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Original Article

Effect of Duration of Exercise on Pulmonary Functions

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Abstract

Introduction: Several studies suggest a beneficial role of exercise in improving one's ability to sustain high levels of submaximal ventilation. Regular training improves the respiratory muscle strength as well as endurance.

Objectives: The objectives of the study are as follows: To assess the pulmonary functions using force vital capacity (FVC), force expiratory volume in 1 s (FEV1), FEV1/FVC, and forced expiratory flow (FEF) 25–75 in males who are involved in regular exercise in gymnasium for ≤1 year (Study group A), for 1–5 years (Study group B), and in sedentary healthy males (Study group C). To compare the pulmonary functions among Study group A, Study group B, and Study group C. To correlate effect of duration of exercise on pulmonary functions.

Materials and Methods: Estimation of FVC, FEV1, FEV1/FVC, and FEF 25–75 in 90 healthy males in the age group of 18–35 years is done by computerized portable spirotech spirometer as per ATS guidelines.

Results: In Group A 7% subjects, in Group B 100% subjects, and in Group C no subjects are having more than FEV1 median value. In Group A 53% subjects, in Group B 100% subjects and in Group C no subject are having more than FVC median value. In Group A 100% subjects, in Group B 33% subjects, and in Group C 63% are having more than FEV1/FVC median value. In all three groups, 57% subjects are having more than FEF 25–75 median value.

Conclusion: In this study, we found positive correlation between duration of exercise and improvement of pulmonary functions.

Key words: Exercise, Force expiratory volume in 1 s, Force expiratory volume in 1 s/Force vital capacity, Force vital capacity, Spirometry

INTRODUCTION

Regular exercise is associated with number of physical and mental health benefits. Each component of physical fitness (i.e., cardiorespiratory fitness, muscular strength, endurance, body composition, and flexibility) affects some aspect of health.[1] The body composition and abdominal obesity are associated with increased risk of adverse health outcomes, whereas greater fat-free mass is associated with a lower risk of mortality.[2] Higher levels of cardiorespiratory and muscular fitness are each associated with lower risks for diseases.[1,3] The minimum level of cardiorespiratory fitness required for health benefit may vary and depend on gender and age.[1]

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Cardiorespiratory fitness includes cardiovascular fitness and respiratory fitness.[4,5] Increase in pulmonary ventilation and O_2 uptake is respiratory responses to exercise. Pulmonary ventilation increases in a linear fashion with increase in the intensity of exercise until an anaerobic threshold is reached.[5-7] The O_2 uptake by blood in the lungs increases from 250 ml/min at rest to about 4 l/min during heavy exercise. This is possible due to increased pulmonary perfusion, increased alveolar capillary PO_2 gradient, increased pulmonary diffusion capacity and Bohr's effect.[6-8]

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MATERIALS AND METHODS

Protocol for this study was designed and approved by the Institutional Ethical Committee. This was an analytical and observational study. Pulmonary functions of 90 healthy males recorded in accordance with the standardized methods which were divided into three groups.

Study group A includes 30 healthy males in the age group of 18–35 years, doing regular exercises in gymnasium (weight lifting exercises for the upper limbs, lower limbs, and torso along with cardio exercises in a well-equipped gymnasium having standard weights and machines) 30–45 min daily for at least 4–5 days/week (150 min/week) for ≤1 year.

Study group B includes 30 healthy males in the age group of 18–35 years, doing regular exercises in gymnasium (weight lifting exercises for the upper limbs, lower limbs, and torso along with cardio exercises in a well-equipped gymnasium having standard weights and machines) 30–45 min daily for at least 4–5 days/week (150 min/week) for 1–5 years.

Control Group, that is, Group C: For comparison, separate group of healthy subjects (only males) belonging to the same age group of 18–35 years, nearly same height and built were taken. They were from the same socioeconomic status and ethnic group as that of study group but they had sedentary lifestyle which means that they did not participate or were not involved in regular isotonic exercises, running, jogging, brisk walking (morning walks), swimming, aerobics, or any other sports activity.

