Section: Miscellaneous

Original Research Article

A COMPARATIVE ANALYSIS OF PULMONARY FUNCTION VARIABLES IN SMOKERS AND ATHLETES

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Abstract

Background: Pulmonary rehabilitation has emerged as a crucial component of respiratory care, evolving significantly in response to increasing respiratory disorders worldwide. Lifestyle factors, particularly smoking, play a major role in the development of chronic respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD) and bronchial carcinoma. Quality of life is closely linked to functional health status, where physical fitness and activity contribute to improved pulmonary function. Smoking remains the most preventable cause of respiratory decline, significantly impacting lung function and contributing to premature mortality. A sedentary lifestyle exacerbates these risks, reducing pulmonary efficiency and contributing to obesity, which further impairs lung function. Spirometry is a widely used diagnostic tool for assessing pulmonary function, measuring key parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), FEV1/FVC ratio, Peak Expiratory Flow Rate (PEFR), and Maximum Voluntary Ventilation (MVV). Pulmonary function tests are essential for understanding the impact of lifestyle factors on respiratory health. The study aimed to assess and compare pulmonary function among three groups of adult males aged 20-30 years. **Materials and Methods:** This descriptive study was conducted at a Government Medical College in North Kerala and the Naval Academy Ezhimala, a defence training institution. A total of 630 male participants, aged 20-30 years, were randomly selected, with 210 individuals in each category (smokers, non-smokers, and athletes) for a period of one year. Subjects were recruited from among undergraduate and postgraduate students, bystanders at outpatient departments, and cadets at the Naval Academy. The measurements were taken using Medicaid Spiro excel, a computerized spirometry system connected via USB to a personal computer. Participants were assessed in a controlled environment, adhering to ATS (American Thoracic Society) acceptability criteria for spirometry. Height, weight, and other anthropometric measurements were recorded before the test. The results demonstrated significant differences in pulmonary function among the three groups. Athletes exhibited the highest lung function parameters, followed by non-smokers, while smokers had the lowest values. A clear gradient in lung function was observed: athletes > non-smokers > smokers. This justifies that even a small amount of cigarette use in adolescence was linked to reduced lung growth over time. The study supports promoting physical activity as a preventive strategy against pulmonary diseases. **Conclusion:** The study is first of its kind done in India wherein a large number was choosen for spirometry. The findings emphasize the need for proactive measures, including early intervention and smoking cessation programs, anti-smoking campaigns and fitness programs, to improve respiratory health in young population.

