DOI: 10.14260/jemds/2014/2192

ORIGINAL ARTICLE

A STUDY OF PULMONARY FUNCTIONS AMONG SWIMMERS – A DESCRIPTIVE STUDY

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HOW TO CITE THIS ARTICLE:
Basavaraj R, Satish M, Noor Jehan Begaum, Arun Kumar S, Ramesh K. "A Study on Pulmonary Functions among Swimmers – A Descriptive Study". Journal of Evolution of Medical and Dental Sciences 2014; Vol. 3, Issue 11, March 17; Page: 2678-2686, DOI: 10.14260/jemds/2014/2192

ABSTRACT: INTRODUCTION: Swimming is considered to be a very good exercise for maintaining proper health and also has a profound effect on the lung functions of an individual; the present study was carried out in 30 young male subjects to assess their Pulmonary Functions**. METHODOLOGY:** Thirty male swimmers who used to swim for more than one year regularly were the study subjects. This study was conducted in Department of Physiology, KIMS, Hubli. Lung volumes were recorded by Pulmonary Function test machine and analyzed statistically. **RESULTS & CONCLUSION:** It was found that Lung volumes were higher in swimmers. Swimming exercise affects lung volume measurements as respiratory muscles including the diaphragm of swimmers are required to develop greater pressure as a consequence of immersion in water during respiratory cycle. This may lead to functional improvement in these muscles and also alterations in elasticity of lung and chest wall or of ventilatory muscles, leading to an improvement in forced vital capacity and other lung functions of swimmers.

KEYWORDS: Swimmers, Spiro meter, Pulmonary function tests.

INTRODUCTION: Any sort of exercise done regularly, is beneficial to the body. Swimming is no exception. Swimming is considered to be a very good exercise for maintaining proper health and also has a profound effect on the lung function of an individual.[1]

Respiratory muscles including diaphragm of swimmers are required to develop greater pressures as a consequence of immersion during the respiratory cycle, this may lead to a functional improvement in these muscles. Also possibilities of alterations in elasticity of lung and chest wall or of ventilatory muscles cannot be ruled out leading to an improvement in lung functions of swimmers.[2]

The ability of the individual to inflate and deflate the lungs depends upon the strength of the thoracic and abdominal muscles, posture of the individual and the elasticity of lungs. Swimming increases the ability by a number of factors. It involves keeping the head extend which is a constant exercise of the Erector Spinae muscle which increases the vertical and the antero-posterior diameter of the lungs and the supraspinatus which increases the antero-posterior diameter of the lungs. The sternocleidomastoid, trapezius and the diaphragm are also being constantly exercised.[3] Formerly, it was widely known that the respiratory system does not limit the exercise performance in humans.[4] However, many researchers stated that the respiratory system can impact the strength and exercise performance in healthy humans and highly trained athletes[5], notably at high intensities.[4,6] Pulmonary functions are generally determined by respiratory muscle strength, compliance of the thoracic cavity, airway resistance and elastic recoil of the lungs.[7] It is well known that pulmonary functions may vary according to the physical characteristics including age, height, body weight,[8] and altitude (hypoxia or low ambient pressure).The purpose of choosing swimmers instead of any other sports person was that previous studies have shown that swimming produces maximum effect on the lungs compared to any other sport.[9] Regular swimming produces a positive effect on the lung by increasing pulmonary capacity and thereby improving the lung functioning.

OBJECTIVE: To study various spirometric measurements like static and dynamic lung volumes in the swimmers.

METHODOLOGY: The present study was conducted on 30 male swimmers aged 18-30 years who were swimming regularly for at least 3days in a week for a period of 1yr and above. The swimmers were selected from various swimming pools from Hubli city, Karnataka. All the subjects were clinically examined to rule out any respiratory disorder.

The study was approved by the ethical committee of the institution and a written informed consent was taken from all the individuals of study. The pulmonary function tests were recorded with the help of modern computerized pulmonary function test machine, Spirolyser-SPL-95:- is a portable spirolyser manufactured in France by French International Medical (FIM). This is a computerized instrument with RS-232 connectivity for PC. It has a built in thermal printer and also an option for external printing (through PC).

There are 3 types of tests that can be done with spirolyser.

