Evaluation of the effect of exercise on pulmonary function in young healthy adults

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Abstract

Background and Objective: Physical activities like games and sports have been the very basis for promoting physical fitness and health from ancient days. Training increases vital capacity and the maximum volume of air the lungs exchange in one respiratory cycle and aids materially in establishing economy in the oxygen requirement. Hence, the present study was undertaken to compare the pulmonary functions in age and sex matched control and athletic subjects.

Materials and Methods: After the institutional ethical clearance and informed consent from all the subjects the spirometric studies done to find out the various pulmonary function parameters such as, Forced vital capacity, Forced expiratory volume in first second of FVC, FEV₁, peak expiratory flow and Maximum voluntary ventilation using standard procedure. Results were expressed as mean ± S.D. Statistical Analysis was done by student’s t-test for group wise comparison and P value < 0.05 was considered statistically significant.

Result: The age, body weight, Height, body surface area and FVC didn’t show statistically significant difference between the nonathletic and athletic subjects. Whereas, FEV₁, FEV₁ / FVC ratio, PEFR and MVV was found to be significantly higher (P<0.001) in athletics as compared to nonathletes.

Conclusion: From this study, we conclude that the normal range of ventilatory function is broad and factors such as athletic conditioning may modify VC, maximum breathing capacity and diffusing capacity. The athletes have larger mean vital capacity and more breathing capacity as well as higher air flow than other subjects.

Keywords: Pulmonary Function Test, Forced Vital Capacity, FEV₁, Peak Expiratory Flow Rate, Maximum Voluntary Ventilation.

1. Introduction

It is well known that only strong will thrive the weak perish. Physical activities like games and sports have been the very basis for promoting physical fitness and health from ancient days. The development of athletic life of a child starts in early infancy. All the athletic events fall into three main classes like running, jumping and throwing. Logically when a baby first begins to toddler, or to play with a ball, it is unconsciously practicing the simplest progressions which in some cases will lead to an Olympic medal¹.

Training increases vital capacity and the maximum volume of air the lungs exchange in one respiratory cycle and aids materially in establishing economy in the oxygen requirement. The process of taking in of air to the lungs and expelling out of the air constitute one respiration (external and cellular) rise external respiration is only taken into consideration, which means taking in of air to the lungs and expelling it out, constitute one respiration. The capacity of respiratory responses is very important for runners which increases and decreases the time of the race. The runner should inhale and exhale through both the mouth and nose. Forced deep breathing is often done by runners, just prior to the start of the run. The purpose or importance is to build up a maximum store of air in the blood and lungs². Breath holding time is the time taken by one who holds his breath at rest. Many athletic events are performed with the breath held, notably swimming and track sprints. The physiology of breath holding involves respiratory, circulatory and cardio changes, all of which are important in the light of recent research. The most obvious changes when the breath is held are the increasing level of CO₂ and the decreasing level of O₂ in the alveolar air. These changes of course reflect the changes in the level of the respiratory gasses in the blood, the result of the continuing metabolism, it will be recalled that CO₂ and O₂ levels are involved in respiratory control, but the rising CO₂ level is more important in determining the length of time the breath can be held. This capacity will increase the speed of a runner.

Physical fitness is the ability to carry out the daily task with vigor and alertness. Physical fitness is essential for all human beings irrespective of their age. According to Bucher, "physical fitness is the ability of an individual to live a full and balanced life". It has been quoted that physical fitness has -not been scientifically proved to help to have a longer life, on the other hand, it has been proved beyond doubt that those who are used to exercise have lesser health problems.²³ Physical fitness is to a hard earned one through physical activity.

Little was known of about the use of PFT in detecting the states of superior physical ability such as might be found highly trained athletes. Stuart, Douglas and WD Collings compared the VC, MBC, MBCAC measurements of 20 athletes and 20 non athletes⁴. A 13.5 liter Spirometer with attached kymograph was used to record vital capacity. The mean VC score of athlete was significantly higher than mean non athlete VC. But insignificant differences existed between the 2 groups in MBC and MBCVC. MBC measured using Douglas bag. It was suggested that the difference in VC due to increased development of respiratory musculature incidental to regular physical training. They also noted that such increased muscular development do not increase MBC, suggesting that this measure may correlate more closely with the patience of airways rather than tone of respiratory muscle. Therefore, the present study was initiated to uncover differences in pulmonary functions in different groups of clinically normal individuals and athletes.