INTRODUCTION

Pulmonary rehabilitation is a dynamic therapeutic field which has rapidly evolved over the last few decades. With the coming in of individual revolution there has been a considerable rise in disorders of respiratory system where habits too play a major role in development of the same and to be more particular smoking has been indicated as one of the chief causes of respiratory diseases ranging from chronic obstructive pulmonary diseases to bronchial carcinoma. Quality of life is directly related to functional status and the ability to maintain independence. Physical fitness improves health related quality of life by enhancing psychological well-being and improving physical functioning in persons with poor health. It is essential to be involved in physical activity which also helps in respiratory muscle strengthening and improvement in pulmonary function. Tobacco use is the single most important preventable risk to human health in developed countries and an important cause of premature death worldwide. Cigarette smoking has an extensive effect on respiratory function and has been clearly implicated in the etiology of chronic respiratory disease. WHO reported that tobacco smoking killed 100 million people worldwide in the 20th century and has warned that it could kill billions in future.[1] Within 1-2 yrs of beginning of smoking regularly many young smokers will develop inflammatory damages in their small airways, although lung function measures of these changes do not predict development of chronic air flow obstruction.[2] Besides direct consequences of smoking on smokers, passive smoking by non-smokers who are exposed to tobacco smoke also have been shown to increase risk of respiratory and cardiovascular problems, even in children. COPD is currently one of the most widespread chronic lung diseases and growing cause of suffering and mortality worldwide.[3-5] Sedentary life style could be associated with less efficient pulmonary functions. Sedentary life style was defined as per centre for disease control and prevention as no leisure time physical activity/ activities for less than 20 minutes/ fewer than three times per week.[6-8] Further more sedentary lifestyle is associated with obesity which decrease the mobility of thorax which cause decrease in FEV1/ FVC. There is always a need for better understanding of relationship of impaired pulmonary function to diseases in order to undertake preventive measures. Spirometry is a physiological test that measures how an individual inhales/ exhales volumes of air as a function of time. The parameters used as the determinants of lung function are tidal volume, FEV1, FVC, FEV1/FVC%, MVV. These parameters provide a qualitative and quantitative evaluation of pulmonary function and therefore of value in various respiratory diseases.[9] Spirometric tests may be useful as a motivating tool to help smokers to quit and attenuate the complications of smoking. These tests permit an accurate reproducible assessment of functional status of respiratory system and allow quantification of the severity of disease, thereby enabling early detection as well as assessment of natural history and response to therapy.[10] Weiss et al,[11] speculated FEV1 as an indicator of general health influenced by environmental toxins exposure and therefore related to survival .FEV1 could affect the physical activity which may prolong survival times through its influences on metabolism. Other lung function parameters FVC, MVV, PEFR also tend to have a relationship with life style indicators such as exercise, smoking and non exercise. Physical activity rehabilitation is widely used in patients with respiratory and other life style diseases.[6] Exercise training remains the cornerstone of various rehabilitation and cessation programs and offers benefits complimentary to pharmacotherapy in chronic lung diseases.[12-13] The present study was done to study the various lung function parameters in three different groups of adult healthy men of age (20-30 years), (asymptomatic smokers healthy nonsmokers, nonsmoking athletes). Beyond the importance of reinforcing antismoking initiatives at all levels of health care process, the recognition of increasing level of physical activity may be especially important in active smokers. Lung function parameters measured at an early age is a predictor of lung function at middle age, which later are predictors of chronic lung diseases.

Aim and Objectives

1. To study the effect of smoking on pulmonary function of healthy male smokers aged (20-30 years).
2. To study the pulmonary function parameters on athletes of the same age group.
3. Comparison of spirometric measures between smokers, athletes and healthy controls of the same age and sex.

MATERIALS AND METHODS

The study was a descriptive type of study and the subjects were selected from a Government Medical College in North Kerala and Naval Academy Ezhimala. The study population included healthy male bystanders accompanying the patients in various outpatient departments of the medical College, undergraduate and postgraduate students of various disciplines of the college were included in the category of smokers and nonsmokers. The athletic group were cadets of Naval Academy Ezhimala, a defence training institution near to the Medical College. A total of 630 subjects - 210 in each category of age from 20-30 years were randomly selected for the study. The subjects were categorized as:

Smokers: Healthy asymptomatic subjects who smoked more than or equal to 5 cigarettes /day [14] in the past one year. Non smokers: Subjects who have not smoked even a single cigarette during his life time. Athletes: The cadets of Naval Academy

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Ezhimala, who had undergone more than nine months of physical training and was non smokers. The cadets were randomly selected from the Naval Academy after obtaining written permission from the concerned authorities. The spirometry was done in the medical care unit room of the academy. Subjects who did not consent and who had any lifestyle disorders were excluded from the study. The study was conducted for a period of one-year Main outcome variables measured were: FVC, FEV1, FEV1/FVC, PEFR, MVV.Statistical analysis was performed using SPSS (version13) software for Windows. Descriptive statistical tools like mean, standard deviation, 95% confidence interval were used in the study. Inferential statistical tool like Analysis of variance (Anova) was used and $p< 0.05$ was considered significant. Medicaid Spiroexcel, an instrument designed for lung function screening, has the core of the system is an intelligent flow meter that connected through an USB cable, turns any personal computer in to a complete spirometric lab. The system is composed by the turbine flow meter, the measurement and data elaboration device (light weight and ergonomic), the communication cable, adult mouth piece adapter nose clips and the Software pack.

Methodology

From the Medical college hospital, the subjects were identified. Anthropometric measurements were recorded for each subject. Under graduate and postgraduate students were selected randomly from the outpatient departments and height, weight and pulmonary function tests were done in the examination room during their free hours. By-standers accompanying the patients were selected randomly. Spirometry and other measurements were done in the examination room of the corresponding outpatient departments and side room of the wards.

