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Physiology Section

The Diffusing Lung Capacity in Swimmers and Non-Swimmers: A Comparative Study

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ABSTRACT

Background: The main function of the lung is gas exchange, which can be assessed in several ways. A spirometer measures the flow and the volumes of the inspired and the expired air, but it does not provide information about the gas exchange. Taking an arterial blood gas sample is the most simple method which can be used to assess the pulmonary gas exchange.

Aims and objectives: To compare the diffusing lung capacity among swimmers and non-swimmers and to test the hypothesis that the ventilatory drive is modified by swimming.

Materials and methods: In this study, 20 subjects who were aged between 19-35 years, with 2-5 years of swimming experience were selected and 20 controls who were in the same age group, at the SRM Medical College were included after obtaining the institutional ethical clearance and their consent. An 'Easy one pro Spiro meter' was used to find out their diffusing lung capacities.

Results: The parameters were analyzed statistically by using the Students 't'-test. There was no significant difference in the age, weight, height and the BMI between the swimmers and the non-swimmers. But there was a significant difference in the mean and the standard deviation of the diffusing lung capacity parameter. The mean and the standard deviation of the swimmers and the non-swimmers were (23.17±6.575) and (14.72±2.912), with a p-value of <0.000, which was more significant.

Conclusion: The results showed a significant difference in the diffusing lung capacity in the swimmers as compared to the non-swimmers, since the O_2 utilization for the muscle was higher in the swimmers. The swimmers had a greater diffusing lung capacity than the non-swimmers, probably due to an increase in the number of alveoli, which acted as a predictor of their performance.

Key Words: Swimmers, Spiro meter, DLCO

INTRODUCTION

Our human body is an amazing machine in which perfectly coordinated events occur simultaneously. These events allow complex functions 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 an 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 which makes the muscle fit. If anyone wants to be a swimmer, his or her physical activity level should be high as compared to that of the non-swimmers. Some physiological changes take place in the human body when a person continuously swims. Swimming may be looked upon as a self imposed change in a self environment [1].

Swimming practically engages all the muscle groups. Hence, the O_2 utilization for the muscle is higher in swimmers. The water pressure on the thorax makes respiration difficult. Breathing is not as free during swimming, as in most other types of exercise, because the respiration during competitive swimming is synchronized with the swimming strokes [2].

Competitive swimmers require a high aerobic capacity to support the sustained performance of severe exercise, and the measurements of the maximal rate of the oxygen uptake which a swimmer can sustain during exercise provides a useful index of physical fitness. The maximum oxygen uptake of swimmers has been determined under various conditions [3,4].

The breathing (respiratory) muscles which are composed of the diaphragm, the external and the internal intercostals, the parasternal, sternomastoid and the scalene, the external and the internal oblique and the abdominal muscles are the vital organs in mammals by which oxygen is delivered to the red blood cells and concomitantly, carbon dioxide is removed and expelled into the environment. These play a crucial role during exercise [5,6]. Since athletes take thousands of breaths during the competition, like all other skeletal muscles, the respiratory muscles also need a required amount of oxygen for them to work properly [6].

Formerly, it was widely known that the respiratory system did not limit the exercise performance in humans (Dempsey, 1986; Leith and Bradley 1976). However, many researchers stated that the respiratory system could impact the strength and the exercise performance in healthy humans and highly trained athletes [7-13], notably at high intensities [14,15].

The general aspect of the gas exchange

A main function of the lung is to establish gas exchange between the body tissues and the surrounding air. O_2 is taken up and CO_2 is eliminated. This process of gas exchange can be subdivided into three stages.

1. Ventilation, which is the mechanism by which the alveolar gas is intermittently refreshed with ambient air. As a result, the O_2 concentration in the alveolar gas is kept high and the CO2 concentration is kept low.

2. Alveolar-capillary diffusion, which is the passage of gases across the blood-gas barrier by passive diffusion.

3. Perfusion, which involves the distribution of blood in the lungs and its removal from the lungs by the blood circulation process [16].

Fick's law: A diffusion process in one medium by which molecules are transferred from a place with a high concentration to a place with a low concentration.

Henry's law: In the lungs, diffusion occurs between a gas and a liquid phase. The concentration in a liquid is a function of the solubility of the gas exchange in the liquid and the pressure of the gas, since the quantity of the dissolved gas is proportional to the pressure.

The diffusion capacity of the lung for carbon monoxide (DLCO) is a standard test in the pulmonary function laboratory. The DLCO is used in the assessment of restrictive as well as obstructive pulmonary diseases, and it is an indicator of the disease severity. In chronic obstructive pulmonary disease (COPD) and in diffuse parenchymal lung diseases (DPLD), the DLCO is a strong predictor for de-saturation during exercise [17,18].