2. Materials and Methods

The present study was conducted at the Institute of Chest diseases attached to the Medical College Hospital Calicut and department of Physiology after the institutional ethical clearance and informed consent from all the subjects with a mean age of 28 ± 5.0 years. In this study, we
selected 60 subjects each of adult healthy controls and athletes. The spirometric studies done to find out the range of values for various pulmonary function parameters includes, FVC - Forced vital capacity, FEV₁- Forced expiratory volume in first second of FVC, FEV₁%, PEFR-peak expiratory flow and MVV- Maximum voluntary ventilation.

Equipment used was a personal computer based Spirometer named micro-Quark. Micro Quark is an instrument designed for lung function screening; the core of the system is the “intelligent” flow meter that, connected through the serial port (RS232), turns any Personal Computer (laptop or desktop) in a complete spirometric lab. The system is composed by the turbine flow meter, the measurement and data elaboration device (lightweight and ergonomic), and the communication cable and by the Software pack. A disposable mouthpiece is attached to the turbine flow meter. There is a sensor in the turbine flow meter. The measured values are displayed by the computer system to the screen. All tests were performed in the sitting posture. All values for both volumes and flows reported have been corrected to Body temperature, ambient pressure and saturated with water vapor (BTPS). This ensures direct comparison of pulmonary Function data from laboratories operating at different ambient temperature and attitudes. After the subject was comfortably seated, the procedure was explained in simple terms. Before the beginning of each test, the appropriate technique was demonstrated. A disposable mouthpiece was used for each subject. The mouthpiece was positioned so that the subject’s chin was slightly elevated and neck extended. After the insertion of mouthpiece, a check was made to ensure that no leaks were present. The subject was exorted to make a maximal effort for each test and was closely watched to ensure that he maintain an airtight seal between the lips and the mouth piece of the instrument.

For vital capacity test, the subject was then asked to breathe via the mouthpiece attached to the turbine flow meter. At first he was asked to breathe quietly and quite normally to establish the resting end-expiratory level. Then, the subject was asked to inspire fully and then, after reaching a plateau at maximum inspiration, to expire maximally. During the last phase of expiration, subjects were encouraged to continue their effort. This expiration was performed as deeply as possible, but slowly. Three consecutive determinations were done % of predicted value and actual value are displayed automatically.

Flow-volume measurement was determined from the flow/volume curve. After a brief period of quiet, normal breathing, the subject was asked to slowly breathe in as deeply as possible, breathe to a maximum, then breathe out as rapidly, forcefully and completely as possible. The subjects were verbally exhorted to continue squeezing out the air at the end of the maneuver. The performance of the maneuver was evaluated by inspecting the graphic output and the subject was reinstructed if necessary.

To measure maximum voluntary ventilation (MVV), the subject was instructed to breathe maximal possible amount of air over a 12 sec interval. At first the maneuver was demonstrated and the subject was permitted to perform practice runs for a brief period, in order to become familiar with the procedure. The subjects were asked to breathe as rapidly and deeply as possible for 12 sec after applying the nose clip. The parameters are extrapolated to 1 min and shown on the screen with the actual/predicted value comparison.

2.1 Statistical analysis: All the values obtained were expressed as mean ± S.D. and as percentages wherever required. The data were analyzed using students t-test in SPSS software. P value less than 0.05 was considered the level of significance.

3. Results

In the present study, pulmonary function tests were done in two groups of healthy persons namely, Group 1- healthy adult controls and Group 2- athletes. Each group consists of 60 persons of the age group 23-33 years. Effect of physical training on pulmonary function was assessed. The results are expressed in figure 1-9 and Table-1. Anova test was done to find out whether the difference in mean among the groups is significant or not. The age, body weight, Height, body surface area and FVC didn’t show statistically significant difference between the nonathletic and athletic subjects. FVC, FEV₁, PEFR and MVV are significantly high (p= 0.000) in athletes when compared to that in nonathletic control subjects. No statistically significant difference between healthy controls and athletes in FEV₁ / FVC was observed. PEFR is significantly high (p= 0.000) in athletes compared to in nonathletic control subjects. MVV is significantly low (p= 0.000) in nonathletic control subjects compared to athletes.

**Fig-1: Comparison of forced vital capacity in Control and Athletes.**

<table>
<thead>
<tr>
<th>FVC in litres</th>
<th>Control</th>
<th>Athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.7</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>4.7</td>
</tr>
</tbody>
</table>

N=60 in each group. P>0.05 between Control and Athletes

**Fig-2: Comparison of forced expiratory volume in Control and Athletes.**

<table>
<thead>
<tr>
<th>FEV₁ in one second</th>
<th>Control</th>
<th>Athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.8</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>4.8</td>
</tr>
</tbody>
</table>

N=60 in each group. P=0.000 between Control and Athletes.
Fig-3: Comparison of forced expiratory volume in Control and Athletes.