RESULTS

The study comprised of 630 subjects with 210 each in smokers, nonsmokers and athlete group. The mean values and standard deviation of parameters are given below.

Table 1: General information of the subjects.

Variables	Smokers	Nonsmokers	Athletes
	Mean/Sd	Mean/Sd	Mean/Sd
Age	25.46/3.28	23.57/2.81	23.2/2.27
Weight	65.3/7.34	67.53/6.32	67.37/7.11
Height Bsa	169.44/6.1 1.71/0.13	171.7/6.7 1.75/0.12	172.6/6.9 1.79/0.11

The mean values and standard deviation of various pulmonary function parameters are given below:

Table 2: FEV1 (l) of the subjects.

Groups	Mean	S.D	95% Ci For Mean
Smoker	3.19	0.65	(3.19,3.02)
Nonsmoker	3.65	0.58	(3.73,3.57)
Athletes	4.02	0.52	(4.09,3.95)

From [Table 2] it is evident that mean FEV1 is highest in athletes and lowest in smokers. To see whether the mean FEV1 was significantly different or not between the three groups one -way Anova was conducted. A significant difference in means was observed, $F (2, 627) = 128.918$, $p<0.001$. Then, the Tukey's post hoc comparisons showed that the athletes had a significantly higher mean FEV1 than the smokers and non- smokers. Comparing the smokers and non-smokers, non-smokers had a significantly higher mean FEV1 than smokers. So, with regard to FEV1, all the 3 groups had significantly different mean FEV1, with athletes having the highest and smokers having the lowest.

Table 3: FVC (l) of the subjects.

Groups	Mean	S.D	95% Ci For Mean
Smoker	3.38	0.78	(3.48,3.26)
Nonsmoker	3.81	0.58	(3.89,3.73)
Athletes	4.43	2.79	(4.81,4.04)

[Table 3], shows the mean values of FVC with athletes having highest and smokers with lowest values of FVC. One way Anova test showed the mean value of FVC differed significantly across the 3 groups, $F (2, 627) = 20.15$, $p<0.001$. Tukey's post hoc comparisons showed that all the 3 groups had significantly different means, with athletes having highest and smokers having lowest mean FVC.

Table 4: Mean FEV1/FVC% of the subjects.

Groups	Mean	S.D	95% Ci For Mean
Smoker	92.41	7.94	(93.48,91.32)
Nonsmoker	95.85	4.44	(96.46,95.25)
Athletes	96.06	3.77	(96.57,95.54)

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The mean FEV1/FVC differed significantly across the 3 groups, F (2, 627) = 27.35, p<0.01. Tukey's post hoc comparison showed the mean FEV1/FVC was significantly lower in smokers when compared to nonsmokers and athletes. Also there was no significant difference between the nonsmokers and athletes.

Table 5: Mean PEFR (l/s).

Groups	Mean	S.D	95% Ci For Mean
Smoker	8.27	3.51	(8.74,7.79)
Nonsmoker	8.98	1.03	(9.12,8.84)
Athletes	9.64	1.43	(9.84,9.45)

The mean value of PEFR differed significantly across the 3 groups, F (2, 627) = 19.31, p<0.001. Tukey' post hoc comparisons showed that all the 3 groups had significantly different means, with smokers having the lowest and athletes the highest PEFR. Comparing the nonsmokers and athletes showed a significantly different mean PEFR.

Table 6: Mean MVV (l/min) of the subjects.

Groups	Mean	S.D	95%Ci For Mean
Smoker	116.63	14.89	(118.66,114.61)
Nonsmoker	128.32	8.81	(129.52,127.12)
Athletes	148.44	9.63	(149.75,147.13)

From [Table 6], it is inferred that mean MVV is highest in athletes and lowest in smokers. The mean value of MVV differed significantly across the 3 groups, F (2, 627) = 416.01, p<0.001. Tukey's post hoc comparisons showed that all the 3 groups had significantly different means, with athletes having the highest and smokers lowest MVV.

