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Original Article

Lung function in athletes and non-athletes aged 13-15 years

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Abstract

Background Regular sports or physical training contributes in increasing the body's pulmonary function. The increase of pulmonary function is determined by the strength of respiratory muscle, thoracic compliance, upper respiratory system resistance, and pulmonary elasticity.

Objective To compare pulmonary function between athletes and non-athletes aged 13-15 years.

Methods This is a cross-sectional analytical study conducted on junior high school students aged 13-15 years throughout June to August 2017. Participants are classified as athletes from particular sports and non-athletes. Assessment of pulmonary function was done using a spirometry test, in which each subject was asked to inhale and exhale in a particular method. Parameters assessed include vital capacity (VC), forced vital capacity (FVC), expiratory volume in 1 second (FEV1), forced expiratory flow (FEF) and FEV1/FVC. Differences in lung function between athletes and non-athletes were analyzed using independent T-test.

Results There were 60 athletes and 60 non-athletes included in this study. The mean age of athletes and non-athletes were 13.38 (SD 0.99) years old and 13.70 (SD 0.76) years old, respectively. The statistically significant differences in mean lung function parameters between athletes and non-athletes were as follows: VC: 85.03% *vs.* 79.41%, respectively (P=0.035); FVC: 95.66% *vs.* 88.43%, respectively (P=0.016); FEV1: 102.10% *vs.* 94.28%, respectively (P=0.016); and FEV1/FVC: 105.95% *vs.* 102.69%, respectively (P=0.011). However, there were no statistically significant differences in the means of FEF 25-75% between the two groups (P>0.05).

Conclusions Parameters of lung function in athletes are in general significantly higher than in non-athletes. **[Paediatr Indones. 2018;58:170-4; doi: http://dx.doi.org/10.14238/pi58.4.2018.170-4]**.

Keywords: *lung function; athletes; non-athletes*

Regular sports or physical training may increase the body's physiologic capacity, including respiratory function.[1] The respiratory system is one of the most important body systems, in which effective gas exchange is required, especially during physical activity. Human lungs are sensitive to conditions that result in increased aerobic metabolism such as running, cycling, and swimming.[1,2] The type, intensity, and duration of regular exercise that athletes practice result in different lung function measures.[3] During intense physical activity, oxygen consumption as measured by maximal aerobic metabolism (VO_2 max) increases. The VO_2 max reflects the total amount of oxygen that can be utilized during physical training (measured in mL O_2/kg body weight/min). Practicing 7 to 13weeks of physical training may increase the VO2 max by more than 10%.[4]

Determinants of pulmonary function include: strength of respiratory muscles, thoracic compliance, upper respiratory system resistance, and pulmonary elasticity.[1,5] Respiratory function increases as

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children grows and develops. Pre-pubertal boys and girls have similar lung physiology, both at rest and during exercise. Significant development of strength, flexibility, and equilibrium occurs at ages 6-12 years. Above this age range, child development will be quite robust including its physical characteristics and movement.[6,7]

Respiratory muscle growth, lung expansion capability, thoracic cavity and bronchial elasticity, and adequate bronchiolus function may increase lung function thoroughly, in terms of vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), ratio of FEV1 and FVC (FEV1/FVC), and forced expiratory flow (FEF). Pulmonary function is examined using spirometry. Spirometry results are interpreted as normal, (normal FVC and FEV/FVC), restrictive (decreased FVC and normal or increased FEV1/FVC), and obstructive (decreased FVC and FEV1/FVC ratio).[5,6] Physical inactivity is a major cause of most chronic conditions, including decreased cardiorespiratory fitness (CRF), in terms of capacity of the cardiovascular and respiratory systems to supply oxygen-rich blood to the working skeletal muscles and the capacity of the muscles to use oxygen to produce energy for movement.[2] Regular physical training may have a positive influence on respiratory and circulatory function, as a benchmark of physical fitness and increased quality of life.[5,8,9] The aim of this study was to compare pulmonary function in athletes and non-athletes aged 13 and 15 years.

