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**ORIGINAL ARTICLE**

# A COMPARATIVE STUDY OF LUNG FUNCTIONS IN SWIMMERS AND NORMAL INDIVIDUALS

Vivek Saboo

Assistant Professor, Department of Physical Medicine and Rehabilitation, National institute of Medical Science and Research, Jaipur, India

**ABSTRACT:**
**Introduction:** Swimming as a form of exercise is unique in many respects. It takes place in water that presents completely different gravitational and resistive forces compared to air. It is performed in a lying position, which alters gravitational effects on circulation. The breathing (respiratory) muscles which are composed of the diaphragm, external and internal intercostals, parasternal, sternomastoid, scalene, external and internal oblique and abdominal muscles are the vital organ in mammals by which oxygen is delivered to the red blood cells and concomitantly carbon dioxide is removed and expelled into the environment and play major role in during the excercise. **Materials and Method:** In this present study included 50 male competitive swimmers, aged between 18-25 years. A similar number of age, height and weight matched medical students not directly engaged in any kind of sports activity served as controls. **Results:** Age: The mean age in swimmers was 22.56 + 3.34 years and in controls was 22.49 + 2.93 years. Height: 166.78 + 6.56 cm and in controls was 168.96 + 4.48 cm. Weight: 62.34 + 7.48 kg and in controls was 62.63 + 7.21 Kg. Body surface area: 1.78 + 0.13 and in controls was 1.74 + 0.12. Body mass index: 22.46 + 2.12 and in controls was 22.34 + 2.42. The mean vital capacity at rest in swimmers was 3.82 + 0.28 liters and in controls was 3.74 + 0.40 liters **Conclusion:** This study has demonstrated that exercise in the form of swimming produces a significant improvement in the pulmonary function. Swimming engages practically all muscle groups. The improvement in pulmonary function could be due to increased strength of respiratory muscles. Hence O2 utilization for the muscle is higher in swimmers.
**Keywords:** exercise swimming pulmonary function.

**Corresponding author:** Dr. Vivek Saboo, Assistant Professor, Department of Physical Medicine and Rehabilitation, National institute of Medical Science and Research, Jaipur, India

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## Introduction :

Swimming as a form of exercise is unique in many respects. It takes place in water that presents completely different gravitational and resistive forces compared to air. It is performed in a lying position, which alters gravitational effects on circulation. Breathing is restricted by stroke mechanics and the aquatic environment. Thermoregulatory demands do not compete with metabolic demands during heavy exercise in water at temperatures normally found during training and competition.[1]
Our human body is an unique machine, in which perfectly specific coordinated events will occur simultaneously. These events allow complex function such as hearing, seeing, breathing and information-processing to continue without one's conscious effort. If anyone performs any activity like swimming, he will be successfully shifting his body system from rest to active state. If he continues this activity several times, then his body gets adapted to that particular activity in a better way. Swimming is a difficult process that makes the muscle fit. If anyone wants to be swimmer, his or her physical activity level should be high when compared with the non-swimmers. Some physiological changes take place in the human body, when a person continuously swims. Swimming may be looked upon as self imposed changes in a self environment.[2]
The respiratory response to swimming may be expected to be different from the response to many other types of man's activities for the following reasons; 1. Swimming is performed in horizontal position. 2. Ventilation is restricted. 3. External pressure is increased. 4. Heat conductance of water is higher than that of air. The above mentioned factors in swimming can be anticipated to produce pulmonary function changes quite different than those observed in other sports activities.[3] Swimming engages practically all muscle groups. Hence O2 utilization for the muscle is higher in swimmers. The water pressure on the thorax makes the respiration difficult. Breathing is not as free during swimming, as in most other types of exercise. Respiration during competitive swimming is synchronized with swimming strokes.[4] Competitive swimmers require a high aerobic capacity to support the sustained performance of severe exercise, and the measurements of the maximal rate of oxygen uptake which a

swimmer can sustain during exercise provides a useful index of physical fitness. The maximum oxygen uptakes of swimmers have been determined under various conditions; running.[5,6] The breathing (respiratory) muscles which are composed of the diaphragm, external and internal intercostals, parasternal, sternomastoid, scalene, external and internal oblique and abdominal muscles are the vital organ in mammals by which oxygen is delivered to the red blood cells and concomitantly carbon dioxide is removed and expelled into the environment and play major role in during the excercise.[7]

Previous studies have shown that swimming produces maximum effect on the lungs compared to any other sport.[8] Regular swimming practice should produce a positive effect on the lungs by increasing pulmonary capacity and thereby improving the lung functioning.

The present study was therefore designed to study whether swimming training causes any effect on pulmonary function. This is a cross sectional study of competitive swimmers who were undergoing training for different periods of time.

**Materials and Method:**

This study was conducted in the department of Physical Medicine and Rehabilitation at NIMS, Jaipur, India In this present study included 50 male competitive swimmers, aged between 18-25 years. A similar number of age, height and weight matched medical students not directly engaged in any kind of sports activity served as controls. The informed consent was taken after the detailed procedure and purpose of the study was explained.

