Gradual Progressive Exercise Increases Lung FVC in Soccer Student Athletes

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KEYWORDS
Respiratory, FVC, Lung, Progressive, Exercise

ABSTRACT
Introduction: Having a good vital lung capacity is very important for athlete, because they can have stable endurance when competing, especially for athletes in sports that require high physical endurance and for a long time, such as playing soccer. Efforts to increase and optimize lung capacity for athletes starting from an early age and entering adolescence with exercise. This research is aimed to investigate the effect of gradual progressive exercise on Forced Vital Capacity (FVC). **Methods**: This research was a quasi experimental with control group design. The intervention consisted of progressive exercise for 10 weeks regularly, 45-60 minutes at intervals, and the control group was not given progressive exercise. There are 60 male soccer students in Palembang City, who have met the inclusion criteria.
Results: There was an increase in actual FVC in the group with progressive exercise from start to finish of 0.3±0.31 (p<0,001). The average FVC was 3.2 liters (SD 0.50), with the maximum FVC value is 4.30 liters and the minimum value 2.20 liters. The average actual FVC in the progressive exercise group tended to be higher than the control group (3,2±0,50 vs 3,1±0,48) and there is no significant difference in the two groups (p=0,218). **Conclusion**: 10 weeks of gradual progressive excercise is increasing the actual FVC significantly from the beginning to the end of training in soccer student athletes aged 14-17 years.

INTRODUCTION

The ability to perform optimal physical activity and training for an athlete is determined by the capabilities of various body systems, including the respiratory system.[1] Every physical exercise has a reciprocal relationship with the respiratory system.[2] The diffusion capacity of trained people is greater than that of untrained people, this is due to the effective blood vessel network in the lung parenchyma, so the area for diffusion is wider.[1] Exercise and the respiratory system are two things that are closely related and influence each other. Research shows that regular exercise will improve the function of the respiratory and cardiovascular systems, which are important components in achieving optimal levels of physical fitness.[3,4,5] For this reason, it is important to develop lung capacity for an athlete, because the faster oxygen will move for energy metabolism. Lung volume is related to aerobic capacity, and aerobic capacity is one of the important factors that supports athlete success.[6]

Each type of sport has a different energy system and depends on the type the practice. energy is an important requirement for physical activity, both during practice or competition.[4] The greater the vital capacity value, the greater it is the ability of the respiratory system to supply oxygen to carry out activities sports, especially for athletes in sports that require high endurance and for a long time, such as playing soccer.[6,7] For this reason, efforts to increase and optimize lung capacity for athletes need to optimizing lung capacity.

Many studies in the field of sports have assessed the effects of regular aerobic or anaerobic exercise on respiratory function, but how lung vital capacity changes after intense progressive and gradual loads training has never been discussed in previous studies.[9,10] One of the recommended training methods to increase endurance, is interval training.[11,12,13] Interval training can be formulated using the principle of progressive and gradual overload, with the aim of achieving optimal physiological adaptation of the respiratory system. Achieving optimal respiratory endurance cannot be done in a short time or in just a few days or weeks.[2,14] Research needs to be carried out to analyze the effects of an intense progressive training model on lung function.

Lung function can be measured using a spirometer. The Buffalo Health Study concluded that lung function can be used to assess the survival rate and health status of an athlete. One of the lung functions that can be used for clinical examination is Forced Vital Capacity (FVC).[15,16] Forced Vital Capacity (FVC) or forced expiratory vital capacity is the maximum air expelled when exhaling forcefully, quickly and completely after maximal inspiration. In measuring lung function, FVC can assess the compliance ability of the lungs and chest wall.[17]
There is a need for research that analyzes how lung function changes with intense progressive training models and evaluates how much influence training has on the lung capacity of soccer athletes in the 14-17 year age group.

METHODS

Study location

This quasy experimental study was carried out during July-September 2023 in Sriwijaya State Sports School, and Farmel Hatta Soccer School, South Sumatera, Indonesia

Subject of the study

Soccer athlete students in Sriwijaya State Sports School and Farmel Hatta Soccer School, South Sumatera, have met the inclusion criteria. All participants have explained the aims of the study and secured written informed consent from participants.

Intervention of Progressive Exercise

The treatment in this study was intense exercise for ten weeks. Athletes were asked to run (jogging) a distance of 150 meter, 200 meter and 300 meter, with intervals (2-3 minutes) after they completed each the distance. The duration of exercise is 45-60 minutes, and repetition load was gradually increased every weeks, similar to the concept of stairs.