Methods

This cross-sectional, analytic, observational study was conducted on junior high school students aged 13-15 years, who were classified as athletes and non-athletes (of particular sports) throughout June to August 2017. Subject selection is conducted using two-stage cluster sampling. We randomly chose two junior high schools from a list obtained from the 'Dinas Pendidikan, Pemuda dan Olahraga' (Education, Youth, and Sport Office) of Denpasar, Bali. A total of 120 subjects from the two schools were included, 60 athletes and 60 non-athletes. Parents consented to their children's participation in this study. Exclusion criteria include obesity, presence upper respiratory tract infection at time of study, history of active and/or passive smoking, history of reduced lung function, such as due to a chronic cough, or recurrent upper respiratory tract infection, abnormal heart function, obstructive lung diseases, such as asthma or thoracic cavity abnormality that may influence the lung volume. Subjects underwent anthropometric and spirometry tests. The lung function test was conducted using a single-blind technique. This study was approved by the Medical Ethics Committee of Udayana University, Sanglah Hospital, Denpasar.

An athlete was defined as someone who had an affinity for particular sports, who competed in those or other sports, and who conducted routine training with a minimum of running 2 kilometers every 2 days per year or swimming at least 300 meters, according to the same schedule. A non-athlete was defined as those without an affinity for sports, did not have competitive experience in a sport, and did not include exercise as a hobby.

Lung function was defined as the ability of the lung to conduct gaseous exchange, in which oxygen was absorbed and carbon dioxide was released, as measured by spirometry. Spirometry is a tool to measure air movement in or out of the lungs during a particular lung maneuver. Vital capacity was defined as the volume of air expired slowly from the end of maximal inspiration until the end of maximal expiration. Forced vital capacity was defined as the speed of expiration flow and the length of inspiration time. The FVC maneuver was done by maximal inspiration, followed by quick and forceful expiration. This maneuver was also used to measure other parameters, such as forced expiratory volume in 1 second (FEV1), FEV1/FVC, and FEF. The FEV1 was defined as the volume of forced expiration in the 1st second. The FEV1/FVC was defined as the ratio between FEV1 and FVC, and the FEF was defined as the speed of air expired during the middle portion of a forced expiration, from 25% to 75%, and considered to be the remaining fraction of the FVC.[10]

Body weight (measured in kg) was measured using a standing scale, with the subject being in a state of minimal clothing, without wearing shoes. Body height (measured in cm) was measured using plastic rulers attached to the wall, with subjects standing upright, back against the wall, without wearing shoes. Body mass index (BMI) was defined as body weight divided by body height squared (kg/m^2).

The data collected included age, sex, height, weight, sports championship history, and length of training. Unpaired mean sample size formula was used to calculate the minimum required sample size, which was 59 subjects in each group. Independent T-test was used for lung function analysis because the distribution of data was normal. Results with P values <0.05 were considered to be statistically significant. Statistical analysis was calculated using *SPSS 18.0 for Windows*.

Results

Out of the 178 adolescents screened for this study, 58 of them were excluded: 23 were screened to have obstructive lung diseases such as asthma, 16 were passive smokers, 12 had upper respiratory tract infection, and 7 were obese. Hence, 60 athletes and 60 non-athletes participated in this study. The mean age was 13.38 (SD 0.99) years for athletes group and 13.70 (SD 0.76) years for non-athletes group. The characteristics of study subjects are shown in **Table 1**.

Table 1. Characteristics of study subjects

Characteristics	Athletes (n = 60)	Non-athletes (n = 60)
Sex, n (%) Male	30 (50)	30 (50)
Mean age (SD), years	13.38 (0.99)	13.70 (0.76)
Mean body weight (SD), kg	48.77 (10.51)	49.67 (12.45)
Mean height (SD), cm	153.80 (7.92)	154.94 (8.71)
Mean BMI (SD), kg/m^2	20.45 (3.03)	20.54 (3.91)
Types of sports, n (%)		
Athletics	18 (30)	
Basketball	21 (35)	
Football	9 (15)	
Swimming	12 (20)	

Table 2 shows the differences in lung function parameters between the two groups. The athlete group had significantly higher mean VC, FVC, FEV1, and FEV1/FVC than the non-athlete group. However, mean FEF 25, FEF 50, and FEF 75 were not significantly different between groups.

