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A Comparative Study Of Cardiopulmonary Efficiency Between Male Swimmers And Sedentary Subjects- A Cross-Sectional Study

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Abstract:
Background: *Swimming is an aerobic exercise which helps, to train the subjects in control breathing. Strength and endurance training is common practice in swimmers, which also increase the strength of Respiratory muscle as well as elastic recoil of lungs as immersion in water increased pressure over lung & heart.*
Objective*: Our main aim is to know whether the short duration of swimming (six months to one year) can significantly change the cardiopulmonary efficiency in swimmers compared to sedentary subjects.*
Methods: *This present study was designed as a cross-sectional study and was proposed to study various cardiopulmonary efficiency tests including Breath holding time, 40 mm endurance test and Harvard step test in male swimmers and sedentary controls. For this purpose, we randomly selected 90 cases (swimmers) and 90 healthy sedentary controls and age between 18 – 25 years with matched anthropometric parameters. Approval of the Institutional Ethics Committee was taken prior to the study.*
Results: *The mean values of age, height, weight, BMI, BSA systolic and diastolic BP was measured and compared to between swimmers and sedentary control and the difference was statistically non-significant. The mean values of pulse and respiration rate were decreased statistically in swimmers as compared to sedentary control. The mean value of PFI, 40 mm endurance test, BHT was significantly increased in swimmers as compared to sedentary control.*
Conclusion: *Various cardiorespiratory fitness parameters were markedly increased in the youths who undertake a couple of hours of swimming.*
Key Wards: *cardiopulmonary efficiency, comparison, male, sedentary, swimming*

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I. Introduction

During exercise inadequate supply of O_2 results in an imbalance between anaerobic and aerobic metabolism. As a result, formation and accumulation of lactic acid occur which in turn causes fatigue of the muscle. This phenomenon can be prolonged by a continuous supply of O_2 [1]. Physical training in athletes may also help in developing greater endurance in respiratory muscles.

Interestingly, enhanced pulmonary diffusion capacities have been demonstrated in swimmers at rest as well as during exercise. The observation of greater diffusion capacity in swimmers has been suggested that there might be alveolar hypertrophy or hyperplasia of alveoli [2].

The aquatic environment may increase the hemodynamic burden on the individual, which increase venous return, Therefore increase in stroke volume and cardiac output.

Generally, an increase in stroke volume can be attributed to not only preload but also afterload and contractility. For patients with chronic heart failure, for example, these changes may place undue stress on an already burdened heart [3]. One of the effects of immersion in water may increase pressure on the thoracic cavity. In swimmers, this increased pressure might produce improvement in cardiopulmonary efficiency. In regular swimmers, cardiopulmonary efficiency may increase in a stepwise manner.

By doing cardiopulmonary efficiency test, we can determine the cardiorespiratory fitness of swimmers and sedentary subjects. We are selecting swimmers because swimming can produce maximum effects on the lungs by increasing pulmonary capacity which may help improving lung functions [4].

Aim And Objectives

Aim: To know whether cardiopulmonary efficiency is different in swimmers as compared to sedentary subjects.

Objectives:
1) To study the cardiopulmonary efficiency in swimmers.
2) To study the cardiopulmonary efficiency in sedentary subjects.
3) To compare cardiopulmonary efficiency between swimmers and sedentary subjects.

II. Materials And Method

Study design: The study was planned as a cross-sectional study**.**

Study place:
1) Tertiary health care center in central India.
2) Municipal swimming pool.

Study period: Present study was conducted over a period of 18 months from
1st January 2016 to 30th June 2017.

Study population
Cases: Swimmers (male) aged between 18-25 years were considered a case.

Inclusion criteria:
Swimmers (male) aged between 18-25 years old, practicing swimming 2-3 hours per day at least 5 days in a week regularly for six months to one year.

Exclusion criteria:
1) Smoker.
2) Chronic respiratory disease.
3) Cardiac disease.
4) A systemic disorder affecting the respiratory system.

Control: Non-swimmer healthy male person aged between 18 – 25 years and not engaged in any kind of sports or yoga considered as sedentary and was selected as control.

Inclusion criteria:
Healthy male person age between 18 – 25 years (patient’s relative, friends of swimmers etc.)

Exclusion criteria:
1) Smoker.
2) Chronic respiratory disease.
3) Cardiac disease.
4) A systemic disorder affecting the respiratory system
5) Persons regularly engaged in any kind of sports or yoga.