Measurement of Parameters

Measurement of the FVC using spirometer microQuark is a PC-based spirometer from COSMED, Italian).

Statistical analysis

Data are expressed as mean (standard error of the mean). Differences between groups were analyzed by one-way analysis of variance followed by the least significant difference test. Statistical analyses were performed using SPSS software version 26 (IBM Corp.,USA). Differences between mean values were considered significant at $p<0.05$.

Ethical Considerations

This research was granted permission by South Sumatera City Government through the South Sumatra Province Education Office. 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).

RESULTS

A. Characteristics of research subjects

Table.1 Characteristics of research subjects in the control group (n=30) and gradual progressive exercise group (n=30)

Characteristics	Group		p
	Control Rates ± SD;CI 95% (min-max)	**Intervention** rates ± SD;CI 95% (min-max)	
Age	14,87±0,694;14,75 (14,00-16,60)	15,90±1,168;16,35 (13,80-17,60)	0,001¥
Body Weight	52,0±9,01:50,5 (37-73)	54,3±10,23:56,0 (33-81)	0,352§
Body Height	164,0±6,46:164,5 (152-176)	164,4±6,96:166,0 (147-176)	0,818§
BMI	19,2±2,51:18,8 (15,8-25,6)	20,0±2,96: 19,4 (13,8-28,7)	0,288§
Nutritional Status			
- more	3 (10,0%)	1 (3,3%)	
- good	27 (90,0%)	27 (90,0%)	
- malnutrition	0 (0,0%)	2 (6,7%)	0,358¶

§ Unpaired t-test; ¥Mann-Whitney test; ¶Fisher-Exact test

Table. 1 showed that based on subject characteristics there were factors that were statistically significantly different between the progressive group and the control group, one of which was the age factor (p=0.001). However, the multivariate analysis with logistic regression results shows that the age variable is weakened or eliminated by other factors so that the age factor is not significantly different (p=0.391) between the two groups. This is estimated because all subjects in this study were in the same age range, between 14-17 years. Mean body weight, height, BMI and nutritional status were not significantly different between the control group and the progressive group (p>0.005).

B. Forced Vital Capacity (FVC)

a. Predicted FVC (%)

Predicted FVC values (%) at the start and end in the progressive exercise group and control group shown in Table.2

Table 2. Predicted FVC % value of research subjects in the control group (n=30) and gradual progressive exercise group (n=30)

FVC % Predictions	Group		p
	Progressive exercise (n=30) mean ± SD; 95% CI (min-max)	**Control (n=30)** mean ± SD; 95% CI (min-max)	
Start	81,7±11,63; 80,0 (60,0 -103,0)	84,8±0,44; 84,0 (70,0 -108,0)	0,741§
Finish	87,7±7,20; 85,0 (80,0 -110,0)	91,7±9,98; 91,5 (73,0 -119,0)	0,056¥
Delta	6,0±8,86; 6,5 (-16,0 - 23,0)	6,9±6,37; 6,5 (-6,0 -22,0)	0,665§
P (start vs end)£	0,002	<0,001	

¥Test Mann-Whitney; £Test Wilcoxon; §Unpaired t-test; $Paired t-test

Based on the data in Table 2. it shows that there was an increase in predicted FVC% in each progressive exercise group and the control group after intense physical exercise for 10 weeks (from start to finish), although statistically there was no significant difference between the two groups (p>0.005). Likewise, the actual FVC values in the progressive exercise group and the control group both experienced a significant increase from start to finish (with each p value being p<0.001). The actual delta FVC value (liters) in the progressive exercise group was higher than the control group, but statistical tests did not show a significant difference between the two group (p=0.218).

b. Classification of predicted FVC

Table 3. Predicted FVC category (%) in control group and progressive exercise group from start to finish

FVC% prediction	Group		p
	Progressive exercise (n=30)	**Control(n=30)**	
Start			
Normal	19 (63,3%)	20 (66,7%)	

Abnormal	11 (36,7%)	10 (33,3%)	0,787*
Finish			
Normal	30 (100%)	28 (93,3%)	
Abnormal	0 (0,0%)	2 (6,7%)	0,492¶

*χ^2 test, ¶Fisher-Exact Test

Table 3. showed that at the end of the study the normal category of FVC % prediction in the progressive exercise group was greater than in the control group, but the results of statistical tests showed that this change was not significant between the two group (p=0,492)

c. Actual FVC (liter)

FVC actual values at the start and end in the progressive exercise group and control group shown in Table.4

