Effect of Swim Training on Pulmonary Functions in Boys of Prepubertal and Pubertal Age

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Abstract

Swimming is an exercise where respiratory muscles are taxed more and its effect may be seen on pulmonary functions. In prepubertal and pubertal age hormonal and other changes are also taking place in a body. In our study we wanted to see the effect of swim training on pulmonary functions in the age group of 9-12 years. The study comprised of study group of competitive male swimmers undergoing training for 3-5 years (n=30) and compared with control group (n=30) of age, sex, height and weight matched healthy subjects not participating in any sports activity.

The parameters taken into account for this study were forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow rate (PEFR). The unpaired student 't' Test was used for statistical significance. In this study we observed the statistically significant higher values of FVC, FEV_1 and PEFR in swimmers than non-swimmers (Mean FVC of control group I-1.973, II-2.253 and study group I-2.193, II-2.480, mean FEV_1 of control group I-1.706, II-1.913 and study group I-1.913, II-2.120, mean PEFR of control group I-4.093, II-4.713 and study group I - 4.453, II - 5.140). We conclude that swimming improves the pulmonary functions of children in a prepubertal and pubertal age as compared to non-swimmers.

Keywords: Forced Vital Capacity, Forced Expiratory Volume in 1st second, Peak Expiratory Flow Rate, Pulmonary Function Test (PFT), Swimming

Introduction

The history of sports is as old as the history of man himself. Swimming is a well-established whole body exercise and it differs from other exercises in several aspects like horizontal position of the body, performed in water, respiratory muscles are taxed more, different type of breathing pattern, more conductance of heat in water as compared to air.

Fitness surveys place it among the top three choices along with walking and running as it is aerobic for healthful conditions, nearly weightless and prevents injuries, works all the major muscle groups, suitable for the people of all ages throughout their lifetime and also necessary safety skill.

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).

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(2).

Pulmonary functions are generally determined by respiratory muscle strength, compliance of the thoracic cavity, airway resistance and elastic recoil of the lungs(3).

The purpose of choosing the swimmers was that fewer studies have been carried out on swimmers as compared to other sports. In this study efforts have been made to evaluate quantitatively the effect of swimming on pulmonary functions. Most of the studies have been carried out in young adults whereas in our study the efforts have been made to evaluate the effect of swim training on FVC, FEV1 and PEFR in children between the prepubertal and pubertal age group of 9-12 years. During this period along with swim training other changes are also taking place in the body which may also contribute in growth and pulmonary functions.

Material and Methods

The present study comprised of two groups, study group and control group of healthy school going boys between the age group of 9 to 12 years. Study group consisted of 30(n) competitive swimmer boys participating at district, state or national level swimming competitions. They were practicing free style stroke of swimming exercise for 2 hours a day, 6 days a week throughout the year for 3 to 5 years in Nagpur.

Control group_consisted of 30(n) non-swimmers who were age, height, sex and weight matched with the study group from same socio-economic status. They were not directly involved in any kind of regular sports activity. Both the groups were divided into 2 subgroups according to the age as shown in Table 1.

The pulmonary function tests were performed on computerized, electronic, dry type of a machine with internal correction of volumes to BTPS – "Medspiror" (CO-Recorders and Medicare system, Chandigarh). After obtaining permission from the ethical committee, the study was carried out in the Department of Physiology of Indira Gandhi Medical College, Nagpur. The following parameters were taken into account:

1. Forced Vital Capacity (FVC) in litres.
2. Forced Expiratory Volume in one second (FEV_1) in litres.
3. Peak Expiratory Flow Rate (PEFR) in litres/sec.

Children were instructed about the nature of the study. Informed consent of parents and children was taken. They had been given an appointment in groups of 4 to 6, for recording of pulmonary function tests in the morning from 10 a.m. to 12 noon after a light breakfast, 2 to 3 hours prior to test. Their age, height, weight, date of birth was recorded.

All the subjects were made familiar with the instrument. Procedure was explained and demonstrated to them. Sufficient practice of the manoeuvre was given to them. The data about the age, sex, height, weight, date and atmospheric temperature was fed to the ''medspiror''. Then subjects were asked to execute forceful expiration, as fast as possible at the end of full deep inspiration. Three consecutive readings were taken and the best of the three was noted. FVC, FEV_1 and PEFR parameters were selected for the study. The statistical analysis of the observations was carried out using student's unpaired "t" test. The observed data is exhibited in results.

