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Progressive Training Program Improves Aerobic Capacity and Physical Fitness in Student Soccer Athletes

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ABSTRACT

The endurance of soccer players in Indonesia is generally still low. Aerobic capacity is an important component for improving physical fitness and endurance. When comparing several age groups, young players have less physical fitness. This study aimed to determine the effects of progressive training on changes in the maximum oxygen volume (VO2max) and heart rate (HR) based on recovery time. This study is quasi-experimental with a control group design and was conducted on student soccer athletes. Sixty athlete students who met the inclusion criteria were divided into a control group (n=30) and a progressive training group (n=30). The intervention consisted of progressive training for ten weeks with marathon running at distances of 150, 200, and 300 meters with rest intervals for each distance. The training load was gradually increased by increasing the number of repetitions every week. VO2 max, and Heart Rate were evaluated before and after the program. The results shown that the VO2 max was significantly different between the groups ($p<0.001$), and the Heart Rate of the subjects in both groups decreased from start to finish. Notably, the HR in the progressive training group was lower than the control group. In conclusion, progressive training is effective in improving aerobic capacity and physical fitness.

KEYWORDS *Progressive;Physical Fitness;Aerobic Capacity;VO2 max;Heart rate*

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INTRODUCTION

Cardiorespiratory endurance is needed in sports that require high endurance, such as soccer (Foster et al., 2015; Iaia & Bangsbo, 2010; Puspitasari, 2019). The physical fitness of soccer players in Indonesia is generally still low. Several factors are thought to be related to the physical fitness of athletes, including a lack of intense physical training and minimal athletic training that starts at an early age and gradually increases through adolescence and into adulthood in a continuous manner (Bryantara, 2016). The limited ability of trainers to create endurance training programs is extensive, systematic, and measurable (Harsono, 2018; Nirwandi, 2017). Several previous studies reported that the endurance capacity of soccer players in several age groups (13-17 years) was deficient and that physical fitness needs to be optimized with effective training (Afandy et al., 2015).

Depending on the talent of an athlete, cardiorespiratory adaptation cannot be achieved in a short time (a few days or weeks) but may take up to one year of development to achieve a high aerobic capacity. The parameter used to determine aerobic capacity is VO_2 max and Heart Rate frequency.The higher the VO_2 max of a person is, the better their cardiorespiratory fitness (Mahotra, 2016; Putra et al., 2023; Tanzila, 2018).

Evaluations to improve the endurance capacity of football players have been carried out through several training interventions, among others interval training, fartlek, cicuit training, And small side games. Among these methods, the one that provides a greater positive effect than other methods is exercise interval (Hohl et al., 2019). Training using the interval method still needs to be developed into an endurance training program with the aim of optimizing the adaptability of the heart and lungs so that it can be known which exercises contribute most to increasing aerobic capacity (VO).2Max). The training model can be modified with the principle of overload training (overloading). This load focuses on repetitions progressively and gradually with a ladder system (step type-approach), or often also called the wave system (wave-like system) from Bompa theory (Busyairi & Ray, 2018). however training days with increased loads should be alternated with light training days (unloading phase) so that there is time for the body's organisms to regenerate so as not to cause fatigue (Hutajulu, 2016).

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days with increased loads should be alternated with light training days (unloading phase) so that there is time for the body's organisms to regenerate so as not to cause fatigue (Yullianto et al., 2020). This research also investigated whether the Heart Rate after progressive training has a response to cardiac adaptation during this program.

RESEARCH METHOD

Subjects and Intervention

Soccer athlete students in Sriwijaya State Sports School and Farmel Hatta Soccer School, South Sumatera, Indonesia, who were males in the 14–17year age group, and met the inclusion criteria were the study group. The aims of the study were explained to all participants and written informed consent was obtained before data collection. The experimental procedures were approved by the Health Research Ethics Committee of the Faculty of Medicine, Diponegoro University (No.62/EC/KEPK/FK-UNDIP/III/2023).

The treatment in this study was intense progressive training for ten weeks from July–September 2023. Athletes were asked to run a distance of 150, 200, and 300 meters. Each time they completed a distance, the athletes rested for an interval of 2-3 minutes. Additionally, the athletes were asked to run at an intensity of 60-85% and for a duration of 50-60 minutes each time (Firmansah, 2021). The repetition load was gradually increased, similar to the concept of stairs. In the 1st, 2nd, and 3rd steps, the load was gradually increased. In the 4th step, the repetition load was lower than the previous steps (unloading phase), and in the 5th, 6th, and 7th steps, the load was increased again until ten weeks was reached (Sinurat, 2019).

