Effects of a Swimming Training Session on Pulmonary Functions in Young Adult Beginners

Susanta Gorai[1], Writtika Chattaraj[2], Kaushik Samajdar[3]

ABSTRACT

Introduction: It is well documented that any sort of exercise done regularly, is beneficial for health. Swimming is no exception and considered to be a very good exercise for maintaining proper health and also has a profound effect on the lung functions. Regular swimming practice gives a positive effect on the lungs by increasing the pulmonary capacity and thus improves the lung functions. The proposed study was carried out with the above background, among swimming beginners undergoing a swimming training session to see how a course of swimming affect the lung function parameters. **Material and Methods:** The study was carried out on 32 males and 12 females' healthy young adults of either sex of age group of 18-35 yrs. At the beginning of the swimming session recording of pulmonary functions tests was done for each selected candidate (control group). Again procedures were repeated at the end of three months and at the end of six months for same candidates (case group).
Results: In the present study, it is observed that there is significant increase (p value <0.05) in FVC, FEV1, PEFR and MVV after three months and after six months of swimming both males and females separately.
Conclusion: From the present study we concluded that even after short course of swimming training session there is significant benefit in some parameters of lung function. The improve lungs function is thought to be duo to increase in respiratory muscle mass. More elaborate and multi-centred studies are needed to corroborate our findings.

Key words: Swimming, Pulmonary Functions, FVC, FEV1, PEFR, MVV

INTRODUCTION

It is well documented that any sort of exercise done regularly, is beneficial for health. Swimming is no exception and considered to be a very good exercise for maintaining proper health and also has a profound effect on the lung functions. Regular swimming practice gives a positive effect on the lungs by increasing the pulmonary capacity and thus improves the lung functions.[1] There are various studies evaluating the effect of swimming on the pulmonary function in healthy adult populations. Swimming is a demanding aerobic exercise that helps to keep heart and lungs healthy by the improved coordination of breathing and movement of the body, which also helps in expanding and strengthening of the lungs. Intensive swimming training enhances static and dynamic lung volumes and improves the conductive properties of both large and small airways.[2] Actually, the response to swimming[3] 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 compared to the vertical position in other sports.
2. The external pressure is higher as the density of the surrounding medium is higher than that of air, which is the usual external medium in other sports.
3. Heat conductance of water is higher than that of air period.

During swimming ventilation is restricted in every respiratory cycle for moment to moment, producing a condition of intermittent hypoxia. This intermittent hypoxia sets up the anaerobic process during swimming. The blood lactic acid level becomes high during swimming.[4] This leads to the stimulation of the respiratory centre 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.[5] In swimming, there is strenuous exercise of the respiratory muscles because of the pressure exerted by water against the chest wall and elevated airway resistance as the result of immersion comprises a conditioning stimulus. Moreover, the requirement that inspirations must occur rapidly from functional residual capacity during short intervals between strokes is also fulfilled in swimming.[6] The spirometer is an instrument that measures the amount of air breathed in and/or out plotted against time and how quickly the air is inhaled and expelled from the lungs while breathing through a mouthpiece.[7] The measurements are recorded on a device called a Spirograph. The pulmonary function test values vary with age, sex, height and weight of the individual.

[1]Demonstrator, Department of Physiology, Bankura Sammilani Medical College, Bankura Sammilani Medical College Road, Kenduadihi, Bankura, West Bengal 722102, [2]Assistant Professor, Department of Physiology, Diamond Harbour Government Medical College, Harindanga, Diamond Harbour, South 24 Parganas, West Bengal 743331, [3]Professor, Department of Physiology, North Bengal Medical College, Sushruta Nagar, Darjeeling, West Bengal 734012, India

Corresponding author: Dr. Writtika Chattaraj, Assistant Professor, Department of Physiology, Diamond Harbour Govt. Medical College, Harindanga, Diamond Harbour, South 24 Parganas, West Bengal 773331, India

How to cite this article: Susanta Gorai, Writtika Chattaraj, Kaushik Samajdar. Effects of a swimming training session on pulmonary functions in young adult beginners. International Journal of Contemporary Medical Research 2019;6(6):F6-F11.

