set the desired running speed during the exercise in accordance with the preference and the condition/ability of students. For example, it can start with slow running, followed with sprint on short distance intensively. Fartlek training combines aerobic demands with continuous movement as well as interval speed, which is a fun training to improve students strength and aerobic capacity [6][12].

An intensive training will increase heart rate (HR) and stroke volume (SV). Cardiac output (CO) is influenced by HR and SV where  $CO = HR \times SV$ . HR is stimulated by the decrease in vagal tones and the increase in sympathetic nerves activities. People who use intensive training will have higher SV, therefore CO will also increase. Heart adrenoreceptor- $\beta$  stimulation increases CO by raising myocardial contractility so that the ventricular systolic discharge can be perfected. The CO number can be seen as someone's durability because CO represents how much the oxygen is distributed to muscles [13].

Exercise or physical activities have a tendency of giving more workload to the body. If this load keeps being applied to the body, many bodily systems will change to work more efficiently under those additional workload. Some organ

systems involved in this process are respiratory, cardiovascular, endocrine, and neuromuscular system. While exercising, many cardiovascular and respiratory mechanism have to work at the simultaneously to fulfill the needs of  $O_2$  on active tissue and to release  $CO_2$  and heat while performing the activity. The  $O_2$  extraction from blood to working muscles will increase, and the ventilation will also increase so additional  $O_2$  volume will be available, where some heat and excessive  $CO_2$  are released [14].

From the explanation above, it can be concluded that circuit training method and fartlek training are effective training method to develop heart and lung endurance ( $VO_2Max$ ). Circuit training has a better influence than fartlek training in increasing  $VO_2Max$  of U-14 soccer students in SSB Baturetno.

#### *B. Differences of influence on high and low expiratory peak flow to the increase of $VO_2Max$*

Analysis result shows that there is a significant difference of influence on high and low expiratory peak low to the increase of  $VO_2Max$  on U-14 soccer students in SSB Baturetno. Students with higher expiratory peak flow are better than students with lower expiratory peak toward the increase of  $VO_2Max$  on U-14 soccer students in SSB Baturetno. Lung functions are influenced by genetic, environmental, and nutrient factors as well as physical training which help to improve the endurance of respiratory muscles. There is a strong relationship between regular physical training and lung function test [15]. Students that perform more physical activity/exercise will have bigger lung function than someone who performs only few physical activity/exercise (sedentary). Exercise will make the durability and strength of respiratory muscles increase so that the lungs ability to expand also increases. Exercises help to improve respiratory muscle ability to overcome respiratory airflow resistance, which in turn increases air volume [16].

Physical training or exercise also have a reciprocal relationship with the respiratory system. Physical training in regular basis will improve the efficiency of respiratory system, whether ventilation, diffusion or perfusion. Changes in lung function due to regular exercise will affect the value of Expiratory Peak Flow obtained. For a person, doing physical training on a regular basis will improve the function of respiratory and cardiovascular system. Meanwhile, a better respiratory system will improve a person's endurance in doing physical training.

The purpose of respiration is to supply the tissue with oxygen and to release carbondioxide. During normal and calm breathing, all respiratory muscle contractions occur during inspiration. Expiration is an almost fully passive process due to the elastic properties of resilience of the lung and ribcage. Inflation and deflation of the chest during expiration and inspiration represent diaphragm contraction, intercostalis muscles functions, elevation and costa depression.

A high  $VO_2Max$  value can improve the performance on endurance activities, which increases the ability of the work average larger or faster. The aerobic threshold in this theory is best improved by high intensity training, despite in practice it is more effective and efficient to do so with long continuous training at an intensity of 1-2% below the existing lactic acid threshold. Increased work intensity to the limit of  $VO_2Max$

will lead to one of the following to occur in oxygen consumption, i.e. a stable state (plateau) or slightly decreased in terms of heart pulse [17].

