Comparative Study of Pulmonary Function Tests in Smokers and Non-Smokers

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Abstract

Objective : The present study was aimed to evaluate the influence of smoking on pulmonary functions. To study the differences in pulmonary function test values in smokers and non-smokers and their variation from other reported values for smokers by other studies. **Materials and Methods :** In cross sectional study spirometry data of 51 smokers & 54 non-smokers were collected by RMS Medispiror computerized spirometer. Expiratory flow volume curves were recorded & FVC, $FEF_{25-75\%}$, PEFR, FEV_1, FEV_1/FVC ratio were obtained. The data were compared between smokers and non-smokers group. **Results :** PFT parameters FVC, FEV_1, PEFR, $FEF_{25-75\%}$ and MVV were significantly reduced in smokers group compare to non-smokers group ($p< 0.05$). The PFT parameters markedly decrease with increase no. of cigarette smoked per day as well as increase duration of smoking. **Conclusion :** The present study brings out substantial variation in most of the parameters of PFTs between smokers and non-smokers confirming PFT values are less in smokers due to toxic effects of tobacco smoking on respiratory system & is the major cause of obstructive lung disease in Indian population.

Key Words : Pulmonary function test, Smokers, Non-smokers

Introduction :

The use of tobacco leaf to create and satisfy nicotine addiction was introduce to Columbus by native Americans and spread rapidly to Europe. The use of tobacco however is predominantly a twentieth century phenomenon, as is the epidemic of disease cause by this form of tobacco. [1]

Tobacco smoking is menace & contagious problem. Every effort is being made at government level to stop smoking. Even it has been declared as a crime & punishable act. Ordinance about penalty to cigarette smokers has been passed but in spite of all cigarette smokers are still flourishing.

Tobacco smoking is an intentionally invited health hazards.

The UN health agency reports that about 4.9 million people die each year across the globe due to cigarette smoking. [2] The overall death rate for male smokers is 70% greater than that for male non-smokers. In United States 4, 40,000 premature deaths are attributed to tobacco smoking, trends are reversed, the figure expected to rise to 10 million deaths per year by 2020 or early 2030 [3] with 70% of those death occurring in developing countries.

Tobacco smoke contains no. of substances which may exert some effects upon body. During burning of tobacco in cigarettes various processes such as pyrolysis, prosynthesis, distillation, sublimination, hydrogenation, oxidation, decarboxylation, dehydration result in generation of more than 4000 identifiable compounds present in tobacco itself or new compound generated thereof. The smoke is composed of a fine aerosol with a particle size distribution predominantly in the range to deposit in the airways and alveolar surface of lung and vapour phase.

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They include particles of smoke dust which disturb the function of respiratory airways, tars which exert an irritant effect upon bronchial epithelium (tar is the aggregate of particular matter after subtracting nicotine and moisture) and nicotine which increase heart rate and elevate systolic blood pressure. The tobacco smoke inhalation causes an immediate rise in the airway resistant which persist for at least an hour. This is due to vagally mediated smooth muscle constriction presumably by way of stimulating submucosal irritant receptors.Experimental studies have shown that prolong cigarette smoking impairs cilliary movements, inhibition of function of alveolar macrophages leads to hypertrophy and hyperplasia of mucus secreting glands. It is probable that smoke also inhibits antiproteases and causes polymorphonuclear leucocytes to release proteolytic enzymes acutely.

Cigarette smoking is by far the most important risk factor for COPD and most important that tobacco contributes risk of COPD. [4]

Cigarette smokers have higher prevalence of respiratory symptoms, pulmonary function abnormality and greater annual rate of decline in FEV_1 and greater COPD mortality rate than non-smokers. [5] The ratio of FEV_1 to FVC is significantly reduced in smokers.

Smoking leads to rapid decline in pulmonary function test specially those indicating diameters of airways such as forced expiratory flow in one second (FEV_1). [6] Even in teenagers who have smoked only for few years, maximum expiratory flow volume curves demonstrate decrease in flow rate at small lung volumes [7] yet another expression of airway obstruction.

If smoking causes changes in small airway calibre at such an early age one might expect that smoking also causes acute changes in these small airways. The changes in small airways may disappear completely after cessation of smoking. Although smoking cessation does not result in complete reversal of more pronounced obstruction. There is significant slowing of decline in lung function in all smokers who give up

cigarettes. Lung function tests are powerful tool in the assessment of respiratory condition. It is probably inappropriate to diagnose an obstructive airway disease without measuring airflow as it is so diagnose hypertension without measuring blood pressure. In addition to helping with the diagnosis lung function test can help to make an objective assessment of severity and monitor the response to treatment.