DISCUSSION

COPD is a major cause of health care burden and the leading cause of death that is increasing worldwide. As COPD is overwhelmingly a disease of smokers, smoking and its associated addiction should be regarded as part of the disease process rather than strictly a risk factor. Accordingly, smoking cessation would assume a high priority and all smokers should be screened for disease progression by spirometry. Considering the smoking-induced inflammatory nature of COPD pathogenesis, higher levels of regular physical activity could reduce the risk of COPD by modifying smoking related lung function decline. Encouraging participation in sports has been recommended for smoking cessation programs. Several cross-sectional studies,[15,16] have reported that physically active adolescents are less likely to be regular smokers compared to sedentary youths. Population spirometric screening in middle-aged smokers proved to be an effective method for early diagnosis of COPD. Pulmonary function with decline in FEV1, FVC, FEV1/FVC% are considered to be predictors of success in smoking cessation.[16] The present study was aimed to compare the effect of smoking and athletic performance on pulmonary variables. The different pulmonary function variables studied in the present study were FEV1,FVC,FEV1/FVC,PEFR,MVV. FEV1 A low FEV1 predicts not only an increased rate of decline in FEV1, but also morbidity and mortality from smoking-related illness (COPD, lung cancer, cardiovascular diseases).The study done by Boskabady MH et al,[17] in Mashhad evaluated the lung function and respiratory symptoms in 176 smokers, found that all pulmonary function variables were reduced in smokers specially those indicating larger airways such as FEV1.The study also showed a negative correlation between pulmonary function variables with the amount and duration of smoking. As proved by Sunita Nigute et al,[18],in their study on pulmonary function of smokers and nonsmokers in a rural area of Gujarat, a significant association was found in all pulmonary function variables between the two groups with lesser values for smokers. The study done by De AK et al,[19] on lung functions of smoking and nonsmoking sportsmen found FEV1 significantly higher in nonsmoking sportsmen than smoking sportsmen. But the present study differed in the selection criteria for athletes, who were nonsmokers. Although Crapo RO et al,[20] Morris JF et al,[21] in their studies, have mentioned the decline in lung function to start at 15-20 yrs of age, also have found that the FEV1 continues to rise to the age of 25 years or even into the fourth decade. As a consequence, due to smoking during adolescence a lower maximum or peak level of FEV1 is achieved. In the study by Pelkonen M et al,[22] to describe the 30 year cumulative incidence of chronic bronchitis and COPD in relation to smoking habits, the presence of airflow obstruction was defined as a FEV1/FVC ratio < 70% the result of the study showed a cumulative incidence of c/c bronchitis and COPD were 42% and 32% respectively in continuous smokers as compared to 26% and 14 % in ex-smokers and 22% and 12 % in nonsmokers. The decrease in FEV1 attributable to chronic bronchitis was most pronounced in those with persistent symptoms and in smokers. The mean values of FEV1 in the present study was 3.12, 3.65, 4.02 litres (Table: 2) respectively in smokers, nonsmokers and athletes and showed a significant difference with (p<0.001) in comparison between the groups. This study in agreement with the previous studies showed a decreased value of FEV1 in smokers. In the study by

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Richa Ghay et al,[23] on BSF trainees in India found that mean FEV1 values were significantly higher after a training period of nine months. Accordingly, this study also showed a significantly higher value of FEV1 in athletes which could be due to an increase in the maximal shortening of the inspiratory muscles as an effect of training, which improves the lung function parameters.

FVC

The absolute volume of FVC is important because it is an index of the state of elastic property of respiratory system where as FEV1 a reflection of resistive property. In the present study the mean FVC is 3.37L for smokers, 3.81L for nonsmokers and 4.43L for athletes and the values were found to be highly significant ($p<0.01$) [Table: 3]. FVC was found to be highest in athletes. In the study done by Prateek Kumar et al,[24] on pulmonary functions of Indian sportsmen found that all the players had higher values of lung functions compared to the controls, thereby confirming that regular exercise has a facilitatory effect on the lungs. According to the study done by Rexhepi AM et al,[25] on 100 subjects of age 20-35 years, smokers had significantly lower values of FVC when compared to nonsmokers and sportsmen. Non-smokers had lower FVC than athletes but not statistically significant. But in the present study, all the three groups had significantly different FVC with the smokers having the lowest and the athletes having the highest. The significant difference between the lungs of smokers and nonsmokers could be explained with the functional and structural abnormalities that smoke cause on terminal bronchioles. The possible explanation for increase in pulmonary function variables in athletes could be that regular forceful inspiration and expiration for prolonged periods during physical activity lead to the strengthening of the respiratory muscles (both involuntary and voluntary). This maximum inhalation and exhalation is an important physiological stimulus for the release of lung surfactant and prostaglandins in to alveolar spaces thereby increasing lung compliance and decreasing bronchial smooth muscle tone respectively.