Measurement of Parameters

VO_2 max measurement was performed via Treadmill test, using the Bruce method. Physical fitness was classified based on the VO_2 max obtained from the two groups. And pulse measurements are based on the results of the ECG monitor recording during the 5 minutes of recovery

RESULT AND DISCUSSION

Volume Oxygen Maximum (VO_2 max)

There was a significant difference in the volume oxygen maximum (VO_2 max) between the progressive training group and the control group ($p<0.001$). The VO_2max value in the progressive training group was greater than that in the control group (Table 1).

Table 1. VO_2 max values for the control group (n=30) and the progressive exercise group (n=30) before and after progressive exercise

VO_2 max (ml/kg/minute)	Group		p[¥]
	Progressive exercise (n=30) mean±SD;median (min–max)	**Control (n=30)** mean±SD;median (min–max)	
Pre	41.0 ± 3.96; 41.7 (20.3-43.1)	41.1 ± 1.60; 41.0 (34.7-42.4)	0.286
Post	56.0 ± 6,09; 54.7 (43.1-67.6)	43.5 ± 3.38; 42.4 (39.6-52.9)	**<0.001**
Delta	15.0 ± 5,64; 14.1 (7.7-26.6)	2.4 ± 3.30; 1.4 (-2.8-10.5)	**<0.001**
P (pre vs. post) [£]	**<0.001**	**<0.001**	-

Table 1. Delta = VO_2 max(post) - VO_2 max(pre); Values were expressed in terms of the mean ± SD, [¥] Mann–Whitney test; [£] Wilcoxon test, Statistically significant data are bolded, VO_2 max: maximum volume of oxygen

The changes in VO_2 max after 10 weeks of exercise in both groups shown in figure.1

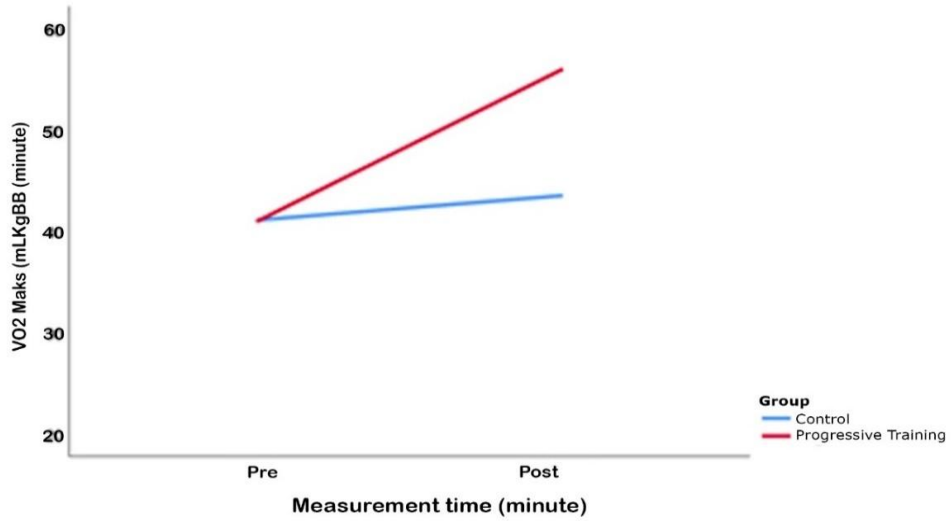


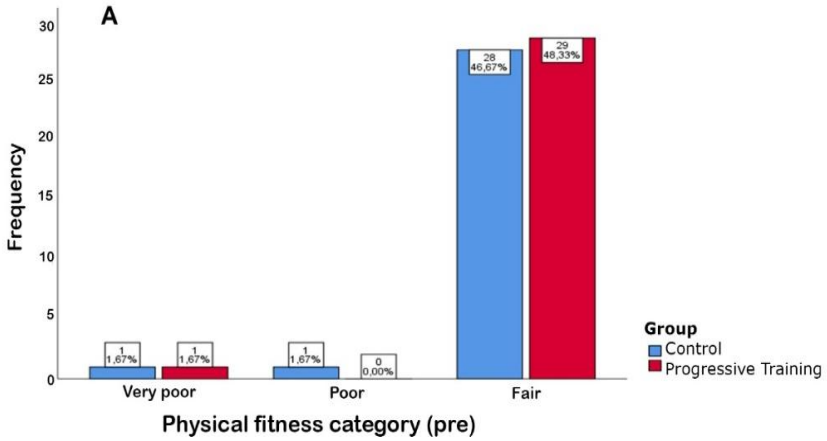
Figure. 1 Changes in VO_2 max before and after 10 weeks of training for each group. The progressive training group had a greater increase than the control group.