Expiratory flow rate are important for diagnosis, prognosis and therapeutic evaluation of COPD. Forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) help to distinguish between obstructive and restrictive lung disorder.

Forced expiratory flow between 200 1200 ml ($FEF_{200-1200}$), between 25 75% ($FEF_{25-75\%}$) and between 75 85% ($FEF_{75-85\%}$) of forced vital capacity are three such important dynamic lung function test which are used to assess the patency of respiratory airways. The values of their flow rates are known to decrease not only in COPD but also in otherwise healthy smokers. Airway obstruction in cigarette smokers is diagnosed relatively late. Earlier detection of airflow obstruction and smoking cessation may result in significant health gain. If cigarette smokers stop smoking peak expiratory flow rates improve with passage of time.

Keeping in mind, the huge physiological and clinical importance I decided to carry out this study. In present study the pulmonary function test of smokers were compare with non-smokers. So, it is expected that this knowledge will help in forming the norms of ventilator functions of Indian subject by giving due weightage to the interfering effect of smoking.

Aims and objective :

The aims and objective of my study includes

1. To study the influence of smoking on pulmonary functions.
2. To study the differences in pulmonary function test values in smokers and non-smokers and their variation from other reported values for smokers by other studies.
3. To study the type of ventilatory impairment caused by smoking viz. obstructive, restrictive or mixed type.
4. To establish normal standards in healthy non-smoker adults.
5. To use pulmonary function test as a tool to identify the quantum of damage to the respiratory tree.
6. To improve the health status of community by inculcating the knowledge about hazards caused by smoking.

The pulmonary function test laboratory has been established and conducted by physiology department of All India Institute of Medical sciences and at physiology department of so many medical colleges. The aim of current study is to be expertise in pulmonary function test and the laboratory of pulmonary function test should be started at our Physiology department and to do some counselling of subjects with tobacco smoking to stop it. The aim of this study is to provide the calculated and measured values about the damage incurred by smoking on respiratory health. Only by this information the smokers can abstain from smoking.

Methodology

The subjects selected for present study were recruited from medical outpatient department at our institution.

Fifty one subject comprised smokers group and fifty four subjects for non-smoker group.

Selection criteria :

The random sample of fifty one smokers and fifty four nonsmokers selected fulfilled the following criteria.

1. ***Non-smokers :***

   According to definition non-smoker is a person who does not smoke tobacco. [8] The person under study was not dwelling in the home where their spouse or other family members were smokers of hookah, cigarette, cigar or bidi. In other words they were not passive smokers. [9] A passive smoker refers to exposure to tobacco consumption products from smoking of others. [10]

2. ***Cigarette smokers :***

   They are persons who are engaged in the inhalation and exhalation of fumes of burning tobacco in cigarettes. By definition, cigarette smokers are the person who inhale, exhale and burn or carry any lightened cigarette. Every smoker must have been smoked at least five cigarettes a day.

Exclusion criteria :

The following groups of persons were not included in the study.

1. Females were not included in this study.
2. The known case of bronchial asthma.
3. The person who were morbid or have full fledged picture of core pulmonale on clinical examination.
4. The person who work in textile mills or other places where lungs are affected by dust or fumes.

- Each person fulfilling the inclusion criteria was included in the study. Clinical history was taken, enquiry was made of their smoking habits and height

and weight were measured in cm. and kg. Respectively.

- All the tests were done between 10:00 to 17:00 hours to avoid possible diurnal variation. Each person was allowed to rest for about two minutes before the actual test. The details of the test were explained and demonstrated to each of them. All the measurements were recorded with the subject in standing position and wearing nose clips. [11]
- Expiratory flow volume curves were recorded by a spirometer (RMS Medispiror, Helios lung function test, Recorders and Medicare system (P) Ltd. Model: RMS Helios 401) and FVC, FEF $_{25-75\%}$, PEFR, FEV_1, FEV_1/FVC ratio were obtained. The person was asked to take deep inspiration from outside and then to expire as forcefully and as fast as he can inside the mouthpiece. The value of forced vital capacity in litres was obtained from the graph.
- Various pulmonary function test included in the assessment of

1) Vital Capacity (forced vital capacity- FVC): the person was asked to take deep inspiration from outside and then to expire in the spirometer as forcefully and as fast as possible. The graph was recorded and value obtained.
2) Peak expiratory flow rate (PEFR): The person was asked to take deep breath and exhale as forcefully as possible in to the mouthpiece in a single blow.
3) Forced expiratory flow ($FEF_{25-75\%}$): This is the average rate of air flow between 25% and 75% of total air flow.
4) FEV_1 (forced expiratory volume in first second): It is the fraction of FVC expired during the first second of the forced expiration. Normally at least 80-83% of the forced vital capacity can be expired in first second.
5) FEV_1/FVC ratio: forced expiratory volume in first second expressed as a percentage of FVC.

