RESEARCH ARTICLE

COMPARATIVE STUDY OF PULMONARY FUNCTIONS IN SWIMMERS AND SEDENTARY CONTROLS

Background: Swimming has many benefits on the body. Swimming engages practically all muscle groups; hence O_2 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 compared to most other types of exercises. Respiratory responses to swimming may be expected to be different from the response to many other types of exercises.
Aims & Objective: To study the pulmonary functions in competitive swimmers and to compare the same with matched sedentary control group.
Materials and Methods: In this study pulmonary functions such as FVC, FEV_1, FEV_1/FVC, MVV, PEFR parameters were studied in 45 Swimmers in the age group of 18- 25 years. These parameters were compared with those recorded in equal number of matched apparently normal healthy sedentary medical students using unpaired t test.
Results: In our study a very highly significant increase ($P<0.0001$) was observed in pulmonary function parameters of swimmers than controls. Swimmer group were having higher mean of percentage value of Forced Vital Capacity (FVC) 2.83 ± 0.64, Forced expiratory volume in first second (FEV_1) 2.61 ± 0.56, Maximum Voluntary Ventilation (MVV) 152.64 ± 17.49 , and Peak Expiratory Flow Rate (PEFR) 8.59 ± 0.84 than controls. However the ratio between FEV_1 and FVC (99.69 ± 1.01) was just significantly more ($P=0.0330$) in controls than swimmers.
Conclusion: This study has demonstrated that exercise in the form of swimming produces a significant improvement in the pulmonary function. The improvement in pulmonary function could be due to increased strength of respiratory muscles. 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 impaired pulmonary function.
Key Words: Swimmers; Forced Vital Capacity; PEFR; Pulmonary Function

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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]

Beneficial effect is seen on various systems of the body due to any type of exercise if performed regularly. These systems are benefited by such exercises by way of improving their functions. Swimming is considered to be the best exercise for maintaining physical fitness and proper health and has a profound effect on the lung function of an individual. Good swimmers tend to be above average for lung capacity. Training during adolescence increases vital capacity and total lung capacity due to the development of a broad chest and long trunk and this increased vital capacity helps swimmers maintain their buoyancy.[2]

Previous studies have shown that swimming produces maximum effect on the lungs compared to any other sport.[3] 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 METHODS

This study was conducted in the department of physiology, Dr. VM Medical College, Solapur, after obtaining the institutional ethical clearance. The present study included 45 male competitive swimmers, aged between 18-25 years, who were residents of Solapur district and were practicing swimming at Park Stadium swimming pool Solapur, for about 2-3 hours per day for at least 5 days in a week regularly since 2-6 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 with history of chronic respiratory disorders, cardiac disease, systemic disorders affecting respiratory system and smokers were excluded from the study. 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: Spirometry was done on both control and swimmer groups with Medspiror a portable, computerized pneumotachometer (Manufactured by Medsystems Pvt. Ltd. Chandigarh). The recordings were carried out at an average temperature of 28 degree C between 9 am-11 am. 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.

Statistical Analysis: The statistical analysis was carried out with SPSS 13. The data obtained were expressed as mean and standard deviation and student unpaired t-test was applied for comparison between two groups. A p value less than 0.05 was considered to be statistically significant.

RESULTS

The recorded anthropometric data in swimmers and control groups did not show any statistical significance as shown in Table 1. The present study shows that among swimmers and sedentary controls, swimmers have significantly higher values (P<0.0001) of forced vital capacity (FVC), Forced expiratory volume in first second (FEV_1), and Maximum Voluntary Ventilation (MVV) and Peak Expiratory Flow Rate (PEFR). FEV_1/FVC was just significantly reduced (P=0.0330) in swimmers than controls as shown in Table 2.

Table-1: Anthropometric Data in swimmers and controls

Parameters	Swimmers (Mean ± SD)	Controls (Mean ± SD)	P value
Age (year)	22.31 ± 2.89	22.62 ± 3.28	0.6355
Height (cm)	164.44 ± 6.39	166.09 ± 5.93	0.2075
Weight (kg)	58.35 ± 9.48	61.66 ± 12.54	0.1613

Table-2: Pulmonary Function Test Parameters in swimmers and controls

Parameters	Swimmers (Mean ± SD)	Controls (Mean ± SD)	P value
FVC (L)	2.83 ± 0.64	1.87 ± 0.54	0.0001
FEV_1 (L)	2.61±0.56	1.59±0.52	0.0001
FEV_1/FVC	98.33 ± 4.089	99.69 ± 1.01	0.0330
PEFR (L)	8.59 ± 0.84	7.33 ± 1.37	0.0001
MVV (L)	152.64±17.49	137 ±15.47	0.0001

DISCUSSION

Our study is in agreement with previous studies and clearly shows that among swimmers and sedentary controls, swimmers have statistically very highly significant values (P<0.0001) of forced vital capacity (FVC), Forced expiratory volume in first second (FEV_1), Maximum Voluntary Ventilation (MVV) and Peak Expiratory Flow Rate (PEFR). FEV1/FVC was reduced just significantly (P=0.0330) in swimmers than control group.