FEV1/FVC%

The mean values of the ratio in the present study were 92.41, 95.86 and 96.06 in smokers, nonsmokers and athletes respectively [Table 4]. Smokers had a significantly lower ratio when compared to the other groups. In the study done by Gold DR et al,[26] showed a significant difference in mean spirometric values of FEV1/FVC in smokers and nonsmokers of age-18-30 years. In our study mean FEV1/FVC ratio is lower in smokers than nonsmokers and athletes. The value was significantly higher in athletes in comparison to smokers and nonsmokers.

PEFR

PEFR is an effort dependent parameter emerging from the larger airways within about 100-120ms of the start of the forced expiration. Even in normal subjects the values may be variable as the parameter is entirely effort dependent resulting in a high intrasubject variability. Nevertheless, it remains an effective tool for assessing a limited aspect of ventilatory function.

The mean values of PEFR in the present study were 8.27, 8.98 and 9.64 l/s respectively in smokers, nonsmokers and athletes [Table 5]. In the study by Dixit MB et al,[27] on the factors affecting PFT, smokers were found to have lower PEFR over all age ranges. Bajentri AL et al,[28] studied the effect of 2-5 years of tobacco smoking on ventilatory function test and found tobacco smoking tends to have a definite tendency to narrowing of both the larger and small airways and significantly lower lung function.

MVV

Among the pulmonary function tests MVV is a parameter that reflects lung volume changes respiratory muscle functioning, compliance of thorax, lung complex & airway obstruction. Inspiratory muscle training increases contracted diaphragm thickness and increase lung volume capacities in healthy people.

In the present study mean values of MVV was found to be 116.63l/min for smokers, 128.32l/min for nonsmokers and 148.44l/min for athletes [Table 6] with athletes having the highest. Statistical analysis showed a highly significant $p<0.001$ value between the three groups. MVV reflects the ventilatory reserve available to respond to the increased physiologic demand during exercise. In a study done by Pitta F et al,[29] showed a significant correlation between MVV and a 6 minute walk test in daily life. Therefore, the fact that MVV is more responsive to exercise training suggests that this outcome has better predictive value to detect improvements in physical activity in daily life after pulmonary rehabilitation programs. Padmavathy KM et al,[30] in a study on beedi smokers and nonsmokers and found that MVV and FVC of beedi smokers are lower than those of nonsmokers possibly due to weakness of respiratory muscle strength and reduction in respiratory reserve . The prevalence of undetected persistent airflow limitation is high. Targeted screening therefore, especially in smokers needs to be considered. Since lung function declines with time, the best time to prevent morbidity and mortality from smoking-related illness should be early in life. The values of spirometric variables presented in this study for the smokers, nonsmokers, athletes might be helpful for the estimation of lung function, for the assessment of severity of disease, and for the assessment of degree of pulmonary dysfunction as a result of influence of smoking. The study also highlights the need to help young smokers quit the habit, by providing them healthy choices that may include physical activity, counseling and nicotine replacement therapy, among many others.

CONCLUSION

The spirometric variables FEV1, FVC was found to be significantly decreased in smokers. FEV1/FVC%

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is found to be lesser in smokers and nonsmokers than athletes. PEFR is found to be significantly reduced in smokers. MVV is significantly higher in athletes. Reducing smoking is a winnable battle with known, effective strategies for success. In view of the considerable increase in smoking among younger adults, determining the impact of smoking on this sector of population is of great public health importance. This study reinforces the idea that physical activity should be incorporated in the pulmonary rehabilitation programs apart from legislative measures like smoke free laws and tobacco taxation. Hence, understanding the early evolution of ventilatory impairment with screening tests is important for prevention of COPD as this disease develops gradually overtime and symptoms severe enough to raise concern appears at a late stage of the disease.

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