DOI: http://dx.doi.org/10.21276/ijcmr.2019.6.6.28

Pulmonary functions are generally determined by respiratory muscle strength, compliance of the thoracic cavity, airway resistance and elastic recoil of the lungs. It is well known that pulmonary functions may vary according to the physical characteristics including age, height, body weight,[2,8,9] and altitude of the area where the subject is placed (hypoxia or low ambient pressure).Several physiological changes take place in the human body, when a person swims. Swimming involves almost all the muscle groups. Hence O2 utilization for the muscles is higher in swimmers. The water pressure on the chest wall makes the respiration more energy consuming. Breathing is not as free during swimming, as in most other types of exercise. Respiration during competitive swimming is synchronized with swimming strokes. 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 (VO2max), which a swimmer can sustain during exercise provide a valuable index of physical fitness.[10,11,12] Pulmonary function testing plays a valuable role in evaluation of cardio respiratory status of an individual. Pulmonary function test is done using a technique called Spirometry.[13,14] Regular exercises produces many changes in the body that result with the lungs being able to increase functions. During swimming, total body muscular activity increase and excessive use of chest and abdominal muscles following periods of breathe holding. 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 that increases the vertical and anteroposterior 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.[15]

The proposed study was carried out with the above background, among swimming beginners undergoing a swimming training session to see how a course of swimming affect the lung function parameters.

MATERIAL AND METHODS

Study was conducted at North Bengal Medical College and Hospital, Siliguri, from April 2016 to March 2017. It was an experimental randomized controlled and paired design study.The study was carried out on 32 males and 12 females' healthy young adults of either sex of age group of 18-35 yrs[16] were chosen from those who attended Siliguri swimming pool near Kanchenjunga stadium. Subjects were chosen after getting informed consent and history followed by general examination.

Exclusion criteria

Subject's history of participation in other sports activities like football, cricket, badminton, or any other exercise was excluded. Known history of COPD, bronchial asthma, any systemic pathology affecting respiratory system and any other chronic medical illness such as diabetes, hypertension, renal disease, and heart disease were excluded from the study.

Method of study:

Every volunteer was explained about the purpose and procedure of the study. After getting verbal consent, they were given the printed consent form to sign after explaining nature and purpose of the study.

They were made familiar with equipment and instructed to discontinue the test if they faced any discomfort and report immediately.The subject upon entering the room of examination was greeted cordially, then the subjects was reassured that none of the procedure is harmful or painful. One thorough health check up was done to exclude any apparent medical illness. At the beginning of the swimming session recording of pulmonary functions tests was done for each selected candidate (control group). Again procedures were repeated at the end of three months and at the end of six months for same candidates (case group).

Pulmonary function test: The FVC, $FEV_{1,}$ FVC/FEV_1 ratio, PEFR and MVV was measured using an electronic flow sensing spirometer by RMS Helios 401. The print out of the machine was kept along with the form and datasheet for every individual. When the person reaches the PFT table they were greeted and explained about the harmless procedure. The procedure was explained and clearly demonstrated to the participants by the examiner. First the subject's particulars were put in the data bank of the instrument itself. Then the pre-broncho-dilatation mode was selected. The subject was asked to hold the recording probe of the instrument and the machine was set to record the FVC. The subject was asked to put the probe in mouth and seal it with lips. Nostril was close using a nose clip. The subject was instructed to take a deep breath through the probe and hold. The subject was asked to exhale as forceful as possible then breathe in a deep breath completing the loop, after making the machine on for recording. Then again machine was set to record the MVV. The subject was instructed to take continuous rapid forceful expiration and inspiration for 15 second after making the probe for recording. Graph was visible within the screen. The probe being a flow sensing type records the data directly and supplies the spirometer instrument. The spirometer is supplied with a built-in thermal printer. Using that a printed copy of the record was obtained and saved for future use.

