ORIGINAL ARTICLE

Physical activity and its effect on forced expiratory volume

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Abstract

Objective: To assess and compare changes in pulmonary functions before and after exercise in young healthy adults.

Methods: The case-control study was carried out from January to March 2010 on 292 medical students aged 18-24 years at Bahria University Medical and Dental College, Karachi. Baseline values for forced expiratory volume (FEV_1) and forced vital capacity (FVC) were measured with a digital spirometer, and the FEV_1: FVC ratio was calculated. The lung functions of Group I comprising 192 volunteers after aerobic exercise of 30 minutes daily, for five days over eight weeks, was compared with Group II having 100 controls who did not participate in any physical activity. SPSS 15 was used for statistical analysis.

Result: At the end of eight weeks, there was a significant rise in FEV_1 (2.49 ± 0.82 to 2.59±0.79 liters), decline in FVC (2.80±0.92 to 2.7±0.87 liters) and an increase in the FEV_1: FVC ratio (89.52±12.66 to 95.56±13.42) in Group I students.

Conclusion: Improvement in pulmonary functions was noticed as a result of physical activity.

Keywords: Forced expiratory volume, Forced vital capacity, FEV1/FVC ratio. (JPMA 63: 310; 2013)

Introduction

Exercise has been a means of testing the physical capabilities and physiological responses of an individual that form the basis of good health and well-being. It develops the ability to tolerate, withstand stress, and carry on in circumstances where an unfit person cannot continue.

Lung function is an important predictive tool of both morbidity and mortality in medical practice. The Buffalo Health Study concluded that pulmonary function is a long-term predictor of overall survival rates in both genders and can be used as a tool for general health assessment[1]. Pulmomary function tests include the forced expiratory volume (FEV_1), which is the amount of air exhaled in one second, and the forced vital capacity (FVC), which is the maximum amount of air that can be exhaled in a single breath. Both FVC and (FEV_1) are measured with the help of a spirometer.[2] Later, the FEV_1/FVC ratio, which is the percentage of the FVC exhaled in the first second, can be calculated.[2]

Exercise is a stressful condition that produces marked change in body functions, improves endurance and reduces breathlessness. Skeletal muscles control many crucial elements of aerobic conditioning, including lung ventilation. The possible explanation could be that regular forceful inhalation and deflation of the lungs for prolonged periods leads to strengthening of respiratory muscles.[3] There might be an increase in the maximal shortening of the inspiratory muscles as an effect of training, which has been shown to improve lung function parameters.[4]

As far as effect of exercise on lung functions is concerned, recent developments in exercise physiology have shown significantly positive improvements.[5] However, non-significant associations have also been reported.[6]

In view of the two contradictory studies, authors were keen to know the role of physical activity in the modification of lung functions; positive results, if derived, could then be communicated to the students for their fitness and well-being.

Subjects and methods

The case-control study was conducted at Bahria University Medical and Dental College, Karachi from January to March 2010. Subjects were assigned to 2 groups (cases and controls) using a system of random number tables. The sample size calculated was a minimum of 94 and 187 for controls and cases respectively.[7]

After taking informed consent, a detailed history was noted. This was followed by a physical exam of each participant and those with a past medical history suggestive of asthma and exercise-induced asthma, smoking, chronic cough, recurrent respiratory tract infection, history of chest or spinal deformity, obesity, and chronic obstructive lung diseases were excluded from the study.

Pulmonary function tests and their ratio was measured for all the subjects before exercise with the help of a digital spirometer (Microlab 3300 electronic spirometer, Micro Medical Limited, Kent, England). Standardised measurement procedures were used: subjects seated comfortably were

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demonstrated the technique, emphasising the tight fit between lips and tube and encouraging the subject to breathe out as long and forcefully as possible. After one trial run, the best-of-three technically satisfactory manoeuvres was recorded by a single experienced technician. The ratio calculated by the spirometer was later confirmed manually.

The experimental group had 210 student volunteers who performed aerobic exercise for 30 minutes, five days per week, for eight weeks.[8] The exercise was supervised cycle ergometry with a target of moderate intensity, performed on an electronically braked cycle ergometer (Medical Graphics, St. Paul, MN). The subjects pedalled at a rate of 60 to 80 revolutions per minute. Trained staff supervised and measured the pulmonary functions after each exercise session.[9]

During the study, 18 candidates were left out: 6 had a fall in FEV_1, 10 developed exercise-induced asthma, and 2 left of their own accord. The control group continued with the routine and performed no specific exercise.[8] The FEV_1, FVC and FEV_1/FVC ratio was then compared with pulmonary functions of the cases. All the data was analysed with SPSS version 15. Values were presented as mean ± standard deviation and p value at <0.05 was considered significant.