Results

Table 1: Subgroups according to age

Age group	Number of subjects (n=30)		Age in years
	Study group (Swimmers)	Control group (Non swimmers)	
I	15	15	9.5 to 10.49
II	15	15	10.5 to 11.49

Subjects have been divided in two groups. Group I – 9.5 to 10.49 and Group II – 10.5 to 11.49.

Table 2: Mean age (years) of swimmers and non-swimmers

Age Group	Control Group		Study Group		Remark	Significance
	Mean	SD	Mean	SD		
I	10.078	0.259	10.054	0.281	↓	NS
II	11.083	0.231	10.996	0.267	↓	NS

Mean age of controls were group I – 10.078, II- 11.083 and study group I – 10.054, II- 10.996. In both groups the difference in age is not significant.

Table 3: Mean height (cm) of swimmers and non-swimmers

Age Group	Control Group		Study Group		Remark	Significance
	Mean	SD	Mean	SD		
I	138.866	3.499	139.200	3.709	↑	NS
II	143.533	2.729	143.600	2.751	↑	NS

Mean height of control group I – 138.866, II- 143.533 and study group I- 139.2, II- 143.6. In both groups the difference in height is not significant.

Table 4: Mean weight (kg) of swimmers and non-swimmers

Age Group	Control Group		Study Group		Remark	Significance
	Mean	SD	Mean	SD		
I	33.933	3.193	33.866	3.138	↓	NS
II	37.133	4.161	37.533	4.256	↑	NS

Mean weight of control group I- 33.933, II- 37.133 and study groups I- 33.866, II- 37.533 which seems to be non significant.

Table 5: Mean FVC of swimmers and non-swimmers

Age Group	Control Group		Study Group		Remark	Significance
	Mean	SD	Mean	SD		
I	1.973	0.161	2.193	0.169	↑	S
II	2.253	0.130	2.480	0.132	↑	HS

Forced vital capacity (FVC) has been increased in study group I and II as compared to control group. Study Group I shows significantly increased FVC whereas high significance in group II (Table 5).

Table 6: Mean FEV1 of swimmers and non-swimmers

Age Group	Control Group		Study Group		Remark	Significance
	Mean	SD	Mean	SD		
I	1.706	0.169	1.913	0.162	↑	S
II	1.913	0.145	2.120	0.164	↑	S

FEV1 in control group I - 1.706, II- 1.913 and in study group was I- 1.913, II- 2.12. It is significantly increased and in study group I and II group as compared control group.

Table 7: Mean PEFR of swimmers and non-swimmers

Age Group	Control Group		Study Group		Remark	Significance
	Mean	SD	Mean	SD		
I	4.093	0.299	4.453	0.298	↑	S
II	4.713	0.414	5.140	0.442	↑	S

PEFR in control group I- 4.093, II- 4.453 and study group I 4.713, II- 5.14 which is significantly increased in study groups I and II as compared to control groups.
(S - Significant at $p< 0.05$, HS -Highly significant at $p< 0.001$, ↑- Increased, ↓- Decreased)

Swimmers show increase in FVC, FEV1 and PEFR as compared to controls in all the age groups and it is statistically significant (Table 5, 6, 7).

Discussion

Present study compares effect of training in swimmers and non-swimmers of age group 9-12 years. Increase in FVC, FEV1 and PEFR parameters of pulmonary functions were observed in swimmers as compared with the control. The difference was statistically significant. FVC, FEV1 and PEFR shows significant increase in a study by Basavraj R et al(4), which were done on swimmers and supports that physical training has a facilitative effect on ventilatory function and physically active persons have greater lung function values in comparison to sedentary persons. In most studies we observed an increase in value of forced vital capacity (FVC) in swimmer group, which was highly significant. Clanton TL et al(5) shows 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. In a study conducted by Bjurstrom RL et al(6), the increase in VC was explained by increased inspiratory muscle strength, since during immersion in water these swimmers experience negative pressure breathing.

