Indian J Physiol Pharmacol 2012; 56(2) : 154–160

A STUDY OF DETERIORATION OF PULMONARY FUNCTION PARAMETERS AMONG SMOKERS AND RECOVERY AMONG EX-SMOKERS IN BUS DEPOT WORKERS

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(Received on November 22, 2010)

Abstract : Smoking has deleterious effects on Pulmonary Function Test (PFT) parameters; however, evidences about recovery in ex-smokers are ambiguous. Therefore present study was conducted to quantify relative deterioration of PFT parameters and to assess reversibility of the same. A cross-sectional study was conducted on 84 bus-depot workers consisting of equal number of smokers, ex-smokers and non-smokers. PFT observations were obtained using Medspiror following standard methods and precautions. Comparisons among three groups were performed employing one-way ANOVA and post-hoc tests. There were substantial effects of smoking on PFT parameters (deterioration was up-to half). Partial recovery was found in all the parameters of ex-smokers. Frequency and duration of smoking were negatively correlated with some of the parameters. In conclusion, present study has demonstrated considerable deterioration of PFT parameters in smokers and indications of recovery in ex-smokers. Further detailed study with larger sample size and stricter definition of ex-smokers is recommended.

Key words : PFT parameters, smoking, reversal of effect, depot workers, Mysore

INTRODUCTION

Smoking has extensive deleterious effects on respiratory functions and is clearly implicated in the etiology of a number of respiratory diseases. More than 2000 potentially noxious constituents have been identified in tobacco smoke, many of which are potential carcinogens (1). Chronic bronchitis, so common among habitual smokers is not as trivial as it was thought. When it persists for years, it may progress to Chronic Obstructive Pulmonary Disorder (COPD), Corpulmonale and Metaplasia of respiratory epithelium, providing a rich soil for cancerous transformations. Epidemiological and clinical observations establish a positive relationship between smoking and lung cancer, which is overwhelming (2).

Smoking is a major risk factor for

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developing COPD. Early diagnosis of COPD is crucial to decrease the rates of morbidity & mortality. It is an established fact that smoking causes inflammation of the air ways & impairment of the lung functions. However the quantum of deterioration in different Pulmonary Function Test (PFT) parameters has great scope for variation. One of the factors that may influence the impact of smoking on the PFT parameters is their occupational exposure. Another question that is, yet to be answered is, whether the PFT parameters return back to normal once a smoker quits smoking. There are only a few studies to state if the negative effect of smoking remains even after a smoker quits this habit. Evidences about the PFT parameters returning back to normal in ex-smokers are ambiguous. Therefore the objectives of the present study were (a) to quantify the relative deterioration of various PFT parameters due to smoking, (b) to study whether the impact of smoking on PFT parameters is reversible, and (c) to assess the correlation present if any, between the various exposure (smoking) and outcome (PFT) parameters.

MATERIALS AND METHODS

It was a cross-sectional comparative study of PFT parameters in three groups viz, smokers, ex-smokers and non-smokers. First group included the subjects who were currently smoking and have smoked at least 5 pack-years. Second group included those who had smoked at least 5 pack years in the past and have quit smoking minimum one year before this study (3). Third group consisted of those who did not smoke at all.

Age and sex are almost universal predictors of any biological phenomena. Further, in case of PFT, occupation is an important potential confounder. Therefore, we restricted the study to male workers working in KSRTC bus depot located in Mysore, between the age group of 30-50 years. The study was approved by the Institutional Ethical Committee of JSS Medical College, Mysore.

Sample size and sampling

The estimation of sample size was based on determination of a difference of 10% in the mean value of different PFT parameters at 5% level of significance and 90% power. Using the mean and standard deviation (SD) for normal controls provided by Mehrotra et al (4), the required sample size was estimated to be at least 28 in each group. As the depot workers are mobile, it was very difficult to prepare a sampling frame and perform simple random sampling; we selected the subjects in the three groups according to convenience sampling.

Inclusion criteria

For smokers	: Current smokers in the age group of 30-50 years who have smoked at least 5 pack years
For Ex smokers	: Persons in the same age group who had smoked atleast 5 pack years and had quit smoking minimum one year before the study.
For non smokers	: Bus depot workers between 30-50 years who had not smoked at all.

All the three groups were exposed to the same environment.