Lung volume is fairly well predicted on the basis of age, height and weight, but lung volumes which are greater than predicted have been repeatedly observed in swimmers.[4] This characteristic of swimmers has largely, been attributed to genetic endowment.[5] Regular swimming practice may tend to alter the elasticity of the lungs and chest wall which leads to improvement in the lung function of swimmers.[6]

Act of swimming differs from other exercises in the following aspects: (1) Horizontal Body Position: As swimmers lie horizontally in the water, whether on land or in the water, the partial pressures in the lungs differ with body position PV=PV (P-pressure, V-volume). This demonstrates pressure and volume are indirectly correlated, one increases and the other decreases, the seesaw effect. This difference leads to increased volumes in different lobes of the lungs, potentially leading to an increase in lung functions. (2) Ventilation is restricted in water and external pressure is increased. (3) Heat conductance of water is higher than that of air. (4) Diaphragm is exposed to greater pressure during swimming. (5) Minimal Resistance: Swimmers are in a medium, water, which has an increased density compared to air. This increase in density causes a swimmer's chest to perform millions of breaths against a small resistance throughout a swimming career. This minimal chest workout could develop the lung and inspiratory muscles, causing an increase in pulmonary functions. (6) Forced Breathing: Not only is swimming an acute hypoxic activity, but it requires forceful exhalation causing a reverse vacuum of pressures. Once again, as pressure changes so does the volume. This alteration could cause extra stress to the lungs and inspiratory muscles enhancing their performance.[7,8]

In the present study, it is observed that there is very highly significant increase in Forced vital capacity in swimmers than controls; 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.[9] The initial part of an expiratory forced vital capacity (FVC) curve depends on non-bronchopulmonary factors like neuromuscular factors and mechanical equipment factors e.g. inertial distortion. The terminal portion of the curve is relatively variable due to factors like maintenance and co-ordination of efforts, which are exercise dependent to some extent. The middle portion is relatively free. The first 20 % of the FVC is affected by non-bronchopulmonary factors.[10] Further, the restricted ventilation experienced during swimming leads the swimmer to face intermittent hypoxia and this may result in alveolar hyperplasia and thus increased FVC.[11]

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 antero-posterior 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.[12]

Forced expiratory volume in first second (FEV_1) was very significantly high in swimmers than controls this in contrast to study done by Armour J[7] and this in agreement with other earlier studies.[13-15] 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]

Maximum voluntary ventilation (MVV) which depend both on the patency of airways and strength of respiratory musculature was very significantly high in swimmers. MVV improvement might be due to improvement in respiratory mechanism and strengthening of respiratory muscles. So the respiratory muscles and diaphragm of swimmers are required to develop greater pressure as a consequence of immersion in water during the respiratory cycle, thus leading to functionally better lung functions in swimmers.[3]

Our study also shows FEV_1/FVC ratio is just significantly high in controls than swimmers. The mean expiratory flow rate (PEFR) of swimmers was very significantly higher than matched control group. Such higher value might be due to the beneficial effect of swimming training on pulmonary efficiency. PEFR can be therefore, be an easy test for quick assessment of improvement of an overall pulmonary function of the sportsmen.[13]

CONCLUSION

This study has demonstrated that exercise in the form of swimming produces a significant improvement in the pulmonary function. The improvement in pulmonary function could be due to increased strength of respiratory muscles. 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.

REFERENCES

1. Ingvar, H. Swimming physiology. Ann Anthrop. 1992;11(3):269-276.
2. Shephard RJ. Human Physiological Work Capacity. Cambridge, UK: Cambridge University Press. 1978.
3. Lakhera SC, Mathew L, Rastogi SK, Sen Gupta J. Pulmonary function of Indian athletes and sportsmen: comparison with American athletes. Indian J Physiol Pharmacol. 1984; 28(3): 187-194.
4. Cordain L, Stager J. Pulmonary structures and function in swimmers. Sports Med. 1988; 6: 271-278.
5. Klissouras V. Genetic limit of functional adaptability. Intern J Agnew Physiol. 1972; 30: 85-94.
6. Newman F, Smalley BF, Thomson ML. A comparison between body size and lung function of swimmers and normal school children. J Applied Physiol. 1961; 156: 9–10.
7. Armour J, Donnelly PM, Bye PT. The large lungs of elite swimmers: an increased alveolar number? Eur Respir J. 1993; 6 (2): 237-47.
8. Courteix D, Obert P, Lecoq AM. Guenon P, Koch G. Effect of intensive swimming training on lung volumes, airway resistance and on the maximal expiratory flow-volume relationship in prepubertal girls. Eur J Appl Physiol Occup Physiol. 1997;76(3):264-9.
9. Cotes JE. Introduction. In: Lung Function Assessment and Application in Medicine, 1st edition. Blackwell Scientific Publications, oxford, 1965; 1-13.
10. Comroe JJ. Physiology of respiration. 2nd Ed. Chicago: Year Book Medical Publishers Incorporated. 1975; 94-141.
11. Curistian W, Zauner, Benson Norms Y. Physical alterations in young swimmers during three years of intensive training. J Sports Med

Phys Fitness. 1981; 21: 179–185.
12. Sharp R, Troup JP, Costill DL. Relationship between power output and sprint freestyle swimming. Med Sci Sports Exerc.1 982;14:53-6
13. Pherwani AV, Desai AG, Solepure AB. A study of Pulmonary Function of Competitive Swimmers. Indian Journal of Physiology and Pharmacology 1989; 33 (4): 228-232.
14. De A.K., 1992; Peak expiratory flow rate in adolescent male swimmers of all India rural swimming meet. Indian J Physiol Pharmacol. 1989;33(4):228-32.
15. Doherty M, Dimitriou L. Comparison of lung volume in Greek swimmers, land based athletes, and sedentary controls using allometric scaling. Br J Sports Med. 1997;31:337-341.

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