Swimming Technique: The swimming sessions was chosen at 7am for males and at 8am for females. The subjects were asked to have a light breakfast at least 1 hour before the swimming session. All the subjects participating in the study were instructed to follow strictly and abide by the laid down protocol of the swimming session. Free style swimming technique were followed for a period of forty-five minutes with intervening rest period of two minutes after every five minutes of swimming. At the end of each swimming session the subjects were asked to take rest for half an hour and then have food of their own choice. The swimming session continued for a period of six months, six days in a week Data was collected at the end of three and six months respectively.

STATISTICAL ANALYSIS

Statistical analysis was carried out using statistical software 'SPSS version 20.0' (SPSS Corp, Chicago, IL, USA). Descriptive data analysis included the use of mean with standard deviation and range for various parameters. Comparison of various parameters of pulmonary test was done using paired T test for both sexes separately.

RESULTS

Paired't' test was done between the pulmonary function parameters at beginning and after three months of swimming both males and females separately. The test showed significant increase (p value <0.05) in FVC, FEV1, PEFR and MVV both males and females (table 1). Again paired't' test was done between the pulmonary function parameters at beginning and after six months of swimming both genders separately (figure-1,2). The test showed significant increase (p value <0.05) in FVC, FEV1, PEFR and MVV both males and females (table 2). Study also compares between the pulmonary function parameters after three months and after

Pulmonary function parameters	At beginning			After three months		Pair 't' test	
	Mean		St deviation	Mean	St deviation	'p' value	't' value
FVC (litre)	M	2.80	0.40	2.88	0.37	0.000	4.73
	F	2.02	0.25	2.05	0.25	0.003	3.85
FEV1 (litre)	M	2.57	0.43	2.66	0.42	0.000	6.22
	F	1.87	0.32	1.94	0.29	0.007	3.29
FEV1/FVC (%)	M	91.8	5.4	92.3	5.8	0.444	0.78
	F	92.0	6.2	94.3	6.2	0.093	1.81
PEFR (litre/sec)	M	7.17	1.10	7.21	1.10	0.002	3.31
	F	4.70	0.60	4.72	0.60	0.001	4.82
MVV (litre/min)	M	117	12	118	12	0.000	5.37
	F	85	11	87	11	0.000	5.33
p value <0.05 significance							

Table-1: Shown comparison between pulmonary function parameters at beginning and after three months of swimming in case of both males and female.

Pulmonary function Parameters	At beginning			After six months		Pair 't' test	
	Mean		St deviation	Mean	St deviation	'p' value	't' value
FVC (litre)	M	2.80	0.40	3.07	0.38	0.000	7.30
	F	2.02	0.25	2.16	0.24	0.001	4.49
FEV1 (litre)	M	2.57	0.43	2.82	0.38	0.000	8.75
	F	1.87	0.32	2.03	0.30	0.000	5.60
FEV1/FVC (%)	M	91.8	5.4	91.9	7.3	0.915	0.11
	F	92.0	6.2	93.5	7.0	0.422	0.84
PEFR (litre/sec)	M	7.17	1.10	7.25	1.10	0.000	5.61
	F	4.70	0.60	4.76	0.60	0.000	7.53
MVV (litre/min)	M	117	12	122	11	0.000	8.03
	F	85	11	91	10	0.000	7.50
p value <0.05 significance							

Table-2: Shown comparison between pulmonary function parameters at beginning and after six months of swimming in case of both males and female.

Pulmonary function Parameters		After three months		After six months		Pair 't' test	
		Mean	St deviation	Mean	St deviation	'p' value	't' value
FVC (litre)	M	2.88	0.37	3.07	0.38	0.000	6.94
	F	2.05	0.25	2.16	0.24	0.002	4.15
FEV1 (litre)	M	2.66	0.42	2.82	0.38	0.000	7.42
	F	1.94	0.29	2.03	0.30	0.000	7.25
FEV1/FVC (%)	M	92.3	5.8	91.9	7.3	0.621	0.50
	F	94.3	6.2	93.5	7.0	0.573	0.58
PEFR (litre/sec)	M	7.21	1.10	7.25	1.10	0.000	9.85
	F	4.72	0.60	4.76	0.60	0.000	6.50
MVV (litre/min)	M	118	12	122	11	0.000	6.87
	F	87	11	91	10	0.000	6.17
p value <0.05 significance							

Table 3: shown compare between pulmonary function parameters after three months and after six months of swimming in case of both males and female.