Sample size: Sample size was estimated, using Open Epi software with following assumptions with previous study knowledge [5] We recruited 90 cases and 90 controls to have adequate power for the study.

Data collection: Approval of the Institutional Ethics Committee (IEC) was taken prior to the study. Prior written informed consent was taken from every participant which was voluntary in nature. Individuals’ identity was kept confidential.

Data analysis: We analyzed the results by using Student’s unpaired t-tests and by using Microsoft Excel 2013. **“P”** value <0.05 was considered as significant.

Study tools:
General examination:
1) Pulse rate: Pulse rate (Radial pulse) was counted for one minute after 5 minutes rest in sitting position [7].
2) Respiratory rate: Respiration rate was counted for one minute when the subject's attention deviated. Normal range in adults varies from 14-18 respiration/minutes [8].
3) Blood pressure: It was measured by a mercury Sphygmomanometer. Blood pressure (systolic and diastolic) was measured after 5 minutes rest in a sitting position by auscultatory method [9].

Anthropometric data: In each swimmer and controls following anthropometric data were recorded under the following parameters.
1) **Age:** in years.
2) **Height:** standing height was measured without footwear by using Stadiometer.
3) **Weight:** Weight was recorded by using the weighing machine.
4) **Body mass index (BMI):** It is the statistical measure which was calculated by using the patient's height & weight. BMI was calculated according to the following formula [9]

BMI= weight in kilogram / height in meter^2

5) **Body surface area (BSA):** Body surface area (BSA) represents the calculated surface area of the human body was calculated using Dubois and Dubois's formula [10]

BSA (m^2) = 0.007184 × weight (kg) $^{0.425}$ × height (cm) $^{0.725}$

Cardiopulmonary efficiency test: By doing cardiopulmonary efficiency test we can easily measure the cardiorespiratory fitness of the subject.

Parameters were measured:
1) Breath holding time: The subject was asked to inhale maximally then hold his breath till breaking point was reached. The time was noted in seconds by using a stopwatch and the value was rounded off to integers. A minimum of three trials was given with a rest period of three minutes between the trials and the highest of three similar best performances was taken for statistical analysis [11
2) 40 mm endurance test (Flack's Airforce manometer test): The subject was asked to take a full breath then close the nostril and blow in the tube of the sphygmomanometer so that the mercury level rises to 40 mm. The subject was instructed to maintain the level as long as he could. A minimum of three trials was given with a rest period of three minutes between the trials and the highest of three similar best performances was taken for statistical analysis [11,12].
3) Harvard step test: In this test, male subjects were asked to step up & step down in a 20 inches high bench 30 times per minute for 5 minutes. At the end of the test ask the subject to sit immediately. Count pulse rate in between 1-1$_{1/2}$ minutes, 2-2$_{1/2}$ minutes, 3-3$_{1/2}$ minute's interval and calculate the Fatigue index or physical fitness index [13] by using this formula.

$$\text{Fatigue Index} = \frac{\text{Duration of exercise in sec x 100}}{\text{2 x (sum of pulse counts during recovery)}}$$

III. Results

Anthropometric profile of swimmers and non-swimmers:

Table (i) Anthropometric profile of swimmers and non-swimmers

Parameters	Swimmers (Mean ± SD)	Non- swimmers (Mean ± SD)	p-value
Age(years)	**20.46 ± 2.36**	**20.48 ± 2.70**	**0.9535 (NS)**
Height(meter)	**1.69 ± 0.06**	**1.68 ± 0.05**	**0.9496 (NS)**
Weight (Kg)	**64.39 ± 6.89**	**65.84 ± 7.56**	**0.1811 (NS)**
Student's unpaired t-test was used for analysis. P value < 0.05 considered significant. NS – non-significant			

Table (ii). Anthropometric profile of swimmers and non-swimmers

Parameters	Swimmers (Mean ± SD)	Non-swimmers (Mean ± SD)	p-value
BMI (Kg/m^2)	22.67 ± 2.13	23.18 ± 2.34	0.1302 (NS)
BSA(m^2)	2.00 ± 0.15	2.02 ± 0.14	0.4115 (NS)
Student's unpaired t-test was used for analysis. p-value < 0.05 considered significant. NS – Non-significant BMI – Body Mass Index, BSA – Body Surface Area			

Vital parameters of swimmers and non-swimmers:

Table (iii) Vital parameters of swimmers and non-swimmers

Parameters	Swimmers (Mean ± SD)	Non-swimmers (Mean ± SD)	p-value
Pulse rate (Per minute)	**74.67 ± 3.61**	**81.6 ± 5.92**	**0.0001****
Respiration rate (Per minute)	**14.76 ± 1.55**	**16.18 ± 1.10**	**0.0001****
Systolic BP (mmHg)	**116.16 ± 3.74**	**117.13 ± 4.13**	**0.0996 (NS)**
Diastolic BP (mmHg)	**75.69 ± 4.46**	**76.04 ± 4.71**	**0.6059 (NS)**
Student's unpaired t-test was used for analysis. p-value < 0.05 considered significant. NS – non-significant. ** - Highly significant. BP – Blood Pressure			

Cardiopulmonary efficiency test of swimmers and non- swimmers

Table (iv). Cardiopulmonary efficiency test of swimmers and non-swimmers

Parameters	Swimmers (Mean ± SD)	Non-swimmers (Mean ± SD)	p-value
PFI (%)	**93.87 ± 2.06**	**78.69 ± 4.62**	**0.0001****
40 mm Endurance test (seconds)	**48.1 ± 3.15**	**39.07 ± 5.76**	**0.0001****
BHT (seconds)	**57.08 ± 3.37**	**46.21 ± 6.09**	**0.0001****
Student's unpaired t-test used for analysis.p-value < 0.05 considered significant. ** - Highly significant * - significant,PFI - physical fitness index, BHT - Breath holding time.			

IV. Discussion

Anthropometric profile (age, height, weight) was matched and found a nonsignificant difference between swimmers & non-swimmers in the present study. Thus, anthropometric profile (BMI, BSA) was matched and the nonsignificant difference was found in between swimmers & non-swimmers in our study.

Probable reason behind the decrease in pulse rate in swimmers may be, regular swimming increases vagal tone and decreases sympathetic activity. As a result, reduction in catecholamine secretion occurs which leads to vasodilation. Hence leading to improvement in peripheral circulation. [14] All these may be the reason for the reduction in resting pulse rate in swimmers.

By practicing swimming for a few weeks, the bulbopontine complex is adjusted to a new pattern of breathing which is slower than its basal rhythm leading to a decrease in respiration rate [15].

PFI (Physical fitness index): In the year 2012 **Patil et al** [16] published a study where they reported the physical fitness index in between swimmers and non-swimmers as a component of cardiovascular endurance. In results, physical fitness index was higher in the case of swimmers compared to control group. This result is agreed with our study.

Swimming is better because of buoyancy, water temperature, water resistance, cardiovascular endurance, muscular strength and Weight Management [17].

40 mm endurance test: As shown in the table (iv) the mean value of 40 mm endurance test was increased in swimmers as compared to non-swimmers and the difference was statistically highly significant.

Regular breath controlling exercise (swimming) may produce a hypometabolic state in our body which helps to decrease O_2 use as well as decrease CO_2 production.

In regular breath controlling exercise develops some breath control over respiration. These are the probable causes which may help to increase the mean value of 40 mm endurance test in swimmers as compared in non-swimmers in the present study [18].

BHT (Breath holding time): As shown in the table (iv) the mean value of BHT was an increase in swimmers as compared to non-swimmers and the difference was statistically highly significant. Breath holding time is the time taken by the subject to hold his breath as long as he can. The point at which the breathing can no longer be voluntarily inhibited is called the breaking point [19].

Swimming enhances respiratory efficiency by increasing the strength of Diaphragm and intercostal muscles [20], and by increasing the number of alveoli. This possibly improves the vital capacity and prolongs the breath holding time. BHT of less than 20 seconds indicates diminished cardiac or pulmonary reserve. Measures should be taken to increase physical activity among non-athletes to improve the ventilatory function and vital functions of the body to lead a superior quality of life [19].

Limitations of the study

This cross-sectional study was done for a period of 1½ years. These study findings cannot be generalized to the community because of the following facts –

- Only the male population was taken.

- The study was done among members of one swimming pool only.

The study did not have any sponsor or funding.
There was no conflict of interest in this study

V. Conclusion

This study has demonstrated that exercise in the form of swimming for a short duration (6 months -1 year) produces a significant improvement in Cardio-pulmonary endurance. This better cardio-respiratory fitness is known to translate into a lower cardiac disease risk in the future. Simple changes in lifestyle by enhancing physical activity would go a long way.

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