The carbon monoxide (CO) diffusing capacity (DLCO) provides an objective measurement of the lung function. It is defined as the lung's ability to take up an inhaled non reactive test gas such as carbon monoxide (CO), which binds to haemoglobin. CO will bind to haemoglobin with such a high affinity; that virtually all of the CO will reach the alveolar space. This will cause the carbon monoxide to cross the alveolar air-blood barrier, to reach a red cell that will bind to haemoglobin and be removed with the exhaled gas.

The carbon monoxide diffusing capacity (DLCO) is the rate of the uptake of carbon monoxide (CO) per driving pressure of the alveolar CO. The simplified equation is:

DLCO = VCO/PACO

VCO = the uptake of CO (milliliters per minute)

PACO = the mean alveolar pressure of CO (milliliters of mercury)

This test can be used for a wide variety of diseases, because it is relatively easy to measure or estimate the two determinants. The component resistances to DLCO include:

a. The pulmonary membrane (the pulmonary tissue and the plasma layer).

b. The red blood cell resistance, which is a function of the rate of CO uptake by haemoglobin and the pulmonary capillary blood volume (Bone RC et al., [19] ; Goldman L et al., [20]).

MATERIALS AND METHODS

This comparative study on the diffusing lung capacity between swimmers and non swimmers observed subjects who were aged between 19-35 years. This present study was conducted in the Department of Physiology, SRM Medical College and Research Centre, Kattankulathur, after ethical clearance was obtained from the ethics committee and informed consent was obtained from the subjects.

The total sample size was 40, of which 20 subjects were swimmers with 2-5 years of experience and 20 subjects were non-swimmers without any swimming experience, who were equally divided into two group A (swimmers) and group B (non-swimmers). An Easy one pro Computerized Spiro meter which was attached to a carbon monoxide cylinder was used to find the diffusing lung capacity of the subjects. A written consent was taken from the subjects and they were asked to breathe as per the instructions, to record the parameters. Smokers and those with a history of abdominal or thoracic surgery, pulmonary, cardiac disorders, and neuromuscular disorders were excluded from the study. The procedure which was used for obtaining the diffusing lung capacity parameter was; the subject's nostrils were closed by using a nose clip and he/she was asked to hold the sensor straight in front of his or her mouth without taking the mouth piece into the mouth as yet. Then, the subjects were asked to do tidal breathing and after 3 or 4 breaths, they were instructed to fully exhale, during which the Activate button (the valve automatically closes at the end of the exhalation) was pressed. Then, the subjects were asked to fully inhale the gas and to hold their breath for 10 seconds. After 10 seconds, the valve opened and the subjects were asked to exhale quickly and to continue with tidal breathing till the end of the test.

The parameters were statistically analyzed by using the paired 't'-test.

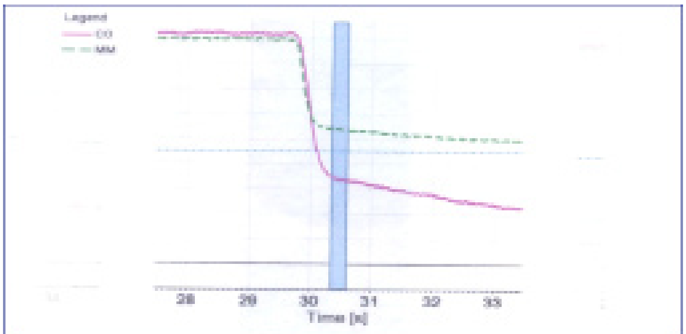
RESULTS

The anthropometric data for DLCO

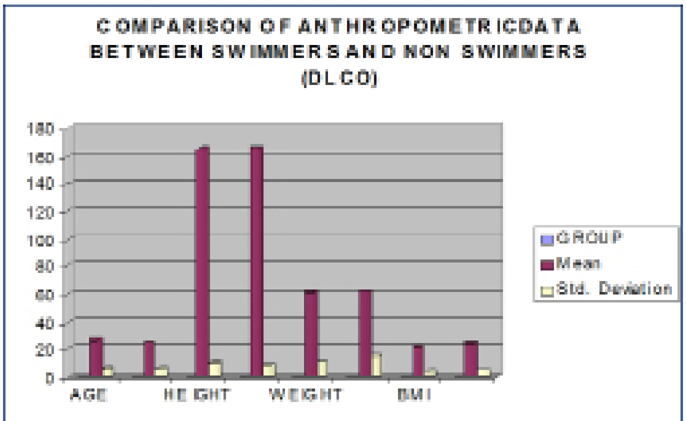
There was no significant difference in the age, sex, height, weight and the BMI between the swimmers and the non-swimmers.