Exclusion Criteria : For all the three groups:
Subjects with respiratory and cardiac illness
Occasional smokers

Collection of data

We visited the depot and considered the workers available. The purpose, procedure and importance of the study were thoroughly explained to the workers and their informed consent was obtained. Data on age, sex, smoking status and the history of respiratory or cardiac illness was collected to decide the eligibility of the subjects for inclusion in one of the three groups. Subsequently, the data on height, weight, frequency and duration of smoking and PFT parameters were recorded. Body Mass Index (BMI) was derived by dividing the weight in kgs by the square of height in meters. Smoking history was calculated in pack-years as the product of tobacco use in (years) and the average number of cigarettes smoked per day and dividing the product by 20 (years x cigarettes per day/20) (5).

PFT observations

It was performed with the help of Medspiror, an electronic PFT machine which is a type of flow sensing spirometer (6). Standard methods and precautions outlined in American Thoracic Society (ATS) 1994 update were followed. The parameters of PFT studied, included Forced Vital Capacity (FVC), Forced Expiratory Volume in first second (FEV_1), Forced Expiratory Flow ($FEF_{25-75\%}$) and Peak Expiratory Flow Rate (PEFR), and Maximal Voluntary Ventilation (MVV). The respiratory maneuvers were demonstrated to each subject before the test. Three reproducible tests were carried out for each measurement & the best result was selected for statistical analysis.

Statistical analysis

We estimated the mean and standard deviation to assess the level of various PFT parameters in the 3 groups and subsequently the relative deterioration among smokers and recovery among quitters was worked out in percentages. In order to compare the level of pulmonary function parameters in the 3 groups (smokers, ex-smokers and non smokers), one way analysis of variance (ANOVA) was applied at 5% level of significance followed by post-hoc tests in case of significant ANOVA test. To assess the linear relationship between different exposure and outcome parameters, Pearson's correlation coefficients were worked out and their statistical significance was tested using t-test. Data entry and statistical analyses were performed using MS-Excel and Epi-Info package respectively.

RESULTS

Basic characteristics of the subjects (Table I)

In order to assess the comparability of three groups, we compared basic parameters, namely, age, height and weight, with main focus on age which is an independent predictor in any biological phenomena. Average age of the subjects in the three groups was 43-48 years with no statistically significant difference among the groups. Similarly average height (163-166 cms) did not depict any significant difference among three groups. In case of weight, there was significant difference between smokers and

non-smokers. However, ex-smokers did not differ significantly from any of other two groups. Consequently, BMI of non-smokers was higher than that of smokers but not significantly different for ex-smokers.

Effect of smoking on PFT parameters (Table II)

Comparison of various PFT parameters under study along with the results of ANOVA and post-hoc tests has been presented in Table II. There appeared to be quite a substantial and statistically significant effect of smoking on the pulmonary functions. All the parameters were found to be deteriorated among smokers compared to non-smokers with statistically significant differences ($p<0.001$). The deterioration of the parameters due to smoking varied from a low of 22% in case of MVV to a high of 47% in case of FVC.

Recovery among ex-smokers (Table II)

It was found that among ex-smokers, there was recovery in all the parameters. However, in case of $FEF_{25-75\%}$ and MVV, the differences between current smokers and ex-smokers were not statistically significant. Regarding quantum of recovery, it was highest in case of FVC followed by FEV_1, $FEF_{25-75\%}$ and PEFR.

Correlation between different exposure and outcome parameters (Table III)

We studied the linear relationship between different measures of exposure, namely, duration, frequency and pack-years of smoking and the measures of outcome

TABLE I: Mean and Standard Deviation (SD) of various anthropometric parameters among the three groups (each 28) along with the results of ANOVA and post-hoc tests

Parameters	*Smokers*	*Ex-smokers*	*Non-smokers*	*p-value*
	Mean±SD	*Mean±SD*	*Mean±SD*	
Age (years)	44.6±8.7	48.3±8	43.3±7.7	0.068
Height (cms)	163.1±5.7	166±8.7	163.8±4.1	0.227
Weight (kgs)	63.3±10.0	64.8±10.0	70±9.0*	0.029
BMI (kg/m^2)	23.8±3.5	23.5±3.4	26.1±3.4*#	0.010

*Significantly different from Smokers ($p<0.05$); #Significantly different from Ex-smokers ($p<0.05$).

TABLE II: Mean and Standard Deviation (SD) of various PFT parameters among the three groups (each 28) along with the results of ANOVA and post-hoc tests.

Parameters	*Smokers*	*Ex-smokers*	*Non-smokers*	*p-value*
	Mean±SD	*Mean±SD*	*Mean±SD*	
FVC (ltrs)	1.91±0.606	2.99±0.744*	3.63±0.585*#	0.000
FEV_1 (ltrs)	1.74±0.518	2.72±0.735*	3.18±0.668*#	0.000
$FEF_{25-75\%}$ (ltrs/min)	2.75±0.908	3.31±1.188	4.17±1.044*#	0.000
MVV (ltrs/min)	91.68±21.09	90.11±25.31	118.1±21.96*#	0.000
PEFR (ltrs/min)	5.44±1.411	6.44±1.400*	7.58±1.574*#	0.000

*Significantly different from Smokers ($p<0.05$); #Significantly different from Ex-smokers ($p<0.05$).