Table 4. FVC actual value of research subjects in the control group (n=30) and gradual progressive exercise group (n=30)

FVC Actual	Group		p
	Progressive Practice (n=30) mean ± SD; 95% CI (min-max)	**Control (n=30)** mean ± SD; 95% CI (min-max)	
Start	2,9±0,62; 3,0 (1,5 - 3,8)	2,9±0,50; 2,9 (2,0 - 4,1)	0,741§
Finish	3,2±0,50; 3,2 (2,2 - 4,3)	3,1±0,48; 3,1 (2,3 - 4,2)	0,785§
Delta	0,3±0,31; 0,3 (-0,3 - 0,9)	0,2±0,19; 0,3 (-0,3 - 0,6)	0,218§
P (Start vs End)$	<0,001	<0,001	

¥Mann-Whitney test; £Wilcoxon test; §Unpaired t-test; $Paired t-test

Table 4. showed that the actual FVC value in both of group significant increased from start to finish (p<0.001), the avarage FVC in the progressive training group was higher than the control group (0.3±0,31 vs 0,2±0,19) but there was no significant difference between the groups (p=0.218).

DISCUSSION

Forced Vital Capacity (FVC) is a parameter in this study, used to see a person's lung capacity. Forced Vital Capacity is the maximum volume of air that can be exhaled forcefully in one breath from maximum inspiration to maximum expiration.[15] A higher vital capacity value can be associated with a person's higher endurance. Increased lung capacity can also indicate an increase in the strength and elasticity of respiratory muscles due to exercise.[16,17] Lung function values will be influenced by various factors including age, height, Body Mass Index (BMI), gender and physical training. The highest lung function values will be achieved at the age of 19-21 years because respiratory function and blood circulation will increase from childhood and become optimal at the age of 20-30 years. After that there will be a decline.

After reaching a maximum point in young adulthood, diffusion, ventilation, oxygen uptake and all lung function parameters will decrease with increasing age.[18]

In this study, the characteristics of all research subjects, both the progressive group and the control group, were not significantly different in terms of gender, height, weight, BMI and race. So the increase in FVC value is not much influenced by these factors, but is more likely to be influenced by the form and type of exercise carried out. From the research results obtained at the beginning, the predicted FVC value (%) category which describes lung function in the two groups was not much different, where 63.3% of the progressive exercise group, and 66.7% of the control group were categorized as normal, and the rest in each group included in the abnormal category, namely mild restriction. At the end of the training results, there was an increase in the predicted FVC value which showed that all 30 subjects (100%) in the progressive training group were declared in the normal category, and 93.3% in the control group were in the normal category, only 2 people were still in abnormal category in the control group. Although the results of statistical tests in the two groups did not show significant differences, but the actual FVC value in the progressive exercise group tended to be higher than the control group (0.3±0.31 vs 0.2±0.19).

In this study, the intervention was carried out over a period of 10 weeks. The researchers' analysis was not able to maximize the functional adaptation of the respiratory system, even though there had been an increase in the mean value from start to finish. Changes in the respiratory system will occur over a longer period of time when compared to the cardiovascular system as a form of adaptation to the process. This is relevant to previous research which concluded that the effects of moderate and regular intensity aerobic exercise for 12 weeks were able to significantly increase FVC and FEV1 lung function.[19]

The increase in FVC which was not significantly different between the two groups could also occur due to the type of exercise given. The type of physical activity can determine how much a person's lung function capacity changes.[20] Based on several conclusions from previous studies, the increase in FVC values will also tend to be higher in types of exercise that predominantly use the respiratory muscles, chest, diaphragm, external And internal intercostal, sternomastoid, and abdominal muscles like a type of swimming exercise.[14,20] Meanwhile, in this study, between the progressive training group and the control group, the types of training were not much different, such as run and other physical activities that emphasized playing techniques that tended to use the lower skeletal muscles.[21,22]

Previous research concluded that exercises that predominantly use the lower skeletal muscles, such as using a stationary bike, treadmill, core strength, and running, the results were not significantly different from other groups who underwent almost similar physical activity.[23,24,25] From the results of this study and from various references to previous studies, it can be concluded that several things are thought to influence the size of the increase in forced vital capacity in this study, namely physiological factors, length of exercise, and the type of physical activity carried out.

CONCLUSION

Gradual progressive exercise increases the actual FVC value (liters) significantly from the beginning to the end of training in soccer student athletes aged 14-17 years

Conflict of Interest

The authors affirm no conflict of interest in this study.

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