Physical Fitness Level Categories Based on VO_2Max Value

Table 2. Physical Fitness Level Categories Based on VO_2max subjects in the control group (n=30) and progressive exercise group (n=30) at the start and end

Physical Fitness Category	Group		p¶
	Progressive Training (n=30)	Control (n=30)	
Start			
Fair	29 (96,7%)	28 (93,3%)	
Poor	0 (0,0%)	1 (3,3%)	0,500
Very Poor	1 (3,3%)	1 (3,3%)	
End			
Superior	14 (46,7%)	0 (0,0%)	
Excellent	11 (36,7%)	2 (6,7%)	**<0,001**
Good	4 (13,3%)	5 (16,7%)	
Fair	1 (3,3%)	23 (76,7%)	

Based on Table 2. it shows that at the start, the physical fitness level category was based on the VO_2max in the two groups was not much different, namely the majority were in the moderate category, and statistically there was no significant difference (p>0.005), and at the end after 10 weeks there was a significant difference in the two groups (p<0.001), where the majority of physical fitness levels in the intervention group were in the superior category. Distribution of physical fitness level categories based on VO_2max at the start and end are also shown in figure 2.



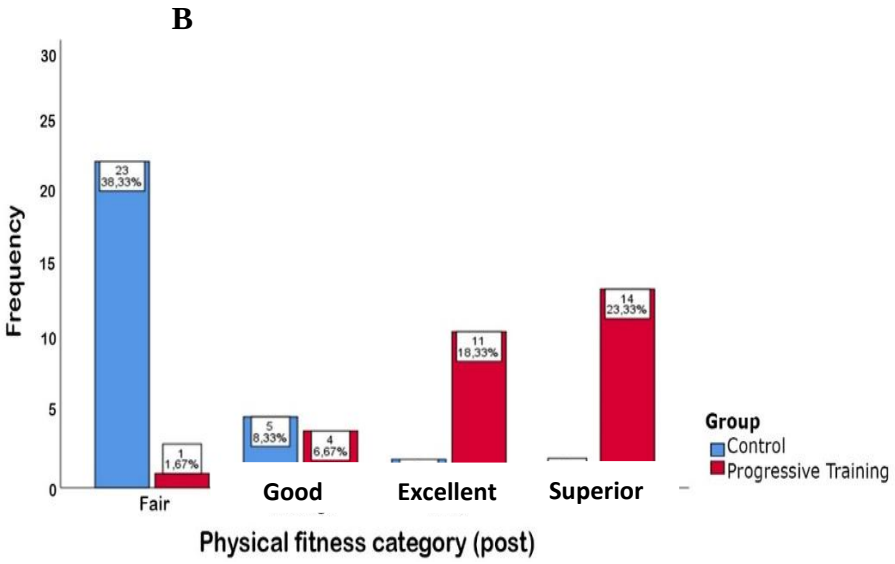


Figure. 2 Distribution of physical fitness categories based on the VO_2Max at the start (image A) and end (image B) of training for the progressive (n=30) and control (n=30) groups. Percentages are calculated based on the total value.

Changes in Heart Rate Based on Recovery Time

Heart Rate Early Time

Table 3. Average HR Recovery Research Subjects in the Control Group (n=30) and Progressive Training Group (n=30) at Baseline

Group	Early (Pre)				
	Recovery minutes to				
	1	2	3	4	5
Control	148,2±14,43; 146,5 (110,0-182,0)	133,5±11,46; 132,5 (113,0-156,0)	124,1±12,20; 126,0 (100,0-144,0)	122,3±13,61; 122,0 (87,0-144,0)	120,6±13,50; 121,5 (95,0-148,0)
Intervention	143,1±12,85; 146,5 (119,0-163,0)	130,3±14,42; 132,0 (102,0-160,0)	125,4±14,45; 125,0 (102,0-160,0)	120,2±13,09; 118,5 (93,0-160,0)	118,6±12,64; 117,5 (92,0-158,0)
p	0,159§	0,355§	0,701§	0,545§	0,549§

¥Test Mann-Whitney, §Unpaired t-test,

Change *Heart Rate* based on time *recovery* in the progressive training group and the control group at baseline (Pre) are also shown in Figure 3.