Results

105 males, 51 smokers and 54 non-smokers matched for age, height, weight, socioeconomic status and physical activity completed this study.

The number of cigarette smoked per day among 51 smokers: 21 smoked average 5 cigarettes per day, 20 smoked average 15 and 10 smoked average 25 cigarettes per day. Duration of smoking among 51 smokers was more than 10 years.

The values of different parameters of pulmonary function tests in smokers were compared with non-smokers i.e. the control group, the results of which are discussed below in the sequence.

Table 1 : Anthropological details of study participants (n=105)

No.	Variable	Frequency	Percentage
1	Age (in Years)		
	41-50	33	31.4
	51-60	35	33.3
	61-70	31	29.5
	>70	06	5.71
2	**Height (in Centimetres)**		
	≤ 160	21	20
	161 – 170	62	59
	≥ 171	22	20.9
3	**Weight (in Kg.)**		
	60	49	46.6
	61-75	40	38
	76	16	15.2

Table 2 : Comparison of various pulmonary function tests between smokers and non-smokers

Sr. No.	Pulmonary function test		Non-smokers	Smokers	P Value
1	FVC (L)	Mean	2.85	1.71	P<0.05
		S.D.	0.57	0.60	
2	FEF $_{25-75}$ (L/S)	Mean	2.77	1.27	P<0.05
		S.D.	1.05	0.52	
3	PEFR (L/S)	Mean	5.93	3.07	P<0.05
		S.D.	1.92	1.68	
4	FEV1 (L)	Mean	2.40	1.20	P<0.05
		S.D.	0.51	0.39	
5	FEV_1/FVC (%)	Mean	84.64	72.15	P<0.05
		S.D.	9.35	14.28	

The difference in values of FVC, $FF_{25-75\%}$, PEFR, FEV_1, FEV_1/FVC ratio observed in two groups was significant (P less than 0.05).

Table 3 : Effect of No. of cigarette smoked per day on Pulmonary function test

Sr. No.	Pulmonary function test		Cigarettes per day			P value
			1-10	11-20	21-30	
1	FVC (L)	Mean	1.97	1.61	1.33	P<0.05
		S.D.	0.63	0.56	0.33	
2	FEF 25-75 (L/S)	Mean	1.27	0.87	0.80	P<0.05
		S.D.	0.60	0.39	0.41	
3	PEFR (L/S)	Mean	3.16	3.10	2.79	P<0.05
		S.D.	1.30	2.26	1.02	
4	FEV1 (L)	Mean	1.40	1.09	0.99	P<0.05
		S.D.	0.41	0.32	0.31	
5	FEV1/FVC (%)	Mean	73.57	69.76	73.94	P>0.05
		S.D.	17.14	13.15	9.69	

The values of FVC, $FF_{25-75\%}$, PEFR, FEV_1 were significantly reduced with increase no. of cigarette smoke per day (P less than 0.05) while FEV1/FVC ratio did not show much difference (P>0.05).

Table 4 : Effect of Duration since smoking on pulmonary function tests

Sr. No.	Pulmonary function test		Duration of smoking (years)			P value
			11-20	21-30	≥31	
1	FVC (L)	Mean	1.91	1.75	1.50	P<0.05
		S.D.	0.40	0.71	0.53	
2	FEF_{25-75} (L/S)	Mean	1.19	1.01	0.93	P<0.05
		S.D.	0.45	0.44	0.65	
3	PEFR (L/S)	Mean	4.05	2.74	2.87	P<0.05
		S.D.	2.00	1.46	1.58	
4	FEV_1 (L)	Mean	1.39	1.23	1.05	P<0.05
		S.D.	0.26	0.42	0.38	
5	FEV_1/FVC (%)	Mean	74.48	72.16	70.70	P<0.05
		S.D.	15.14	12.76	16.05	

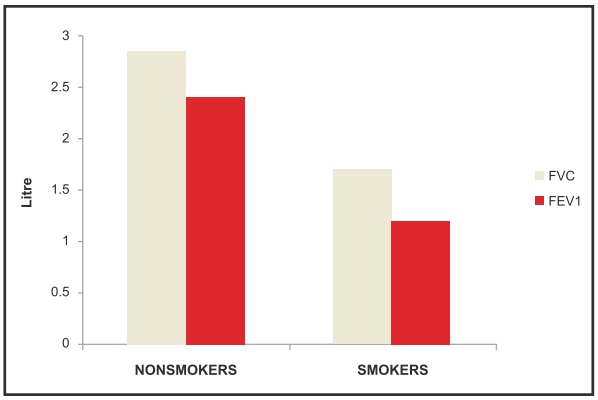
Significant decrease in pulmonary function test values was found with increased duration since smoking (P<0.05).