TABLE III : Pearson's correlation coefficient (r) between different exposure and outcome parameters under study along with p-values for the statistical significance.

Exposure parameters	*Outcome parameters*	*Smokers*		*Ex-Smokers*	
		r	*p-value*	*r*	*p-value*
Frequency	FVC	0.193	0.326	–0.16	0.417
	FEV_1	0.263	0.176	–0.188	0.338
	$FEF_{25-75\%}$	0.374	0.050	–0.471	0.011
	MVV	0.091	0.645	–0.456	0.015
	PEFR	0.078	0.693	–0.274	0.159
Duration	FVC	–0.104	0.597	–0.412	0.029
	FEV_1	–0.052	0.791	–0.352	0.066
	$FEF_{25-75\%}$	–0.042	0.832	–0.058	0.770
	MVV	–0.271	0.163	–0.021	0.916
	PEFR	0.158	0.423	–0.208	0.288
Pack years	FVC	0.123	0.532	–0.507	0.006
	FEV_1	0.221	0.258	–0.469	0.012
	$FEF_{25-75\%}$	0.322	0.095	–0.466	0.013
	MVV	–0.219	0.263	–0.336	0.080
	PEFR	0.348	0.070	–0.401	0.034

consisting of PFT parameters. No significant correlation was observed among current smokers. However, many statistically significant correlation coefficients were noticed among ex-smokers. Frequency of smoking was significantly correlated with $FEF_{25-75\%}$ and MVV. Duration of smoking was significantly correlated with FVC. Pack-years of smoking which is a combination of other two exposure variables, was significantly correlated with most of the PFT parameters. All the significant correlations were negative indicating that higher the exposure of smoking, lower is the value of PFT parameter.

DISCUSSION

Respiratory disorders develop much earlier and therefore respiratory morbidity is also higher in smokers (7). It is a known fact that pulmonary function values are influenced by many socio-demographic, physiological and environmental factors like race, age, sex, height, weight & other unknown variables having a wide range of normal values (8). However, these exposures are by and large irreversible and therefore the risk is difficult to avoid. On the other hand, the role of smoking in the impairment of ventilatory functions is also an established fact but the same is potentially reversible. Hence this study was conducted with the main emphasis on the assessment of reversibility of the deterioration in PFT parameters.

Three groups under study were comparable on gender, occupational exposure and basic physiological parameters except that average weight and BMI were higher among non-smokers compared to other groups. We also know that if there is any correlation between BMI and PFT parameters, it is negative. Thus higher BMI

may result in reduction in the values and therefore significant differences observed may not be explained by the differences in BMI.

This study has substantiated the findings of other studies (9-11) that tobacco smoking has an impact on all the PFT parameters and the resultant deterioration may be due to the carbon monoxide, tar and other toxic contents of tobacco smoke adversely affecting the alveoli (12). The lower values of FVC, FEV_1, and $FEF_{25-75\%}$ in smokers when compared with non smokers were also observed in a study conducted on workers exposed to dust and fumes (7). The statistically significant reduction in values of FVC suggests that smoking is an initial step contributing to the development of COPD by causing narrowing of the airways. Reduction in $FEF_{25-75\%}$ values can be used as a screening measure to detect airway narrowing. $FEF_{25-75\%}$ values are known to decrease in early COPD (13) which is demonstrated in our study also. Analysis of relation between smoking state and ventilatory functions disclosed significant reduction of PEFR in current smokers .Some studies have reported a relationship between narrowing of small airways and a decrease in FEV_1, which was observed in our study also.

Smoking is associated with abnormalities of airway structure (11). The significant correlation of MVV with the frequency of smoking indicates the proportionate degree of weakness of respiratory muscles and reduction in respiratory reserve in ex smokers. This is similar to the observation made by an ICMR study which states that there is a reduction in MVV in direct proportion to the degree of weakness of respiratory muscles in malnourished patients (14).

Though some studies have suggested that ex smokers still show lung damage and the negative effect remains even after a smoker quits (15), our study revealed recovery in all the pulmonary functions in ex smokers. But still these lung functions were significantly below that of the non smoking group. These findings are similar to another study where ex smokers had better lung function values than smokers, but their mean curves were below the values of non smokers (9). Another study conducted on elderly men had also reported recovery of PFT parameters in ex-smokers (16).