The diffusing lung capacity data

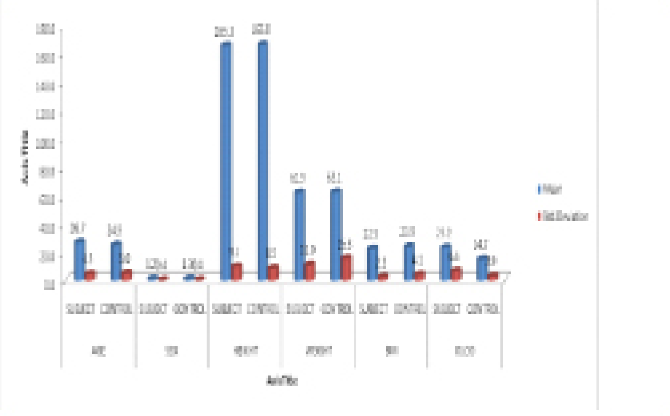
The mean and the standard deviation of DLCO in the swimmers were 23.17±6.575, whereas in the non-swimmers, they were



[Table/Fig-1]: The diffusing lung capacity cure:



[Table/Fig-2]: Comparison of Anthropometric data between swimmers and non-swimmers (DLCO)



[Table/Fig-3]: Comparison of DLCO in swimmers and non-swimmers

	Group	N	Mean	Std. Deviation	T value	P value
Age	Subject	20	26.65	4.522	1.196	0.239
	Control	20	24.85	4.987		
Sex	Subject	20	1.15	0.366	-.777	0.442
	Control	20	1.25	0.444		
Height	Subject	20	165.25	9.727	-.260	0.797
	Control	20	166.00	8.510		
Weight	Subject	20	61.85	11.028	-.059	0.953
	Control	20	62.10	15.345		
Bmi	Subject	20	22.48	2.246	-1.331	0.191
	Control	20	23.87	4.074		

[Table/Fig-4]: Comparison of Anthropometric data between swimmers and non-swimmers (DLCO)

	Group	N	Mean	Std. Deviation	T value	P value
Dlco	Subject	20	23.17	6.575	5.255	0.000
	Control	20	14.72	2.912		

[Table/Fig-5]: Comparison of DLCO in swimmers and non-swimmers

14.72±2.912. There was a significant increase in these values in the swimmers as compared to the non-swimmers, with a p-value of 0.000.

DISCUSSION

In our study, we also found that the DLCO was significantly higher in the swimmers as compared to that in the non-swimmers. Our results were similar to the results of few other studies, though only very few studies had assessed the DLCO in swimmers.

In a study which was conducted by Paul Vaccaro et al., [21] on the physiological characteristic of young well-trained swimmers, the DLCO was found to be significantly higher as compared to that in non swimmers.

J Armour et al., [22] found that the pulmonary diffusing capacity (DLCO) was highest in swimmers, while all the other indices of the lung function, which included pulmonary distensibility, elastic recoil and diffusion co-efficient were similar between the swimmers and the non-swimmers. These findings suggested that the swimmers may have achieved greater lung volumes than the non-swimmers, not because of the greater inspiratory muscle strength, or the differences in the height, fat free mass or the alveolar distensibility, but by developing physically wider chests which contained an increased number of alveoli, rather than alveoli of increased sizes.

In a study which was conducted by Magel John K et al.,[23] on young trained Norwegian swimmers, the DLCO at rest in the trained swimmers was significantly higher as compared to that in the non-swimmers. The maximal values for the DLCO in the trained swimmers averaged approximately 51% above the resting level, while the increase was significantly less (35%) for the untrained subjects.

CONCLUSION

Globally, very few studies were conducted and documented between the swimmers and the non swimmers by using different methods and standardized criteria. In this study, especially students were selected for both the groups and a spiro meter was used to determine the diffusing lung capacities.

Statistically, the parameter (DLCO) was analyzed and compared by using the ‘paired t’-test. The results which were obtained from this study showed a significant difference in the mean and standard deviation. The means of all the parameters were significantly higher in the swimmers; so we conclude that the swimmers had greater diffusing lung capacities as compared to the non swimmers due to the increased inspiratory muscle strength and the increase in the number of alveoli. More information can be obtained if this study is continued for a longer duration.

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