In the normal individuals pulmonary functions depend on many factors like expansibility of chest wall, pleura and alveoli, negative pressure of pleural cavity, Elastic properties of the lung parenchyma, patency of the bronchopulmonary tree, respiratory muscle power and voluntary neuromuscular co-ordination and surfactant status. Pherwani AV et al(3) stated in his study that in swimmers the reasons for enhancement of pulmonary functions may be many. Respiratory muscles are used more along with upper extremity which may affect the pulmonary functions. There may be the hypertrophy of diaphragm in swimmers as during swimming it performs more work for a prolonged period. Respiratory muscles are taxed more during swimming as water is having more density than air. Swimmer has to produce more pressure during respiratory cycle so the strength of these muscles may be increased(2).

Swimmers usually follow different type of breathing i.e. deep breathing followed by breath holding so large tidal volume may be attained which may increase lung volume and surface area for gas exchange(7). Repeated restricted ventilation during swimming may produce intermittent hypoxia, releasing the growth hormone. This may enhance the lung growth in adolescents(8).

In swimmers growth hormone release due to upper extremity exercise may be more as compared to lower extremity exercises. This may increase the growth of lung parenchyma and chest cavity, enhancing the lung functions of swimmers[9].

Swim training may produce the hypertrophy and conditioning of the respiratory muscles and also increase the airway calibre permanently in adolescents, increasing the FEV_1 in swimmers[10].

Increased PEFR in swimmers may be attributed to increased strength of respiratory muscles, enhanced elasticity of chest wall, pleura and pulmonary parenchyma due to different type of breathing pattern during swimming. There may be increase in compliance. Permanent increase in airway calibre may increase PEFR[2,11].

The large metabolic demand of strenuous exercise requires an efficient oxygen transport system from the atmosphere to the active tissues and 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[7,12-14].

Testosterone controls the muscle size, promotes male sex characteristics. Hypersecretion results in musculinization. Its secretion increases with exercise. With maximal exercise trained subjects have a hormonal response that is either identical or somewhat higher than the response of untrained subjects. This is true for both the catecholamines and the pituitary hormones. In some studies it is also concluded that well trained free style swimmer's arm length, leg length is largely governed by genetics and may influence stroke length and frequency[15].

It may be likely due to an increase in heart and other organ size that may be attributed to the role of growth hormone in exercise during puberty when individual may be more sensitive to growth hormone[16].

Androgens in normal amount may not have much masculinizing effect but in excessive amount can cause it as occurs in prepubertal age. Growth hormone spikes are high in puberty so its mean plasma levels are high. It stimulates IGF-1 levels which are high in childhood. Growth spurt during puberty might due to interaction among sex steroids, growth hormone and IGH-I. It has been seen that androgens increase the secretion of growth hormone in response to various stimuli and increases plasma IGF-I secondary to this increase in circulating GH which in turn causes the growth[17].

Conclusion

A statistically significant increase in FVC, FEV1 and PEFR is observed after 3-5 years of swim training in boys of prepubertal and pubertal age. We conclude that swim training improves the pulmonary functions. In the growth of respiratory muscles as well as growth of lung parenchyma and elasticity of lung and thoracic wall during that particular age of pre-puberty and puberty swimming may contribute. During this age it may also be due to changes in hormonal levels of androgens, growth hormone, IGF-I and other hormones which might have additional effect on growth of muscles. We have compared the parameters with age, sex, height, and weight, matched non-swimmers in whom also hormonal changes are going on but in swimmers swim training may have an additional effect on growth of lung parenchyma and elasticity of lung and thoracic wall. But in our study we have not estimated the hormonal levels. It might also be due to genetically determined arm and leg length. The detailed thorough observation of work shows that the age, height, weight, being matched, the analysis of FVC, FEV1 and PEFR reveals that swimming improves the lung volumes, betterment of flow rates and thus overall wellbeing of a swimmer. In this study where not only exercise but other factors like growth hormone, testosterone as well as some other hormones may be having effects on growth and development of a child. Swimming improves the pulmonary functions but in this age group further detailed study of hormonal levels should be done so that whether it is only exercise or other factors are responsible for improving pulmonary functions can be concluded.

Conflict of Interest: None
Source of Support: Nil

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