History taking was followed by detailed clinical examination and based on the above findings, eligible subjects were finalized.

Collection of Data

Complete procedure was explained to the subject and a written informed consent was taken.

Spirometry[9]

For estimation of pulmonary functions, computerized portable spirotech spirometer was used as per ATS guidelines.

Procedure

The subject was asked to sit comfortably in the chair. The complete procedure was explained, any doubts would be addressed. Subject was instructed to take a deep breathe by deep inspiration with nostrils closed by applying nasal clip. The subject was asked to seal the lips around the sterile mouthpiece of spirometer and forcefully expire the air out, as fast as possible. Best of three recordings will be recorded and interpreted.

Following pulmonary function parameters have been recorded:

- Force expiratory volume in 1 s (FEV1)
- Force vital capacity (FVC)
- FEV1/FVC
- Forced expiratory flow 25–75% (FEF 25–75).

Statistical Analysis

Excel and R programming software were used for data analysis. Median and inter quartile range of continuous characteristics among 1-year exercise, 1–5 years of exercise groups, and no exercise group has been accessed using descriptive statistics. After the data were tested for normal distribution, pulmonary functions parameters were compared using Kruskal–Wallis test. Binary logistic regression was used to assess the association between exercise duration and pulmonary functions. Statistical significance was evaluated at 0.05 alpha level after using two-sided *P*-value.

RESULTS

Table 1 shows comparison between Study group A, Study group B and Study group C with respect to age, weight, height and body mass index.

Table 2 shows comparison between Study group A, Study group B and Study group C with respect to pulmonary functions.

Table 3 shows Logistic regression to assess the association between pulmonary functions and exercise duration.

In Group A 7% (2/30) subjects, in Group B 100% (30/30) subjects and in Group C no subject is having high FEV1 %P value. In Group A 53% (16/30) subjects, in Group B 100% (30/30) and in Group C no subject is having high FVC %P value. In Group A 100% (30/30) subjects, in Group B 33% (10/30) subjects and in Group C 63% (19/30) subjects are having high FEV1/FVC %P value. In all three groups the high FEF25-75 %P value is 57% (17/30).

DISCUSSION

We have compared pulmonary functions of Group A (≤1 year of exercise), Group B (1–5 years of exercise), and Group C (control). We found that there is statistically significant increase in FEV1, FVC, and FEV1/FVC in Group A compared to Group C and Group B compared to

Table 1: Comparison between Study group A, Study group B, and Control group C with respect to age, weight, height, and body mass index

Characteristics	No exercise (Group C) Median, IQR *n*=30	≤1 Year exercise (Group A) Median, IQR *n*=30	1-5 Years exercise (Group B) Median, IQR *n*=30	*P*-value
Age (years)	18 (18–19)	19 (18–21)	19 (18–22)	>0.05
Weight (kg)	62.79 (53.60–71.98)	62.53 (53.59–71.47)	61.21 (52.58–69.84)	>0.05
Height (m)	1.70 (1.65–1.75)	1.70 (1.66–1.74)	1.70 (1.65–1.75)	>0.05
BMI (kg/m^2)	22.4 (21.6–23.1)	22.7 (21.7–23.5)	22.7 (22.6–22.8)	>0.05

IQR: Inter Quartile Range, *n*: Number of subjects, m: meters, kg: kilograms, BMI: Body mass index, *P*>0.05 is statistically not significant, *P*≤0.05 was considered as significant at 95% confidence interval, *P*<0.0001 was considered as highly significant

Table 2: Comparison between Study group A, Study group B, and Control group C with respect to pulmonary functions

PFT Parameters	Group C	Group A	Group B	*P*-value
FEV1				
Median	98	110	119	0.0001*
IQ	(96–99)	(108–113)	(118–120)	
FVC				
Median	84	95	106	0.0001*
IQ	(82–87)	(93–97)	(103–108)	
FEV1/FVC				
Median	115	116	112	0.003**
IQ	(111–117)	(115–117)	(110–116)	
FEF 25–75				
Median	56	56	56	0.99***
IQ	(54–58)	(54–58)	(54–58)	