N=60 in each group. P=0.586 between Control and Athletes.

Fig-4: Comparison of peak expiratory flow rate in Control and Athletes.

N=60 in each group. P=0.000 between Control and Athletes.

Fig-5: Comparison of Maximum Voluntary Ventilation in Control and Athletes.

N=60 in each group. P=0.000 between Control and Athletes.

Fig-6: Comparison of age in years in Control and Athletes.

N=60 in each group. P is nonsignificant between Control and Athletes.
Fig 7: Comparison of height in centimeters in Control and Athletes.

N=60 in each group. P is nonsignificant between Control and Athletes.

Fig 8: Comparison of weight in kilograms in Control and Athletes.

N=60 in each group. P is nonsignificant between Control and Athletes.

Fig 9: Comparison of body surface area in square meters in Control and Athletes.

N=60 in each group. P is nonsignificant between Control and Athletes.

Table 1: Correlation between the ages of the athletes with the pulmonary function test.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Correlation coefficient between normal and athletes</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>-0.198</td>
<td>0.343</td>
</tr>
<tr>
<td>FEV1</td>
<td>-0.193</td>
<td>0.354</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>-0.320</td>
<td>0.118</td>
</tr>
<tr>
<td>PEF</td>
<td>-0.439</td>
<td>0.028</td>
</tr>
<tr>
<td>MVV</td>
<td>-0.279</td>
<td>0.177</td>
</tr>
</tbody>
</table>

4. Discussion

It is well known that athletic training has a significant effect on respiratory function. Studies have confirmed that athletes have larger lung volumes and capacities than non-athletes of comparable age group. Ventilatory muscles like other skeletal muscles change their strength or their endurance in response to appropriate specific training programmes. Ventilatory muscle strength can be defined and measured as the maximum and minimum static pressures measured at the mouth and attributable to muscle effort. Ventilatory muscle endurance has been defined and measured as the capacity for sustaining high levels of ventilation for relatively long periods.

Pulmonary diffusing capacity in athletes was higher than in non-athletes at any given level of VO2. It was postulated that only in disease does diffusing capacity limit exercise, cardiac output being the chief limiting factor in health. It was also reported the relationship of body composition to O2 consumption in normal young men during sub maximal work and the better relationship of maximum O2 consumption with fat free body mass and active tissue mass. Habitual physical activity affects cardiovascular performance. Recent years few investigators have summarized the available knowledge of changes in body composition which occur under the influence of physical activity.
Physical performance can be improved following warm-up exercise. The benefit of higher temperature during exercise lies in the fact that, the metabolic processes in the cell can proceed at a higher rate as these processes are temperature dependent. At higher temperature, the exchange of O₂ from the blood to tissues is much more rapid. This in turn helps in the transmission of nervous impulses faster. The duration and intensity of warm up should be adjusted according to the environmental temperature and the amount of clothing with regard to duration of warm up. Later it was reported the better results after 15 minutes warm up rather than 25 minutes which remain unaltered even after extending the time up to 30 minutes. Warm up exercise are designed to prepare the body for ensuring sporting activity. It helps to prevent injury and to enhance performance. During exercise the lungs and chest wall helps in the maintenance of homeostatic regulation of arterial blood gases at minimum cost. As the intensity of exercise is increased, the threat to a steady states of ventilator response results and thereby an upward drift in breathing frequency and minute ventilation results.

In the present study, we observed that the FVC, FEV1, PEFR and MVV are significantly high in athletes when compared to that in nonathletic control subjects and no statistically significant difference between healthy controls and athletes in FEV1 / FVC was observed. This is in agreement with the observations on physiological readjustment after pneumo neumonectomy, where in reduction in Vital Capacity. Sharpiro William et al also had the opinion that observation on superbly conditioned non-smoking athletes may help in detecting factors limiting the maximum ventilatory performance. Therefore, the physical training exhibit a facilitatory effect on pulmonary function and further long terms follow up and other tests are necessary to evaluate irreversible change in lung function that can occur due to physical exercise.

5. Conclusion
From this study, we conclude that the normal range of ventilatory function is broad and factors such as athletic conditioning may modify VC, maximum breathing capacity and diffusing capacity. The athletes have larger mean vital capacity and more breathing capacity as well as higher air flow than other subjects.

References