A

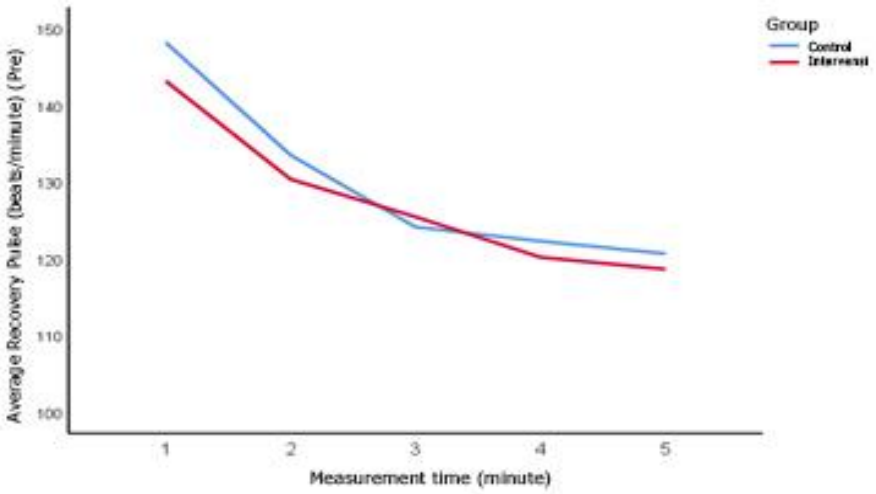


Figure 3a. Changes in heart rate based on recovery time in the progressive group (n=30) and control group (n=30) before training **(pre)**

Figure 3a. shows that Heart Rate recovery at the start in the two groups was not much different and statistical tests proved that it was not significantly different, the baseline in the progressive exercise group was lower than the control group

Heart Rate Final Time

Table 4. Average Heart Rate research subjects in the control group (n=30 and progressive exercise group (n=30) at the end (post)

Group	End (Post)				
	Recovery minutes to-				
	1	2	3	4	5
Control	144,9±18,46 ; 143,5 (119,0-187,0)	130,7±13,86 ; 128,0 (111,0-160,0)	124,2±13, 00; 123,0 (99,0-156,0)	118,9±11, 15; 117,0 (99,0-142,0)	119,8±11,51 ; 117,5 (98,0-145,0)
Interventio n	138,0±17,23 ; 136,5 (108,0-180,0)	129,9±15,19 ; 128,5 (105,0-167,0)	125,9±13, 80; 124,0 (98,0-165,0)	118,0±15, 87; 117,0 (82,0-142,0)	113,1±18,36 ; 109,5 (81,0-139,0)
p	0,167¥	0,846§	0,625§	0,815§	0,129¥

¥Test Mann-Whitney, §Unpaired t-test

From Table 4. it shows that the average Heart Rate the final time in the progressive exercise group tended to decrease more than Heart Rate in the control group, but statistics show that there is no significant difference between the two group. The results of this study also show that changes Heart Rate recovery in the progressive exercise group and the current control group final lower than Heart Rate recovery at the start Change Heart Rate based on time recovery End time (Post) is also shown in figure 3b.

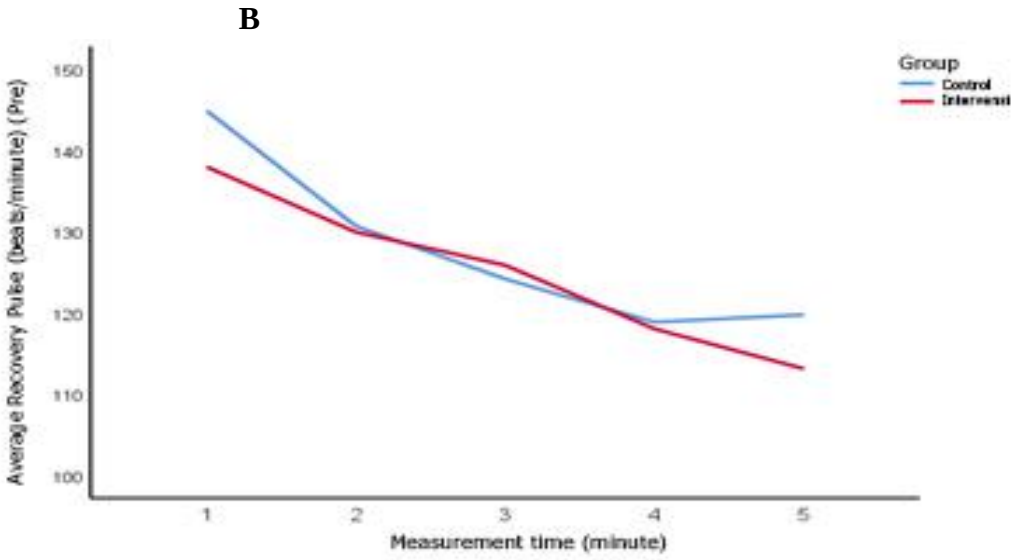


Figure 3b. Changes in heart rate based on recovery time in the progressive exercise group (n=30) and control group (n=30) at the end of training **(post)**

Discussion

Increases in the VO_2 max

Along with increases in the VO_2 max, the physical fitness of subjects in both groups also improved. Based on initial data (pre), the majority of subjects in this study had physical fitness in fair categories. At the end (post), the majority of subjects in the progressive training group were in superior and excellent categories, while the majority of subjects in the control group were in fair categories.