Those were excluded from the study with history of chronic respiratory disorders, cardiac disease, systemic disorders affecting respiratory system and smokers. A thorough history taking & clinical examination was carried out to rule out the exclusion criteria and the vital data was recorded. Standing Height was measured without foot wear with subjects back in contact with the wall and with both heels together and touching the base of the wall. Weight was recorded with light clothing using a digital weighing machine. Both the height and weight were measured to the nearest 0.1cm and 0.5 kg respectively.

Pulmonary Function Testing: On both control and swimmer groups with Medspiror a portable, computerized pneumotachometer was done by Spirometry. The recordings were carried out at room temperature. All the maneuvers were performed with the subjects in sitting position. Thorough instructions were given to each subject regarding the test and sufficient time was provided for them to practice the maneuvers. A soft nose clip was put over the nose to occlude the nostrils and disposable mouthpieces were used to minimize cross infection. Three readings were taken and maximum reading was recorded.

**Results:**

Table No. 1: Anthropometric data of swimmers and controls

| **Parameter** | **Swimmers Mean + SD** | **Controls Mean + SD** | **P value** |
|---|---|---|---|
| Age (years) | 22.56 + 3.34 | 22.49 + 2.93 | >0.05 |
| Height (cm) | 166.78 + 6.56 | 168.96 + 4.48 | >0.05 |
| Weight (kgs) | 62.34 + 7.48 | 62.63 + 7.21 | >0.05 |
| Body surface area (sqm) | 1.78 + 0.13 | 1.74 + 0.12 | >0.05 |
| Body mass index (wt./ $ht^2$) | 22.46 + 2.12 | 22.34 + 2.42 | >0.05 |

Age: The mean age in swimmers was 22.56 + 3.34 years and in controls was 22.49 + 2.93 years. There was no statistically significant difference between the two groups.

Height: The mean height in swimmers was 166.78 + 6.56 cm and in controls was 168.96 + 4.48 cm. There was no statistically significant difference between the two groups.

Weight: The mean weight in swimmers was 62.34 + 7.48 kg and in controls was 62.63 + 7.21 Kg. There was no statistically significant difference between the two groups.

Body surface area: The mean body surface area in sq.m in swimmers was 1.78 + 0.13 and in controls was 1.74 + 0.12. There was no statistically significant difference between the two groups.

Body mass index: The mean body mass index (kg/$mt^2$) in swimmers was 22.46 + 2.12 and in controls was 22.34 + 2.42. There was no statistically significant difference between the two groups.

Table No. 2: Vital data for swimmers and controls

| **Parameter** | **Swimmers Mean + SD** | **Controls Mean + SD** | **'p' value** |
|---|---|---|---|
| Pulse rate (beats/min) | 74.24 + 7.69 | 76.68 + 9.41 | >0.05 |
| Blood pressure systolic/ diastolic (mm Hg) | 115 ± 7.65<br>70.80 + 5.60 | 116.80 ± 7.90<br>73.40 + 5.87 | >0.05 |

Resting pulse rate: The mean pulse rate at rest in swimmers was 74.24 + 7.69 beats/min and in controls was 76.68 + 9.41 beats/min. There was no statistically significant difference between the two groups.

Blood pressure: The mean of blood pressure in mmHg at rest in swimmers was 115 ± 7.65systolic and 70.80 + 5.60 diastolic and in controls was 116.80 ± 7.90 systolic and 73.40 + 5.87 diastolic. There was no statistically significant difference between the two groups.

Table no. 3: Forced Vital capacity parameters for swimmers and controls

| **Parameter** | **Swimmers Mean + SD** | **Controls Mean + SD** | **'p' value** |
|---|---|---|---|
| Forced vital capacity (L) | 3.30 + 0.38 | 3.04 + 0.36 | <0.05 |
| FEV1(L) | 3.09 + 0.33 | 2.80 + 0.37 | <0.05 |
| Expiratory time (sec) | 1.44 + 0.56 | 1.64 + 0.79 | >0.05 |
| FEV1/VC | 0.81 + 0.05 | 0.81 + 0.07 | >0.05 |
| FEV1/ FVC | 0.96 + 0.05 | 0.96 + 0.05 | >0.05 |
| MMEF(L/sec) | 4.29 + 0.82 | 4.21 + 1.03 | >0.05 |

Forced vital capacity: The mean forced vital capacity at rest in swimmers 3.33+0.40 liters and in controls was 3.07+0.39 liters. There was statistically significant difference between the two groups.
Forced Expiratory Volume in one second: The mean FEV1 at rest in swimmers was 3.06+0.34 liters and in controls was 2.84+0.39 liters. There was statistically significant difference between the two groups.
Expiratory time: The mean expiratory time at rest in swimmers was 1.46+0.55 sec and in controls was 1.62+0.77 sec. There was no statistically significant difference between the two groups.
FEV1/VC: The mean FEV1/VC at rest in swimmers was 0.79+0.06 and in controls was 0.79+0.09. There was no statistically significant difference between the two groups.