1) Static lung volumes
2) Dynamic lung volumes & flow rates and flow volume loops.
3) MVV or ventilation over a period of 1 min.

Following measurements are obtained:

1) Static or slow VC (or VC on instrument)
   a) VC
   b) TV
   c) ERV
   d) IRV
   e) IC
2) Dynamic of forced VC (FVC button on instruments)

a) FVC	d) MMEF	g) MEF 50	j) FEV_1/VC
b) FEV_1	e) PEFR	h) MEF 25	k) MEF/VC
c) Ex.t	f) MEF	I) FEV_1/FVC	

3) Maximum Voluntary Ventilation: (MVV button on instrument).

An interview schedule was used for all subjects in the study to obtain information related to.
The following vital data was collected from both controls and subjects:

- Name, Age, Sex,
- Height-standing height was measured without footwear with the subject's body in contact with the wall.

- Weight-was recorded in shorts and Banians with a digital weighing machine. A thorough Clinical examination to rule out any cardio-respiratory illness was carried out and the vital data was recorded.
- Blood Pressure - right arm, sitting position, auscultatory method.
- Pulse rate - was measured for 1 min. during rest.

STATISTICAL ANALYSIS: Data was entered in Microsoft excel and analyzed using mean and standard deviation.

RESULTS:

Parameter	Swimmers Mean ± SD
Age (yrs.)	22.63 ± 3.38
Height (cms)	165.93 ± 6.64
Weight (kgs)	61.53 ± 7.51
Body surface area (sqm)	1.69 ± 0.12
Body mass index (wt / ht^2)	22.34 ± 2.05

Table 1: Anthropometric measurements

The mean age in swimmers was 22.63 ± 3.38 years
The mean height in swimmers was 165.93 ± 6.64 cm
The mean weight in swimmers was 61.53 ± 7.51 kg
The mean body surface area in sq.m in swimmers was 1.69 ± 0.12
The mean body mass index (kg/mt^2) in swimmers was 22.34 ± 2.05

Parameter	Swimmers Mean + SD
Pulse rate (beats/min)	74.16 + 7.66
Blood pressure systolic(mm Hg)	114 ± 7.50
Blood pressure diastolic (mm Hg)	69.86 + 5.63

Table 2: Vital Parameters

The mean pulse rate at rest in swimmers was 74.16 ± 7.66 beats/min.
The mean of blood pressure in mmHg at rest in swimmers was 114 ± 7.50 systolic and 69.86 ± 5.63 diastolic.

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Parameter	Swimmers Mean ± SD
Vital capacity (L)	3.97 ± 0.30
Expiratory reserve volume (L)	1.25 ± 0.30
Inspiratory reserve volume (L)	1.68 ± 0.32
Inspiratory capacity(L)	2.42 ± 0.30
Tidal volume (L)	0.69 ± 0.11

Table 3: Slow vital capacity parameter

The mean vital capacity at rest in swimmers was 3.97 ± 0.33 litres
The mean expiratory reserve volume at rest in swimmers was 1.25 ± 0.30 litres
The mean inspiratory reserve volume at rest in swimmers was 1.68 ± 0.32 litres
The mean inspiratory capacity at rest in swimmers was 2.42 ± 0.30 litres
The mean tidal volume at rest in swimmers was 0.69 ± 0.11 litres

Parameter	Swimmers Mean + SD
Forced vital capacity (L)	3.33 + 0.40
FEV1(L)	3.06 + 0.34
Expiratory time (sec)	1.46 + 0.55
FEV1/VC	0.79 + 0.06
FEV1 / FVC	0.95 + 0.05
MMEF(L/sec)	4.25 + 0.80

Table 4: Forced Vital Capacity parameters

The mean forced vital capacity at rest in swimmers 3.33 ± 0.40 litres
The mean FEV_1 at rest in swimmers was 3.06 ± 0.34 litres
The mean expiratory time at rest in swimmers was 1.46 ± 0.55 sec
The mean FEV_1/VC at rest in swimmers was 0.79 ± 0.06
The mean FEV_1/FVC at rest in swimmers was 0.95 ± 0.05
The mean MMEF at rest in swimmers was 4.25 ± 0.80 litres/sec