Results

There study included 292 students with the mean age of 19±2 years. Group I (cases) comprised 192 students: 103 (53.64%) females and 89 (46.35%) males. Group II (controls) had 100 students: 46 (46%) males and 54 (54%) females. The baseline FEV_1, FVC and FEV_1/FVC of all students represented the first set, while the second set of readings in Group I after exercise was compared with Group II. There was no change in baseline pulmonary functions in the controls, while FEV_1 was raised, FVC was reduced and FEV_1/FVC ratio was raised in the cases (Table).

Discussion

Physical activity, vital for healthier existence, is a complex behaviour that is nurtured by environmental and biological factors.[10] In day-to-day life, moderate level of physical activity has a number of positive influences on all systems, especially cardiovascular and respiratory.

Respiratory function depends on many factors, including nervous system, strength of respiratory muscles, and lung dimensions. There are different parameters used for the measurement of lung functions, but FEV_1 has been proven to be most crucial in detecting pulmonary changes easily and effectively in clinical settings the patient turnover is high and in settings where obesity is prevalent.[3] Another variable is the FVC, which is the maximum volume of air exhaled with maximal effort with deep inspiration, and predicts the compliance of lungs and the chest wall. FEV_1/FVC (FEV_1%) is the ratio between the two and in healthy adults this should be approximately 75-80%.[12] In our study improvement in FEV_1 after an 8-week exercise course is comparable to a study in which significant augmentation in FEV_1 and FVC were observed after physical training in healthy male welders.[13] These results also agreed with a previous study which proved that ventilatory exercise programme improves all measured pulmonary parameters.[14]

An association between physical activity and FEV_1 and FVC has been reported by previous studies in the general population. Men who remained active had higher FEV_1 and FVC than those who led a sedentary lifestyle.[15] Another study found no correlation between pulmonary functions and physical activity.[16] Our results correspond with a study that reported significant improvement in FEV_1 (mean change of 17%) after one month of physical training in healthy volunteers from the jute and hemp industry.[17] As far as airways are concerned, activity-induced bronchodilation reduces airway resistance and improves pulmonary ventilation. It is known that normally the volume and pattern of ventilation are initiated by neural output from the respiratory centre in the brainstem. This output is influenced by input from chemoreceptors, proprioceptive receptors in muscles, tendons and joints, and impulses sent by nerves to the intercostal and diaphragmatic muscles. Muscular exercise increases the rate and depth of respiration to improve FVC, the consumption of oxygen and the rate of diffusion.[18] The increase in FVC post-exercise might be related to the

Table: Comparison of lung function tests in study and control goups (with and without exercise).

	Initial values		Eight week (final) values		p-value
	Experimental group I Mean±SD	Control group II Mean±SD	Experimental group I Mean±SD	Control group II Mean±SD	
FEV_1(litre)	2.49±0.82	2.40±082	2.59±0.79	2.40±082	<0.0001
FVC (litre)	2.80±0.92	2.80±0.92	2.7±0.87	2.80±0.92	<0.0001
FEV_1/FVC (%)	89.52±12.66	89.50±12.66	95.56±13.42	89.50±12.66	<0.0001

enhanced strength of respiratory muscles following training, reduction in air trapping, improvement in lung compliance, reduced airway resistance, reduced blood lactate concentration and improved lactate uptake by these trained muscles (as fuel for their own activity) along with a motivation which enforces the subject to take deep inspiration and fill all air passages after training.[19, 20]

It is well known that physical activity can help reduce bodyweight and increase muscle mass in the general population. Exercise training has been shown to improve respiratory capacity, airway resistance, exercise tolerance, and work of breathing.[21] The study gives a clue to improvement in muscle strength, endurance, maintaining of positive pressure in the airways and improving the efficiency of ventilation with regular exercise.

We observed a slight fall in FVC, an isolated finding which could be either due to variation in height, age and weight of the participants. Spirometric measurements show a variability because the results are dependent on patient's efforts and consistency. Thus, in order to reach an effective level of FVC, people may have difficulty compared to producing FEV_1.[22]

Restrictive lung disease is characterised by decreased FEV_1 and FVC, and the ratio is often between 85%-100% of normal. So an isolated fall in FVC cannot suggest restrictive lung disease. According to the American Thoracic Guidelines, the lower limit of normal (LLN) is variable and patient values that are falling in close proximity should be interpreted with caution. The diagnosis of restrictive disease is usually based on the presence of a reduced total lung capacity. A reduced FVC in the presence of a normal FEV_1/FVC may be used to suggest but not to diagnose the presence of a restrictive abnormality.[23]

Our study was the first research in the region done in order to analyse the effects of physical activity on lung functions in healthy adults. It limitations included the small sample size, inability to measure maximal oxygen uptake (VO_2 max), forced expiratory flow and peak expiratory flow.

Conclusion

Repeated periodic exercise helped in improving lung functions, especially FEV_1 and ratio of FEV_1/FVC. Periodic measurement of FEV_1 can help in generating awareness regarding lifestyle modifications, and acquiring a healthy habit of being active.

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