**P*<0.0001 was considered as highly significant. ***P*≤0.05 was considered as significant at 95% confidence interval. ****P*>0.05 is statistically not significant, FVC: Force vital capacity, FEV1: Force expiratory volume in 1 s, FEF: Forced expiratory flow

Table 3: Logistic regression to assess the association between pulmonary functions and exercise duration

PFT parameters	Group C	Group A	Group B
FEV1			
High FEV1%P	0	2 (7)	30 (100)
OR 95%C.I.	-	-	-
P-value	-	-	-
FVC			
High FVC%P	0	16 (53)	30 (100)
OR 95%C.I.	-	-	-
P-value	-	-	-
FEV1/FVC			
High FEV1/FVC%P	19 (63)	30 (100)	10 (30)
OR 95%C.I.	-	-	-
P-value	-	-	-
FEF 25–75			
High FEF 25–75%P	17 (57)	17 (57)	17 (57)
OR 95%C.I.	1	1	1
P-value	-	-	-

High FEV1% P: Defined as those who had FEV1% *P*≥115 (Median value of the overall FEV1% P), High FVC % P: Defined as those who had FVC % *P*≥95 (Median value of the overall FVC% P), High FEV1/FVC% P: Defined as those who had FEV1/FVC% *P*≥115 (Median value of the overall FEV1/FVC% P), High FEF 25–75%P: Defined as those who had FEF 25–75% *P*≥56 (Median value of the overall FEF 25–75% P), FVC: Force vital capacity, FEV1: Force expiratory volume in 1 s, FEF: Forced expiratory flow

Group A. We found that there is no statistical significance in the FEF 25–75 among Study group A, B, and Control group C.

West (1996) showed that exercise training is beneficial for improving one's ability to sustain high levels of submaximal ventilation.[10]

Cheng *et al*. (2003) showed that men who were engaged in exercise had higher FEV1 and FVC than the sedentary group.[11]

Farid *et al*. (2005) showed that the course of aerobic sport exercise causes an obvious increase in FEV1, FVC, and FEF 25–75 in asthmatic patients. Thus, the exercise training and regular short duration sports activity are involved in the improvement of pulmonary function.[12]

McArdle *et al*. (2010) showed that regular training improves the ventilator muscle strength as well as endurance. Twenty weeks of training improve ventilatory muscle endurance by approximately 16%. It also increases inspiratory muscle capacity to generate force and sustain a given level of inspiratory pressure.[4]

Pulmonary Functions

Physical training may have little effect on maximal static S and dynamic measures of pulmonary functions. However, it is beneficial for improving one's ability to sustain high levels of submaximal ventilation. Regular training improves the ventilator muscle strength as well as endurance.[4,13,14]

Mechanism

1. There is an increase in aerobic enzyme levels because of physical training[4,14-16]
2. Oxidative capacity of respiratory musculature increases after few weeks of exercise[4,14-16]
3. Furthermore, the capillary vascularization is increased in the pulmonary tissue as a result of physical training. There is an increase in number of functioning alveoli and their better inflation. Therefore, respiratory system becomes more efficient and capable of providing the better oxygenation.[4,14-16]

CONCLUSION

In the present study, we found that there is a statistically significant improvement in pulmonary function parameters – FEV1, FVC, and FEV1/FVC in ≤1 year exercise group compared to the no exercise group. Whereas there is profound improvement in pulmonary function parameters – FEV1, FVC, and FEV1/FVC in 1–5 years exercise group compared to 1 year exercise group. This shows a positive correlation between duration of exercise and improvement of pulmonary functions.

LIMITATIONS OF THE STUDY

In this longitudinal study, intermediate measures of other independent variables (different types of sports, diet and other medical conditions) were not performed; thus we cannot assess the influence of concurrent changes on results. Almost all of our control participants were from mid to upper socioeconomic strata, so generalization to other groups is not advised.

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