Progressive training in this study included an interval training model that was formulated with the principle of overload, the presence of intervals or breaks in training sessions and the presence of a load reduction phase, which provided the heart an opportunity for nutrient recovery and allowed regeneration of organisms

in the body. In contrast, an excess load was used to emphasize that the physiology of a person can adjust or adapt to demands to improve capabilities better than before. Progressive exercise done intensely increases cardiac output, and cardiac output is the main factor influencing VO_2 max. The strength and ability of the heart to pump blood with each contraction increases, thereby reducing the number of pulses per minute. The cardiovascular changes in the group given progressive training resulted in a significant increase in the VO_2 max a response of the heart and blood vessel system to the performed exercise.

The interval training method has been used in previous research. Busyairi (2018) reported the VO_2 max increase of 3.59 ml/kg/min. Hutajulu, (2016), reported a VO_2 max increase of +3.55 ml/kg/min. Pahala Tua, in a 2019 study on U18 junior soccer athletes, reported a VO_2 max increase of +3.55 ml/kg/minute after 10 weeks. From several previous studies that also applied the interval endurance training model, it is known that the results of this study provide a much greater effect in increasing aerobic capacity, namely, +15.1 ml/kg/minute. This training program is believed to be more effective in increasing the aerobic capacity and physical fitness of junior group soccer players aged 14-17 years.

Decrease in Heart Rate Based on Recovery Time

The increase in aerobic capacity in this study is related to changes in heart rate. The results revealed that subjects in both groups experienced a decrease in heart rate based on recovery time, and the heart rate frequency in the progressive training group was lower than that in the control group, which increased more at the end of recovery. The results of this study showed that there were changes in pulse rate in both groups from start to finish based on recovery for 5 minutes. The group with progressive training and the control group experienced a decrease in heart rate from start to finish, the average heart rate in the progressive training group was lower or slightly decreased compared to the control group.

This decrease in heart rate is caused by an increase in parasympathetic nerve tone, a decrease in parasympathetic nerves, and a decrease in sympathetic nerves. With a decrease in heart rate, the heart has a reserve heart rate which is higher. There is also a decrease in the frequency of impulse output from the lungs and heart. With a change in volume, the volume of the stroke (stroke volume) becomes greater and if the heart rate reserve increases the result is cardiac output (output) will be higher and thus oxygen transport will be even higher. In this way, the metabolism will run effectively and the person will recover from fatigue more quickly. Because the stroke volume at rest is greater, this allows the heart to pump the same amount of blood every minute with fewer beats. then there is a direct relationship between pulse rate and VO_2 max. A person with a VO_2 Max level the high one has a low heart rate (pulse).

The results of this study are relevant to research by Khasan et al., 2012 which states that there is a relationship between resting pulse frequency and maximum oxygen volume, because pulse frequency tends to be low in athletes, indicating the heart's ability to pump blood. The lower the resting heart rate, the higher the oxygen volume, because the more efficient the heart is in pumping blood throughout the body.

In the previous discussion, it was explained that the group with progressive training experienced an increase in VO_2max is greater and significantly different from the control group. This is in line with the results of final pulse measurements based on time recovery, where the average heart rate of the progressive exercise group tends to be lower or decreases more when compared to the control group. If seen from the average frequency, it is still above 100x/minute, this is still considered an adaptation response to the effects of the load given progressively, and the research subjects are in the category of not being professional athletes. So even though there was a decrease in heart rate from start to finish, statistical tests showed that it was not significantly different from the control group. It still takes a long period of time and routine for athletes to carry out training so that the recovery of training and resting heart rates will be lower along with increases in stroke volume and cardiac output.

CONCLUSION

The findings of the present study revealed that ten weeks of progressive training effectively improved the aerobic capacity and physical fitness of soccer athlete students aged 14-17 years through adaptation of the cardiovascular system. The decrease in NT-proBNP levels in the blood is a physiological adaptation response of the heart during progressive exercise and does not cause an increase in cardiac stress.

Conflict of Interest

The authors declare that they are no conflicts of interest in this study.

Author Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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