Exercise for normal person can improve optimum physical fitness and endurance that affects lung function especially to students, which results in an increase in expiratory peak flow value and develops greater endurance of respiratory muscles, therefore, student in every sports must have a good expiratory peak flow in order to have a good physical endurance as well. It is important for students to have a good expiratory peak flow because they may have a stable endurance while in a competition. For example, a soccer player should possess good muscle endurance and cardiorespiratory endurance which is a condition that enables the body to work for a long time without experiencing excessive fatigue after completing the work. Thus, to be able to have a good body endurance a student must possess a good expiratory peak flow in order to get an optimum exercise activities [18]. With a good expiratory peak flow, an individual can perform respiratory ventilation function well in order to create good physical state and fitness, but if a person does not have good expiratory peak flow, then it can disrupt respiratory system and lead to intermittent airway obstruction due to thoracic wall and respiratory muscles that do not work well [19].

Theoretically, the more oxygen that can be used during high-level exercise, the more ATP (energy) that can be generated. This often occur with the endurance of an outstanding student that usually have high  $VO_2Max$  value.

Aside from genetic factors, there are three other components that have great impact on  $VO_2Max$  they are (1) age; although varies by individual and training program, generally  $VO_2Max$  is higher on a 20 year old and drops almost to 30% on a 65 year old, (2) gender; many female students have higher  $VO_2Max$  than male students, but because of difference in body size and composition, blood and volume of hemoglobin content, a females  $VO_2Max$  is usually around 20% lower than male  $VO_2Max$ , and (3) Altitude; because of the lack of oxygen at a higher altitude there will be decline on student by 5 %  $VO_2Max$  output in a 5,000 feet altitude [17].

Maximum oxygen volume ( $VO_2Max$ ) output varies. The average for each settled is close to 35 ml/kg/min. The average endurance of an excellent student is 70ml/kg/min. One of the highest  $VO_2Max$  ever recorded (90 ml/kg/menit) is on a ski student. Cyclist Lance Armstrong is reported to have  $VO_2Max$  of 85 ml/kg/min.

Most excellent students will posses better  $VO_2Max$  value at 60 ml/kg/min. A high  $VO_2Max$  on a student may show very high potential for aerobic endurance, but there are other factors that are able to determine victory in a competition [20].

### C. Interraction between circuit and fartlek training method and expiratory peak flow (high and low) to $VO_2Max$ increase

Based on the result presented in this research, there is a significant interaction between circuit and faterlek training method and expiratory peak flow (high and low) to  $VO_2Max$  increase of U-14 soccer students in SSB Baturetno. The research result shows that circuit training method is the most

effective method to be utilized by students with high expiratory peak flow and fartlek training method is more effective for students with lower expiratory peak flow. With this observation, we can say that  $VO_2Max$  is an important factor that determines the maximum performance, but that does not mean it should limit the combination of other factors". The effect of training leads to improvement of lung work efficiency of a trained person so it can process more air with less energy. During an exhausting work, a trained person can process air for almost two times per minute than a normal person. Thus a trained person can provides more oxygen to be used to the process of energy formation [17].

### III. CONCLUSIONS

Based on the research results and data analysis, a conclusion is obtained, as explained below. (1) There are significant influence differences between circuit and fartlek training method on  $VO_2Max$  improvement of U-14 soccer students in SSB Baturetno. Circuit training method is better compared to fartlek exercise method on the  $VO_2Max$  improvement of U-14 soccer students in SSB Baturetno. (2) There are significant influence differences between high and low expiratory peak flow on  $VO_2Max$  improvement of U-14 soccer students in SSB Baturetno. Students with higher expiratory peak flow are better than students with lower expiratory peak toward the increase of  $VO_2Max$  on U-14 soccer students in SSB Baturetno. (3) There is a significant interaction between circuit and fartlek training method as well as peak expiratory flow (high and low) on  $VO_2Max$  increase of U-14 soccer students in SSB Baturetno.

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