Parameter	Swimmers Mean + SD
PEFR (L/Sec)	6.74 + 1.43
Mid expiratory flow rate 75 (MEF75)(L/Sec)	5.97 + 1.57
MEF50 (L/Sec)	4.69 + 0.94
MEF25 (L/Sec)	2.75 + 0.83
MEF/FVC	1.34 + 0.29
MVV(L/min)	124.54 + 12.78

Table 5: Forced Vital capacity and Maximal Voluntary Ventilation

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The mean PEFR at rest in swimmers was 6.74 ± 1.43 litres/sec
The mean $MEFR_{75}$ at rest in swimmers was 5.97 ± 1.57 litres/sec
The mean $MEFR_{50}$ at rest in swimmers was 4.69 ± 0.94 litres/sec
The mean $MEFR_{25}$ at rest in swimmers was 2.75 ± 0.83 litres/sec
The mean MEF/FVC at rest in swimmers was 1.34 ± 0.29
Mean MVV at rest in swimmers was 124.54 ± 12.78 litres/min

DISCUSSION: The subjects for the study were taken from corporation swimming pool. The study group comprised of 30 swimmers in the age group of 18to 30 years who were involved in swimming for a period of more than 1 year. A lot of data has been published on the concept of pulmonary adaptation to different type of training activities.

The mean vital capacity at rest in swimmers was 3.97±0.33 litres and similar results were found in studies conducted by other workers like Clanton TL, Bjurstrom RL, Armour J and Lekhara SC. [10, 11, 12]

Like in most studies we observed an increase in value of vital capacity (VC) in swimmer group, which was highly significant. Increase in VC observed in swimmers may be the result of changes in the inspiratory muscles strength induced by swim training. Load comprised of the water pressure against the chest wall and elevated airway resistance due to submersion could comprise conditioning stimulus for increase in inspiratory muscle strength. [10]

In a study conducted by Bjurstrom RL and Shoene RB the increase in VC was explained by increased inspiratory muscle strength, since during immersion in water these swimmers experience negative pressure breathing.[11]

The results discussed above clearly indicate that swimmers had higher values of lung functions compared to the controls, thereby confirming that regular swimming has a facilitating effect on the lungs. Similar results have been obtained by other workers in this field.[13, 14]

The large metabolic demand of strenuous exercise requires an efficient oxygen transport system from the atmosphere to the active tissues. The results of the present study support the idea that physical training has a facilitative effect on ventilatory function and physically active persons have greater lung function values in comparison to sedentary persons.[15, 16, 17, 18]

The ventilation is restricted in every respiratory cycle for one moment or the other, producing a condition of intermittent hypoxia. This intermittent hypoxia sets up the anaerobic process during swimming. The lactic acid levels in the blood go on rising resulting in Lactic Oxygen deficit.[19]

This leads to the stimulation of the respiratory center in the medulla thereby increasing the respiration. Further, the restricted ventilation experienced during swimming leads the swimmer to face intermittent hypoxia and this may result in alveolar hyperplasia and thus increased VC and FVC.[20]

The ability of the individual to inflate and deflate his lungs depends upon the strength of the thoracic and abdominal muscles, posture of the individual and the elasticity of the lungs.[21]

Swimming increases this ability by a number of factors. It involves keeping the head extended which is a constant exercise of the Erector Spinae muscles and increases the vertical and antero-posterior diameter of the lungs as also supra spinatus which increases the antero –posterior diameter of the lungs. Besides the Sternocleidomastoid, Trapezius and the diaphragm are being constantly exercised.[3]

Armour J et al (1993) reported that swimmers had significantly increased total lung capacity, vital capacity, and inspiratory capacity than the elite long distance athletes and elite control subjects. They also found that FEV_1 was largest in swimmers. They suggest that the swimmers may have achieved greater lung volumes than either runner or control subjects not because of greater inspiratory muscle strength or differences in height, fat free mass, alveolar distensibility, age at commencement of training or sternal length or chest depth, but by developing physically wider chests containing an increased number of alveoli, rather than the alveoli of increased size.[12]

CONCLUSION: Thus it can be concluded that swimming is the best exercise for the respiratory system. Such helpful exercises in milder form might help for rehabilitation of patients with compromised lung functions.

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Date of Submission: 17/02/2014.
Date of Peer Review: 18/02/2014.
Date of Acceptance: 03/03/2014.
Date of Publishing: 11/03/2014.