RESEARCH ARTICLE

Assessment of pulmonary functions FVC, FEV1, and FEV1/FVC ratio among athletes and non-athletes

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ABSTRACT

Background: Pulmonary function will improve by regular and intense physical activity. There will be difference in degree of improvement or increase in pulmonary functions in different types of athletic activities. Recent studies have stated forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), and FEV1/FVC ratio to be higher in athletes than in the normal sedentary control individuals. Few studies have found lower values of dynamic pulmonary function while few other studies have found higher values of dynamic pulmonary function tests. We undertook this study to know the pulmonary function in athletes of Bengaluru and compare it with controls. Aim and Objective: This study aims to record dynamic pulmonary function tests (FVC, FEV1 and FEV1/FVC) using COSMED computerized spirometer in athletes and to compare with non-athletes. Materials and Methods: This is a case–control study which included 50 non-smoking athletes of 18–25 years age group from Shree Kanteerava Stadium, Bengaluru, and 50 non-athletes as control group after considering inclusion and exclusion criteria. Subjects were age and gender matched. FVC, FEV1, and FEV1/FVC were recorded using COSMED computerized spirometer. For statistical analysis, independent Student’s t-test was used. Results: FVC, FEV1, and FEV1/FVC (P < 0.001) were significantly increased in athletes than non-athletes. Conclusion: Regular exercise and athletic training will improve the lung function tests.

KEYWORDS: Athletes; Forced Vital Capacity; Forced Expiratory Volume in 1 Second; COSMED Spirometer

INTRODUCTION

The word athletics was derived from the Greek word – athlētēs which means “combatant in public games” and from athlon, which means “prize.” Among different types of sports, running or track and field sports are preferred as most popular athletics events. One of the oldest forms of sports are track and field, which includes running, walking, jumping, discus throw, and javelin throw. This also includes race walking and marathon running.[2,3]

We all know doing any type of physical exercise may enhance health. Physical activity of any form may improve pulmonary functions.[4] There are many factors by which pulmonary function can be governed like genetic makeover of the person, environmental factors such as air quality, pollution, and dietary and nutritional factors such as vegetarian and non-vegetarian food which may help in the growth and development of respiratory muscles. Pulmonary function might increase by regular and intense physical activity and there can be difference in pulmonary functions in different types of athletic activities.[5] For example, individuals who swim regularly have good lung function, while swimming in water creates pressure on chest wall and also staying in water
for a longer time results in strengthening of respiratory muscles which, in turn, can increase the airway resistance. Regular physical activity improves pulmonary functions not only in children but also in elderly individuals. Athletes who usually get trained from their childhood will have better pulmonary ventilation compared to athletes who get trained later in life. Pulmonary function can be improvised or increased by practicing moderate levels of exercise regularly in elderly age group individuals also. Exercise may increase ventilation as tidal volume and respiratory frequency increases. During intense exercise, volume of ventilated air may increase about 10–20 times rather than resting times; however, structure of ventilation system is administrated appropriately to adapting with high ventilation demands during such exercises. Thus, higher physical activity is related to a slower decline in pulmonary function in any age group.

However, some athletes have reported with exercise-induced asthma (EIA) which is characterized by bronchospasm and increase in airway resistance. More than 10% decline in forced expiratory volume in 1 s (FEV1) is the common standard criteria for EIA. Athletes may be more prone to EIA as they are exposed to dust, many allergens and air pollution during their practice seasons. Many elite athletes without any asthma history may show significant bronchospasm signs during or after exercise.

Many lung functions studies have been done in other sports activities such as swimmers and water polo but very few studies are conducted on running. Hence, we undertook this study to see how running improves the lung function in athletes and also to see whether it can cause EIA.

**Objective**

The objective of the study was to record dynamic pulmonary function tests (FVC, FEV1, and FEV1/FVC) using computerized spirometer COSMED in athletes and to compare with non-athletes.

**MATERIALS AND METHODS**

A total of 50 athletes (short distance runners) and 50 non-athletes who were taken who of 18–25 years. Subjects with known cases of chronic bronchitis, bronchial asthma, tuberculosis, chronic obstructive pulmonary disease, any allergic disorders or endocrine disorders, any abnormalities of the vertebral column and thoracic cage, neuromuscular diseases, history of occupational lung diseases, nasolaryngeal disorder, family history of any respiratory disease, history of any previous surgery, history of diabetes, or any cardiovascular disease were excluded from the study. The study protocol was fully explained to the subjects. Informed consent was taken by all subjects. Student’s “t-test” was used for statistical analysis.