Table 5 : Comparison of various pulmonary function tests among smokers and non-smokers in relation to different age groups

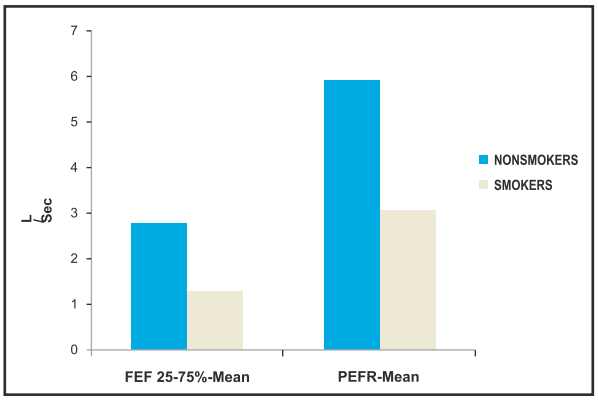
Sr.No.	Variable	Age group (in years)	Non-smokers		Smokers		P value
			Mean	S.D.	Mean	S.D.	
1	FVC(L)	41-50	2.87	0.47	1.70	0.46	<0.05
		51-60	2.86	0.43	1.66	0.43	
		61-70	2.87	0.47	1.71	0.46	
2	FEF 25-75 (L/S)	41-50	2.80	0.89	1.04	0.43	<0.05
		51-60	2.75	0.86	1.03	0.42	
		61-70	2.78	0.86	1.03	0.40	
3	PEFR (L/S)	41-50	5.97	1.59	3.05	1.22	<0.05
		51-60	5.90	1.52	3.04	1.20	
		61-70	5.54	1.61	3.07	1.24	
4	FEV1(L)	41-50	2.42	0.38	1.20	0.33	<0.05
		51-60	2.41	0.36	1.18	0.33	
		61-70	2.42	0.38	1.20	0.33	
5	FEV1/FVC (%)	41-50	84.78	8.08	72.31	11.76	<0.05
		51-60	84.46	8.03	72.73	11.39	
		61-70	84.67	7.76	72.15	11.36	

Comparing mean observed forced vital capacity, FEF_{25-75}, PEFR, FEV_1, FEV_1/FVC ratio of smokers and non-smokers in different age group significant difference in the values of all PFTs were observed in smokers (P<0.05).

Graph 1 : Forced vital capacity and forced expiratory volume in first second in smokers and nonsmokers



Graph 2: Forced expiratory flow between 25% to 75% and peak expiratory flow rate in smokers and nonsmokers



Discussion

105 males, 51 smokers and 54 non-smokers matched for age, height, weight, socioeconomic status and physical activity completed this study.

The number of cigarette smoked per day among 51 smokers are 21 smoked average 5 cigarettes per day, 20 smoked average 15 and 10 smoked average 25 cigarette per day. Duration of smoking among 51 smokers was more than 10 years.

The values of different parameters of pulmonary function tests in smokers were compared with non-smokers i.e. the control group. The results showed statistically highly significant decrease in FVC, FEV_1, FEV_1/FVC ratio, PEFR, $FEF_{25-75\%}$ among smokers compare to non-smokers. In the present study the effect of quantity and duration of smoking on various PFTs were also examined which showed strong correlation between impairment of pulmonary functions and duration since smoking and no. of cigarettes smoked per day. Wihelmensen and Tibblin [12] have reported that the lung function tests show uniform tendency of deterioration with increasing tobacco consumption. M.S. Islam et al [13] studied changes of ventilator functions among smokers and non-smokers and observed fall in FVC amongst the smokers. Also the MEF25-75% was markedly diminished amongst smokers. In a study by E Hnizdo [14], in a population of gold miners, none of the subjects who died from COPD were non-smokers; an interaction between smoking history and dust exposure in determining COPD mortality was found. In recent time Anand kumar et al [15] conducted study among smokers and non smokers and concluded that the actual values of FVC, FEV1, ratio of FEV1/ FVC, FEF25-75% and PEFR are decreased in smokers compared to non smokers and all the values are more decreased with increase in duration of smoking and increase in number of cigarettes smoked per day. These showed a dose response relationship. Hani A et al [16] conclude in their study of pulmonary function test among smokers and non-smokers that mean FVC, FEV1 and PEFR were higher in non-smoker in each age group and BMI was not significantly associated with the most of spirometric values.