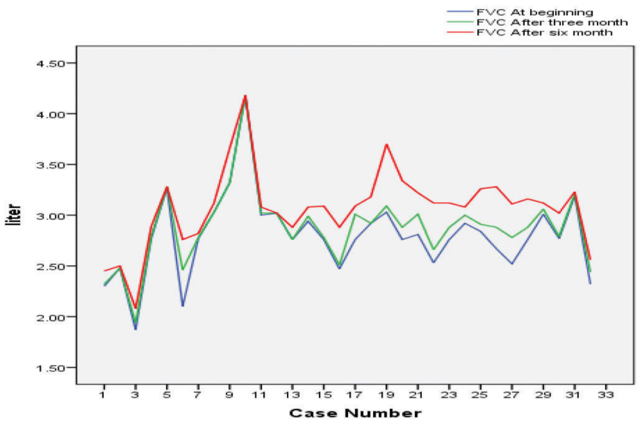

Figure-1: Multiple line diagram shown changes FVC at beginning, after three months and after six months swimming in case male.

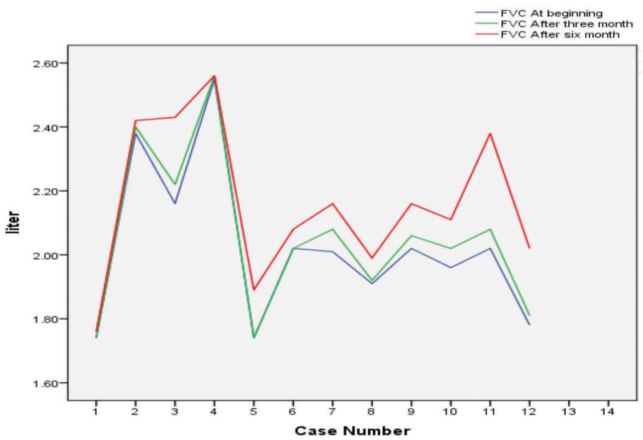

Figure-2: Multiple line diagram shown changes FVC at beginning, after three months and after six months swimming in case female.

three months of swimming. The test showed significant increase (p value <0.05) in FVC, FEV1, PEFR and MVV (table 3) both males and females.

DISCUSSION

The aim of the present study was to see the effect of a short course of swimming training on the pulmonary functional parameters in young individuals. Pulmonary functional parameters were assessed by computerized spirometry before, after three months and after six months of the swimming sessions.

The study was compare the FVC of the participants in the beginning, after three months and after six months of training.Showed significant increase in FVC in both males and females after three months and after six months respectively. In 2012 Kate N N., et al in their study observed significance increase vital capacity in the two groups of swimmers out of three. The increase in vital capacity may be attributed to increase in strength and better endurance of respiratory muscles.[17]

Our study was also compare the FEV1 of the participants and showed significant increase in FEV1 in both males and females after three months and after six months respectively. In swimming, there is strenuous exercise of the respiratory muscles because of the pressure exerted by water against the chest wall increasing the thoracic and abdominal muscle strength.[18] Shashi M. et al in 2013 in their study observed significant increase in FEV1. This was explained on the basis of increased respiratory muscle strength, improved thoracic mobility and the balance between lung and chest elasticity which the swimmers may have gained from training.[19]