**Ethical Committee Clearance was obtained from Bengaluru Medical College and Research Institute to Conduct this Study (NO. BMC/PGs/289/2016-17)**

Using COSMED microQuark PC-based Spirometer, PFT (FVC, FEV1, and FEV1/FVC) of all the subjects was measured before and immediately after 6 min of treadmill exercise test. It has got digital turbine flowmeter which is validated by LDS Hospital (ATS standards). Flowmeter is designed in such a way that it records a wide range of flows with good precision and has a very low resistance.

After automatic calibration of the instrument, the subject was asked to take a deep inspiration keeping the flow meter away. This was followed by a forceful maximum expiration into the flow meter for a duration of 6 s. The values of FVC, FEV1, and FEV1/FVC were noted. The procedure was repeated twice with an interval of about 5 min and the best of the three recordings was selected for statistical analysis. The values of both groups were recorded and compared. The collected data were statistically analyzed.

**RESULTS**

The findings of the present study are presented in Tables 1-3.

**DISCUSSION**

Respiratory system functioning can be affected by many factors such as sedentary lifestyles, air quality and pollution, dietary intake, variation in age, and body weight. Regularly exercising and thus maintaining physical fitness of an individual play a major role in performance of respiratory system reflected by increase or decrease the pulmonary function tests.

Regular exercise can result in various changes in body functions. It can increase the endurance, reduce breathlessness,

| Table 1: Comparison of FVC in case and controls |
|-----------------|-----------------|-----------------|
| FVC: Forced vital capacity | FVC: Forced vital capacity |
| Pre | 4.77±0.06 | 2.90±0.35 | <0.001** |
| Post | 4.73±0.06 | 2.88±0.34 | <0.001** |

| Table 2: Comparison of FEV1 in cases-controls |
|-----------------|-----------------|-----------------|
| FEV1: Forced expiratory volume in 1 second | FEV1: Forced expiratory volume in 1 second |
| Pre | 3.82±0.04 | 2.57±0.31 | <0.001** |
| Post | 3.78±0.05 | 2.54±0.31 | <0.001** |

| Table 3: Comparison of FEV1/FVC ratio in cases-controls |
|-----------------|-----------------|-----------------|
| FEV1/FVC ratio: Forced expiratory volume in 1 second | FEV1/FVC ratio: Forced expiratory volume in 1 second |
| Pre | 0.80±0.01 | 0.88±0.05 | <0.001** |
| Post | 0.80±0.01 | 0.88±0.05 | <0.001** |
and prevent the occurrence of many chronic diseases. Regular forceful inspiration and expiration could lead to good ventilation of lungs strengthens the muscles of respiration, increases the elasticity of lungs, expansion of alveoli, and decreases airway resistance. During exercise signals from chemoreceptors, muscles and joint proprioceptors stimulate the respiratory centers in brainstem, in turn, the signal is sent by nerves to the muscles of respiration. Thus, exercise improves forced vital capacity (FVC) and oxygen consumption from tissues.

Among all types of sports, running is the most common form of athletics and aerobic exercise which has a profound effect on pulmonary functions. In athletes to notice any improvement in lung function, running regularly for a period of 1 month–8 months can bring improvement on lung functions.

In our study, we observed that there is a significant increase in FVC in athletes (short distance runners) (4.77 ± 0.06) than controls (2.90 ± 0.35). With regular physical exercise, rate and depth of respiration increase markedly, and thus, it also improves FVC, oxygen consumption from tissues and increases diffusion rate. The improved FVC after exercise is due to the increased strengthening of muscles of respiration post-training, decrease in trapping of air, reduced resistance in airways, decreased lactate levels in blood, improvement in compliance of lung, and increase in lactate uptake by respiratory muscles along with encouraging the subjects which will help them to take deep inspiration and fill the respiratory tract with air post-training.