Conclusion & Recommendation

During last few decades pulmonary function tests evolved from tools for physiologic studies to clinical investigation in assessing respiratory status. They also become a part of routine health examination in respiratory, occupational, sports medicine and public health screening.

FVC, FEF_{25-75}, PEFR, FEV_1, FEV_1/FVC ratio were the pulmonary function tests selected for the present study. A permanent record of spirogram of all the subjects was obtained on a graph paper with the help of spirometer.

Observations were made for the effects of cigarette smoking on pulmonary function in 51 smokers in comparison with 54 non-smokers. Normal standards for the healthy non-smoker adults were established.

FEF_{25-75}, PEFR and FEV_1 values were found to be significantly lower in smokers than in non-smokers. FVC and FEV_1/FVC ratio were also found to be decrease in smokers.

Gradually with increasing age all parameters of pulmonary function tests were markedly lower in smokers compare to that in non-smokers.

Decline in all parameters of pulmonary function tests were seen when there is an increase in no. of cigarette smoked per day as well as increase duration of smoking. This suggests that severity of COPD directly proportional to no. of cigarette smoked per day and duration of smoking.

This pulmonary function test analysis proved that pulmonary function decrease in smokers with increasing age, no. of cigarette or bidis smoked per day and duration of smoking.

Finally it may be concluded that smoking causes definite pulmonary function impairments specially the obstructive type.

References :

1. Harrison's principles of Internal Medicine. Vol.2, 15th edition, p.2574
2. Fellows JL: Annual smoking attributable mortality, years life lost and economic costs United States, 2002; 51-300
3. WHO A global status report Anonymous, Tobacco or health; World Health Organization Geneva 1997; 115-117
4. Auerbach O, Harmmond EC, Garfinkel L, Bennate C: Relation of smoking and age to emphysema. Whole lung section study. N. Eng. Journal Medicine, 1971.286(16), 851-853
5. Lebowitz MD, Burrows B, Quantitative relationships between cigarette smoking and chronic productive cough. International Journal of Epidemiology 1977; 6(2), 107-113
6. Burrows B,Kunson R J, Cline MG, Lebowitz MD, Quantitative relationships between cigarette smoking and ventilator function. Am. Rev. Respir. Dis. 1977, 115(2), 195-205
7. Seely J E, Zuskin E, Bomuy's : Acigarette smoking objective evidence of lung damage in teenagers science 1971, 172(984), 741-743
8. The American Heritage. Dictionary of the English Language, Fourth edition. 2000: Houghton Mifflin Company updated in 2003, p.957.
9. Hanrahan JP and Wress ST. Environmental tobacco smoke Harber's occupational and environmental respiratory diseases. St. Lunis Mosby. 1996, 767-783.
10. Golding John F smoking. In Respiratory Medicine. Gibson GJ Saunders Elsevier Science Ltd. 3rd ed. 2003; 1:665.
11. Standardization of spirometry, 1994. Update. American Thorasic Society. Am. J. Respir. Crit. Car MED. 1995; 152(3)1107-36.
12. Wilhelmensen L. And G. Tibblin: Tobacco smoking in fifty year old man. Respiratory symptoms and ventilatory function tests. Scand. J. Resp. Dis. 47: 121, 1966.
13. M.S. Islam, P.K. Dutta, D.K. Mitra and M.K. Chakraborty: Changes of ventilatory functions among smokers and non-smokers. Ind. J. Of Physiology and Pharmacology. July 1970 vol.14, no.3, 165-173.
14. E Hnizdo: Combined effect of silica dust and tobacco smoking on mortality from cold in Gold miners. Br. J. Ind. Med. 47: 656-664, 1990.
15. Anand Kumar, Harika Priyadarshini, Prathyusha, Prashanth Kumar: A comparative Study of Pulmonary Function Tests in Tobacco Smokers and Non-smokers. Int J Biol Med Res. 2013; 4(4): 3570-3572.
16. Hani A. Nawafleh, Shalabia A- Sayed Abo Zead, Dua'a Fayez Al-Maghaireh: Pulmonary Function Test: The value among smokers and non-smokers. Health Science Journal. Volume 6, Issue 4 (October December 2012).