Recovery however depends on many factors, such as, duration, frequency and type of smoking before quitting and the resultant deterioration, duration since quitting and many other life style related factors. It was not possible to consider these factors in the present study given the sample size which was estimated to be enough to detect the difference in different groups. Therefore a further study with the larger sample size incorporating associated factors may be recommended. It may be noted that behavior of tobacco use is a habit very difficult to change, even with medicinal aids for cessation. Only a small proportion of smokers stop smoking successfully on their own. Therefore, once established, the facts about recovery after quitting the habit may be important information useful for counseling the smokers for quitting the habit.

Conservatism is an important issue in any study related to smoking. Generally the smokers are expected to be conservative in

reporting the duration and frequency of smoking. This is more so in case of ex-smokers. There is a possibility that a person claiming to have quit the habit, smokes occasionally. This might have had an impact on the findings about the reversibility of the deterioration in the PFT parameters. Therefore the estimate of quantum of reversibility reported by present study may be the conservative one. More stringent criteria in selecting ex-smokers may resolve the issue of conservatism in reporting.

In conclusion, this study has demonstrated the substantial deterioration of pulmonary functions in smokers and the indications of recovery among ex-smokers. However, in view of the limitations and potential biases, there is a possibility of conservatism in the estimates of deterioration and recovery. Therefore, we recommend further active research with larger sample size taking into account the quantum of exposure and duration of quitting. This may possibly establish the recovery of PFT parameters among ex-smokers, a very important fact from public health policy point of view.

REFERENCES

1. Nunn J.F. Nunn's Applied Respiratory Physiology, Fourth edition Butterworth – Heinemann publications. 1993; 378–379.
2. Vinay Kumar, Abdul K. Abbas, Nelson fausto. Robins & Cotran Pathologic basis of Disease 7th edition. Saunders, Noida, New Delhi, 2008; 758–759.
3. Mwaiselage J, Bratveir M, Moen BE, Marshalla Y. Respiratory symptoms and chronic obstructive pulmonary disease among cement factory workers. *Scand Work Environ Health* 2005; 31: 316–323.
4. Mehrotra PK, Varma N, Tiwari S, Kumar P. Pulmonary functions in Indian Sportsman playing different sports. *Indian J Physiol Pharmacol* 1998; 42: 412–416.
5. Hideo kobayashi, Soichiro Kanoh, Kazuo motoyoshi. Serum surfactant protein, but not Surfactant protein-D or KL-6, can predict preclinical lung damage induced by smoking. *Biomarkers* 2008; 13: 385–392.
6. American Thoracic Society (ATS). Standardisation of spirometry 1994 update. *Am J Respir Crit Care Med* 1995; 152: 1107–1136.
7. Viju T Mhase, Reddy PSN. Effect of smoking on lung functions of workers exposed to dust and fumes. *Indian Journal of Community Medicine* 2002-03; 27: 26–29.
8. Lakhera SC, Kain TC. Comparison of Pulmonary function amongst Ladhaki, Delhi, Varanasi and Siddi boy atheletes. *Indian J Physiol Pharmacol* 1995; 39: 255–258.
9. Gregg I, Nunn AJ. Peak expiratory flow in symptomless elderly smokers and ex smokers. *Br Med J* 1989; 298: 1071–1072.
10. Stanescu D, Sanna A, Veriter C, et al. Airways obstruction, chronic expectoration and rapid decline of FEV1 in smokers are associated with increased levels of sputum neutrophils. *Thorax* 1996; 51: 267–271.
11. Wright JL, Lawson LM, Pare PD, Wiggs BJ, Kennedy S, Hogg JC. Morphology of peripheral airways in current smokers and ex-smokers. *Am Rev Respir Dis* 1983; 127: 474–477.
12. Craig PJ, wells AU, Doffman S, et al. Desquamative interstitial pneumonia, Respiratory bronchiolitis and their relationship to smoking. *Histopathology* 2004; 45: 275–282.
13. Santos S. Peinado VI, Ramirez J, et al. Characterization of pulmonary vascular remodeling in smokers and patients with mild COPD. *Eur Respir J* 2002; 19: 632–638.
14. Arora NS Rochester DF. Respiratory muscle strength and maximal voluntary ventilation in under nourished patients. *Am Rev Respir Dis* 1982; 126: 817–818.
15. Kenzo Soejema, Kazuhiro Y, Eiichi, Kei T et al. Longitudinal follow up study of smoking induced lung density changes by high resolution computed tomography. *Am J Respir Grit Care Med* 2000; 161: 1264–1273.
16. Higgins MW, Enright PL, Kronmal RA. Smoking and lung function in elderly men and women. *JAMA* 1993; 269: 2741–2748.