The respiratory muscles are designed in such a way that it deals with the raise in the lung ventilation during exercise. The diaphragm the main inspiratory muscle contains almost 60% of slow twitch fibers that have higher oxidation and blood flow than muscles of hands and legs. As the diaphragm works constantly during the lifetime, it needs all these features to work continuously. The most important feature of fibers of respiratory muscles are that it gets adapted with physical exercise and training, gets altered with age, respiratory disorders, and certain drugs such as beta-2-agonists and corticosteroids. There are some studies done on animals, especially rat, which show that physical training induces increase in mitochondrial enzymatic activity, glycogen concentration, increase in type I myosin, and a decrease in type IIb myosin chains in diaphragm. Expiratory muscle is made up of predominately fast twitch fibers than slow twitch fibers that are easily fatigable as fibers have a less activity of oxidative enzymes than muscles of inspiration.

FEV1 was highly significant in athletes (3.82 ± 0.04) than controls (2.57 ± 0.31). FEV1 was significantly different in both groups due to maximum power of expiration and overall low resistance to air movement in the lungs. It corroborates with the study done by Vedala et al. who concluded that the FEV1 in athletes was more than subjects with sedentary lifestyle. On contrast, a study done by Fatemi et al. showed that intense exercise can lead to reduced FEV1 and cause EIA.

In our study, FVC and FEV1 were found to be significantly high (FVC = 4.77 ± 0.06 and FEV1 = 3.82 ± 0.04) in runners than controls (FVC = 2.90 ± 0.35 and FEV1 = 2.57 ± 0.3). The reason behind this could be that exercise might increase oxygen consumption in respiratory muscles which send signals to higher centers which, in turn, will stimulate muscles of inspiration and cause forceful inhalation and exhalation. This will lead to high concentration of surfactant on surface of alveoli which will reduce the surface tension in alveoli and reduce the physiological dead space which further improves ventilation and thus the lung function in athletes.

In our study, we found that there was 4% decrease in FEV1 and according to the standard criteria for EIA diagnosis, it should be more than 10% decline in FEV1. Athletes in our study were practicing running only for few years, it may require many more years for inducing EIA. However, EIA can be seen generally after 2–10 min of moderate physical activity and not observed in intense physical activity. Hence, may be in our study, the intensity of exercise was more but it was not a heavy exercise.

The results also showed that in both athletes and the control group, FVC and FEV1 were decreased after 6 min of exercise. In athletes, FVC decreased from 4.77 ± 0.06 to 4.73 ± 0.06, and in controls, it decreased from 2.90 ± 0.35 to 2.88 ± 0.34 and FEV1 in athletes decreased from 3.82 ± 0.04 to 3.78 ± 0.05, and in controls, it decreased from 2.57 ± 0.31 to 2.54 ± 0.31. The cause for this slight decrease may be due to fatigue of respiratory muscles and increase in pulmonary blood volume after exercise which reduces the lung functions. Exercise can also cause bronchoconstriction which may affect FEV1. FVC may be decreased as there is reduction in small airway diameter because of pulmonary edema or due to rise in thoracic blood volume after physical exercise which leads to less capacity for air. Hence, may be in our study, the intensity of exercise was more to cause little bronchoconstriction, but not as much as to cause an EIA. Vedala et al. found FVC, FEVI, and FEV1/FVC ratio to be higher in athletes compared to sedentary individuals.

A study done by Fatemi et al. who showed that the FEV1/ FVC was significantly reduced after test in the study group. Similarly, there was a statistically significant difference between the study and the control groups in the ratio FEV1/ FVC. There was reduction in FEV1, but the value of FVC remains unchanged, thus, leading to reduction in the ratio of FEV1/FVC in the following the test. If the muscle of expiration is weakened, it will lead to reduction in force of expiration. This will reduce FEV1/FVC ratio, without airway obstruction.
Hence, we can say that regular exercise or running can cause strengthening of respiratory muscles with improvement in lung function. Involvement in certain physical activities or sports could help in respiratory muscle strengthening and thus lead to improvement in lung function.

One of the limitations of our study was that the athletes were practicing running since the past 1–2 years only which may not alter the dynamic pulmonary function.

CONCLUSION

Running improves the lung function which, in turn, might further help in strengthening of respiratory muscles. The values of FVC, FEV1, and FEV1/FVC were decreased after 6 min of exercise both in athletes and the control group. This may emphasize on lifestyle modification and practice physical exercise to maintain normal and healthy well-being. We can recommend regular running as it may improve the pulmonary function of an individual.

REFERENCES


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