The present study was compared the FEV1/FVC ratio of the participants and didn't showed any significance increase in FEV1/FVC ratio in both male and female after three months and after six months. Chhabra A M. et al in 2013 in their study compared FEV1 as percentage of FVC where they found that swimmers have lower value than the control group, meaning that FEV1 did not proportionally increase with FVC. The reason stated was that the training of muscles of shoulder girdle leads to an increase in the vital capacity by reason of the increased strength of the accessory muscles of inspiration while FEV1 remains unaltered or didn't increase proportionately.[3]

Again the present study was compare the PEFR of the participants and showed significant increase in PEFR in both males and females after three months and after six months of swimming respectively. The increase in PEFR in both the groups in our study signifies increase in force of expiratory muscle groups due to training or decreased bronchial outflow resistance or both. During swimming the surrounding water exert higher pressure than air. Therefore the respiratory muscles along with diaphragm develop greater pressure for respiration. This leads to improvement in the functional efficiency of these muscles. Mehorta PK et al. in 1997 shows the swimmers have a higher value of PEFR and the difference is highly significant (P value < 0.005) when compared with control. They suggested that such exercise produces a long-lasting effect on the PEER while the FVC and FEV-l are temporarily improved. Study indicates that such exercises have a positive effect on the lungs.[20]

A study done in 2013 by R. P. Pareek and Pintu Modak in healthy student population showed significant increase in FVC, PEFR and PIFR after 8 weeks of swimming training. Significant increases were explained as the effect of swimming on the static and dynamic lung volumes of the test subjects.[21]

Our study was comparing the MVV of the participants. Significant increase in MVV was observed in both male and female after three months and after six months of training. The increases in MVV after the training sessions are thought to be due to better respiratory muscular performance in the subjects due to training. Our observation on MVV corroborated with the findings of studies done by Aydin & Koca in 2014 who also observed significant increase in MVV after swimming training.[22]

Study done by Pherwani et al in 2012 stated that swimmers had better values of VC, IRV, FVC, FEV and V25 than controls. IC is the first pulmonary function to improve after 6 to 12 months of regular swimming, probably due to reduction in FRC. FVC, FEV1 and a lesser extent PEFR improve after 1 to 2 years. The greater increase in PFFR after 5 years of swimming may be due to hypertrophy of the diaphragm. MMEF and V50, which are mainly dependent on bronchopulmonary factors, were not different than control groups.[15]

In the present study, it is observed that there is significant increase in FVC, FEV1, PEFR and MVV in swimmers after three months and after six months of swimming training. These findings can be explained on the basis of better endurance of respiratory muscles after three and, six months of training as compared to beginning. Training of muscles of the shoulder girdle leads to an increase in the vital capacity by the increased strength of accessory muscles of expiration.[23] An increase in lung size as a possible explanation of the observed improvement in this study is nullified in view of the relatively short period of the training in the present study. The present study was conducted with participation of 44 swimmers only. Further studies involving more candidates are required to establish any definitive correlation between improvement of lung function and the swimming training. Duration of the study was short; moreover, the participants were mostly beginners. Long term flows up of the participants are required to establish cause and affect relationship. The participants of the present study underwent only a particulars swimming technique (free style). Comparison should be made in between the outcome of spirometry in participants undergoing different swimming techniques (such as breast stroke; butter fly etc.). Moreover, studies involving other sports activities (like football, running, cycling etc.) should be undertaken to know whether swimming offers any specials benefit in the participants in comparison to the other sports activities.

CONCLUSION

From the present study we concluded that even after short course of swimming training session there is significant benefit in some parameters of lung function. The improve lungs function is thought to be due to increase in respiratory muscle mass. More elaborate and multicenter studies are needed to corroborate our findings.

ACKNOWLEDGMENTS

The authors are thankful to all faculties of Department of Physiology, North Bengal Medical College and Hospital, West Bengal for proper guidance. Also thankful to all members of Siliguri swimming pool and all participating swimmers providing facilities to carry out this work.