Table No. 4: Slow vital capacity parameter for swimmers and controls

| **Parameter** | **Swimmers Mean + SD** | **Controls Mean + SD** | **'p' value** |
|---|---|---|---|
| Vital capacity (L) | 3.82 + 0.28 | 3.74 + 0.40 | <0.01 |
| Expiratory reserve volume (L) | 1.27 + 0.29 | 1.31 + 0.36 | >0.05 |
| Inspiratory reserve volume (L) | 1.72 + 0.30 | 1.83 + 0.35 | >0.05 |
| Inspiratory capacity(L) | 2.44 + 0.30 | 2.43 + 0.32 | >0.05 |
| Tidal volume (L) | 0.72 + 0.10 | 0.66 + 0.14 | >0.05 |

Table No. 5: Forced Vital capacity and maximal voluntary ventilation for swimmers and controls

| **Parameter** | **Swimmers Mean+SD** | **Controls Mean+SD** | **'p' value** |
|---|---|---|---|
| PEFR (L/Sec) | 6.86+1.45 | 7.30+1.60 | >0.05 |
| Mid expiratory flow rate75 (MEF75)(L/Sec) | 6.27+1.64 | 6.62+1.57 | >0.05 |
| MEF50 (L/Sec) | 4.81+0.96 | 4.86+1.16 | >0.05 |
| MEF25 (L/Sec) | 2.74+0.82 | 2.86+0.92 | >0.05 |
| MEF/FVC | 1.38+0.27 | 1.42+0.38 | >0.05 |
| MVV(L/min) | 126.56+12.64 | 120.49+14.82 | >0.05 |

**Discussion:**

A number of studies have been conducted to compare the lung functions of persons involved in different sports activities and normal people. There is a paucity of studies conducted on pulmonary functions in swimmers. The subjects for the study were taken from corporation swimming pool. In this present study included 50 male competitive swimmers, aged between 18-25 years. A similar number of age, height and weight matched medical students not directly engaged in any kind of sports activity served as controls.

There was no significant difference between the two study groups with respect to resting pulse rate and blood pressure. In this present study is in agreement with previous studies and clearly shows that among swimmers and sedentary controls, swimmers have statistically very highly significant values of forced vital capacity (FVC), Forced expiratory volume in first second (FEV1), Maximum Voluntary Ventilation (MVV) and Peak Expiratory Flow Rate (PEFR). FEV1/FVC was reduced just significantly in swimmers than control group.

The mean vital capacity at rest in swimmers was 3.82 + 0.28 liters and in controls was 3.74 + 0.40 liters. There was statistically highly significant difference between the two groups. Similar results were found in studies conducted by other workers like Clanton TL, Bjurstrom RL, Armour J and Lekhara SC.[8,9,10,11] these findings can be explained on the basis of better endurance of respiratory muscles. Another factor which may contribute to explain our result may be greater lung size in swimmers. Training of muscles of the shoulder girdle leads to an increase in the FVC by the increase strength of accessory muscles of expiration.[12]

FVC and FEV1 are significantly increased in swimmer group compared to controls. Similar results were found in studies conducted by other workers like Pherwani AV, Mehrotra PK, Lakhera SC.[8,13,14] Also, the mean values for VC and FEV1 were found higher in swimmers of both sexes by Newman et al.[15]

The ability of individual to inflate and deflate the lungs depends upon the strength of thoracic and abdominal muscles, posture of individual and elasticity of lungs. Swimming increases this ability by number of factors. It involves keeping the head extended which is constant exercise of erector spinae muscle which increases anteroposterior and vertical diameter of the lungs and the supraspinatus which increases the antero-posterior diameter of the lungs. The sternomastoid, trapezius and the diaphragm are also being constantly exercised.[16] Forced expiratory volume in first second (FEV1) was very significantly high in swimmers than controls this in contrast to study done by Armour J[11] and this in agreement with other earlier studies.[13,17,18] Reason for the difference between the two groups is an increased strength of the respiratory musculature, a factor that contributes to forced maneuvers, since there is evidence of a positive relationship between upper-body strength and swim performance.[13]

The value of MVV was higher in swimmers group compared to controls but the value was insignificant. MVV values depends on the patency of airways and tone of respiratory musculature.[8] probably this value of MVV also requires more number of years of swimming practice to become significant.[13] Observations in our study show that swimming as an exercise is a good stimulant for increasing lung volumes and capacities. In our study VC, FVC and FEV1 are significantly increased in swimmers compared to the control group. Thus observation of the present study are in accordance with many western and Indian studies in that the PFT values increase significantly in swimmers.

**Conclusion:**

This study has demonstrated that exercise in the form of swimming produces a significant improvement in the pulmonary function. Swimming engages practically all muscle groups. The improvement in pulmonary function could be due to increased strength of respiratory muscles. Hence O2 utilization for the muscle is higher in swimmers. Regular swimming produces a positive effect on the lung by increasing pulmonary capacity and thereby improving the lung functioning. So swimming can be recommended so as to improve the lung function of an individual and swimming in milder form might help in rehabilitation of patients with compromised pulmonary function.

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