Discussion

Lung function may be influenced by genetic, environment, and nutritional factors. Routine physical activity during childhood growth and development may increase the lung-muscle endurance. Routine physical activity during adolescence may increase hyperplasia of alveolar tissue, the formation of new alveoli, and lung microcirculation.[11,12] Athletes undertaking high intensity physical training have increased lung function compared to non-athletes. Several Indian studies showed that the duration of physical activity that influence lung function was between 1 and 8 months.[11,12] Several other studies showed that lung function in males is better than in females, possibly due to differences in thoracic cage size and muscle strength.[13,14]

Routine physical activity may also increase production of contractile protein, including actin and myosin. Increased muscle contraction strength may increase an athlete's lung function compared to that of non-athletes, because of lung changes in muscle strength, expansion, elasticity, and equilibrium.[15] We used spirometry to measure lung function parameters in our subjects. Vital capacity (VC) is measured using a combination of lung dimension, lung compliance, and respiratory muscle strength. We found that athletes had mean VC of 85.03%, which was significantly higher than that of non-athletes (79.41%; P=0.035). A study

Table 2. Comparison of lung function parameters between athletes and non-athletes

Variables	Athletes (n=60)	Non-athletes (n=60)	Mean difference (95%CI)	P value
Mean VC (SD), %	85.03 (13.79)	79.41 (15.10)	5.62 (0.39 to 10.85)	0.035
Mean FVC (SD), %	95.66 (14.03)	88.43 (18.07)	7.23 (1.38 to 13.07)	0.016
Mean FEV1 (SD), %	102.10 (13.92)	94.28 (20.56)	7.80 (1.45 to 14.15)	0.016
Mean FEV1/FVC (SD), %	105.95 (5.86)	102.69 (7.87)	3.26 (0.74 to 5.77)	0.011
Mean FEF25 (SD), %	93.25 (22.6)	92.89 (20.26)	0.35 (-7.41 to 8.13)	0.927
Mean FEF50 (SD),%	111.68 (30.72)	111.64 (24.15)	0.04 (-9.95 to 10.03)	0.994
Mean FEF75 (SD), %	127.31 (43.25)	123.42 (42.6)	3.89 (-11.63 to 19.42)	0.620

in India showed that among adults measurements after exercise, there was a significant increase in VC in both athletes and non-athletes.[10]

The FVC was measured by maximal inspiration followed by maximal expiration.[16] We found that the mean FVC in athletes was significantly better (95.66%) compared to that of non-athletes (88.43%). Similarly, Vedala *et al.*[17] and Mahotra[18] stated that the FVC in athletes was significantly higher than in non-athletes. Muscular exercise increases the rate and depth of respiration and improves FVC, the consumption of O_2, and the rate of diffusion. Physical activity was observed to be positively correlated to the changes of FVC between ages 13-27 years.[7]

The FEV1/FVC ratio is used as a marker for obstructive and restrictive conditions of the lungs.[18] The mean FEV1/FVC in athletes (105.95%) was significantly higher compared to that of non-athletes (102.69%; P=0.011), similar to results from Vedala *et al.*[17] However, Akhade *et al.* found no significant difference in mean FEV1/FVC percentage between athletes and non-athletes.[19] Regarding the FEF of 25-75%, we found no statistically significant differences between athletes and non-athletes.

General lung function test revealed an overview of lung function in athletes compared to non-athletes, with significantly higher VC, FVC, FEV1, and FEV1/FVC values in the athlete group. A Turkish study conducted in 15-16-year-olds also noted significant differences of lung function between regular exercise and sedentary individual or inactive individual.[20] Regular exercise training is thought to increase the oxygen demand in working muscles, which stimulate the respiratory centers in the brain stem and send strong signals to the inspiratory muscle group. These muscles cause forceful inspiration and expiration, as well as increased secretion of surfactant and prostaglandin (PGE2) in the alveolar space to decrease alveolar surface tension and decrease physiological dead space. Consequently, these actions are reflected as increased pulmonary function in atheletes. Increased lung compliance and decreased bronchial smooth muscle tone tend to increase the general lung function of athletes.[15,19] Our study may be indicative of changes in lung and muscle function, thoracic cage movement, and equilibrium between lung and thoracic cage elasticity in response to regular physical activity. Limitation of this study was that we only performed lung function test one time and not evaluating physical activities before spirometry test that might influence the test.

As a conclusion, lung function in athletes is significantly higher compared to non-athletes, in terms of VC, FVC, FEV1, and FEV1/FVC. However, FEF 25-75% are not significantly different between athletes and non-athletes. Routine physical activity may have positive effects on lung capacity. More studies should be done on the differences between lung function in athletes from various sports.

Conflict of Interest

None declared.

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