REFERENCES

1. 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; 28:187-94.
2. Hirano H, Enamido K, Suzuki N. Examination of the peak flow level in the Shinjuku-ku asthma child swimming classroom participation child. Information & Knowledge Database of Tokyo Women's Medical University Sep. 1995; 65: 792-793.
3. Chhabra AS, Julka A, Mehta M. Study of Anthropometric Parameters and Pulmonary Function tests of Swimmers of Indore City. Journal of Evolution of Medical and Dental Sciences 2013; 2: 2348-2353.
4. Medbo JI, Mohn AZ, Tabata I. Anaerobic capacity determined by maximal accumulated O2 deficit. J Applied Physiol 1988; 64: 50-60.
5. 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.
6. Mahotra N, Shrestha, L. Effects of type sports on pulmonary function tests: a comparative study in Nepalese settings. Journal of Nobel Medical College 2013; 2: 18-21.
7. Pulmonary Function Tests. http://www.hopkinsmedicine.org/ healthlibrary/test_procedures/ pulmonary/ *pulmonary_function_tests_92, P07759.*
8. Udwadia FE, Sunavala JD, Shetye VM. Lung function studies in healthy Indian subjects. J Assoc. Physicians, India 1987; 35:491-6.
9. Iwamoto M, Dodo H, Ueda Y, Yoneda J, Morie T. A study of pulmonary functions in elderly men and women by flow-volume curve. The Japanese Society for hygiene Feb. 1983; 37: 886-891.
10. Jindal SK, Wahi PL. P.F lab in the tropics; needs, problems and solutions in: Sharma Op-ed. Lung Diseases in the tropics 1991, Marcel dekker Inc. NY: p. 523-542.
11. Matsui T, Miyachi M, Hoshijima Y, Takahashi K, Yamamoto K, Yoshioka A, et al. Effects of water immersion on systemic cardiovascular responses during recovery period following steady state land exercise. The Japanese Society of physical Fitness and Sport Medicine Feb. 2002; 51: 265-273.
12. Polgar C, Promadhat V. Standard values. In: Cherniack RM. Pulmonary function testing in children: techniques and standards. Philadelphia: WB Saunders; 1979. p. 87-122.
13. Ranu H, Wilde M, Madden B. Pulmonary function tests. Ulster Med J. 2011;80:84–90.
14. Woolcock AJ, Colman MH, Blackburn CRB. Factors affecting normal values for ventilatory lung function. Am Rev Respir Dis 1972; 106: 692-709.
15. Pherwni AV, Desai AG, Solepure AB. A study of pulmonary function of competitive swimmers. Indian. J. Physiol. Pharmac. 1989; 33; 228-232.
16. Erik K, Michael T. Guide to young adult ministry, Unitarian Universalist Association Office of Young Adult and Campus Ministry, Retrieved from.
17. Kate NN, Chandrika G, Kondam A, MadhuriA, et. al. The Effect of Short, Intermediate and Long Duration Of Swimming On Pulmonary Function Tests. IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) 2012; 4:18-20.
18. Vaccaro P, Clarke DH, Morris AF. Physiological characteristics of young well-trained swimmers. Eur. J. Appl. Physiol 1980; 44: 61-66.
19. Shashi M, Arora K, Gupta P. The effect of swimming on the lung functions in healthy young male population of Amritsar. International Journal of Applied Exercise Physiology 2013; 2: 11-15.
20. Mehrotra P K, Verma N, Yadav R, Tewari S, Shukla N. Study of pulmonary function in swimmers of Lucknow

city. Ind J Physiol Pharmacol 1997; 47:83-86.
21. Pareek R P, Modak P. The effect of swimming on pulmonary function in healthy student Population. International Educational E-Journal 2013; 2:31-35.
22. Aydin G, Koca I. Swimming training and pulmonary variables in Women. Journal of Human Sport & Exercise 2014; 9: 474-80.
23. Stuart D G, Collings WD. Comparison of vital capacity and maximum breathing capacity of athletes and non-athletes. J. Appl. Physiol 1959; 14: 507-509.

Source of Support: Nil; **Conflict of Interest:** None

Submitted: 08-05-2019; **Accepted:** 31-05-2019; **Published:** 23-06-2019