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AIR POLLUTION AND FUEL VAPOUR INDUCED CHANGES IN LUNG FUNCTIONS: ARE FUEL HANDLERS SAFE ?

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Abstract : Automobile exhaust derived air pollutants have become a major health hazard. Coupled with the inhalation of fuel vapour, as occurs in petrol station workers, this may lead to significant impairment of lung function. Spirometric lung functions were studied in 58 petrol station workers to examine this possibility. The forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), forced expiratory flow 25%–75% (FEF_{25-75}) and peak expiratory flow (PEF) were recorded and analysed separately for smokers and non-smokers. The workers were divided into 5 groups for analysis of data based on the number of years of work in the petrol pumps. Outdoor air analysis was also carried out. The FVC, FEV1 and PEF declined significantly with increasing years of work in petrol stations in both smokers and non-smokers. Smoking as an independent variable was found to affect the FEV1 significantly but not FVC or PEF. The FEF_{25-75} was found to be the most affected spirometric value with a significant reduction with increasing years of work. Smoking as such did not affect it. Oxides of nitrogen (NOx), suspended particulate matter (SPM) and particulate matter less than 10 microns (PM_{10}) in outdoor air were higher than the national ambient air quality standards. Exposure to automobile exhaust and fuel vapour impairs lung function in a time-dependent manner. Cigarette smoking appears to accelerate the decline.

Key words : automobile exhaust; lung function; fuel vapour; petrol station workers

INTRODUCTION

The rapidly multiplying number of automobiles in most towns and cities and the corresponding increase in air pollution is a cause of grave concern. Certain groups, by virtue of their occupation, face an increasing threat of its adverse health effects. The present study was carried out to assess the dynamic ventilatory lung functions of one such group, the petrol station workers. In addition to automobile exhaust fumes, these workers are also at a risk of inhaling fuel vapour. The combined effects of the two may result in accelerated decline of lung function. Fuel handlers as well as personnel working in close proximity to fuel exhaust such as vehicle mechanics

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and convoy drivers may stand similar risks. A study carried out on petrol pump workers in Delhi reported adverse effects in the form of small airway involvement and restrictive impairment (1). This study however only reported the mean values of spirometry of a group of petrol pump workers who ranged from 20 years to 40 years as compared to a group of healthy controls. In addition it did not take into account the number of years the workers had spent in the petrol pumps. The latter is essential to comment on the long term effects of exposure to automobile exhaust and fuel vapour inhalation. Longitudinal studies to monitor the state of lung function over a period of time, though ideal, are difficult to carry out. This is especially so in establishments such as petrol stations where the workforce is of a temporary nature making follow-up assessments of lung function very difficult. As a substitute therefore, the present cross-sectional study was designed to assess the spirometric lung functions in petrol station workers with the aim to comment on the long term effects of the work environment on lung function.

METHODS

A total of 58 petrol station workers in the age group of 18–35 years volunteered for this study. The subjects were divided into two groups based on the history of smoking. The inclusion criterion for smokers was defined as those smoking 5 or more cigarettes a day for more than one year. Of the 58 subjects studied, thirty-five were smokers and 23 were non-smokers. Each of these groups (smokers and non-smokers) was further divided into five subgroups (Group A to E), based on the duration of work in petrol stations (Table I). A standard proforma was used to record particulars of the subjects, which included height, weight, duration of work in petrol stations, smoking habits and history of any respiratory diseases in the past or respiratory symptoms at present. The respiratory system was examined clinically to rule out any obvious lung pathology. Spirometry was carried out by using a microprocessor based, turbine type Pneumotachometer (Medspiror-Med Systems Pvt Ltd., Chandigarh, India) and Wright Peak Flow Meter (Clement and Clarke International Ltd., London). Calibration of the spirometer for flow and volume was carried out daily using a standard three-liter calibration syringe as recommended by the American Thoracic Society. Spirometry was carried out as per the guidelines laid down by the American Thoracic Society and European Respiratory Society with the subjects seated (2). The Forced Vital Capacity (FVC) was recorded and Forced Expiratory Volume in 1 second (FEV1) and Forced Expiratory Flow between 25% and 75% of the FVC (FEF_{25-75}) were calculated by the instrument. Peak Expiratory Flow (PEF) was measured separately with a Wright Peak Flow meter. All tests were performed between 1400 and 1600 hours to exclude the bias of circadian rhythms (3).

TABLE I: Distribution of the sample population based on the number of years of work in petrol stations and smoking habits.

Years of work	*Smokers (n=35)*	*Non-smokers (n=23)*
Group A (< 2 years)	6	5
Group B (2–5 years)	12	9
Group C (6–10 years)	9	3
Group D (11–15 years)	5	2
Group E (16–20 years)	3	4

Analysis of outdoor air for levels of common air pollutants was also carried out at the petrol stations that contributed the subjects for this study. This was done using a Respirable Dust Sampler-APM 451(Envirotech Instruments Pvt. Ltd. New Delhi. India). The pollutants measured were oxides of Nitrogen and Sulphur (NOx, SOx), suspended particulate matter (SPM) and particulate matter less than 10 microns (PM_{10}). Air analysis was carried out for 12 hours each on two separate days.

Analysis of Spirometric Data. The observed results of spirometry for each subject were then expressed as 'percentage of predicted'. Predicted values referred to were those for healthy Indian males (4). The mean of the 'percentage of predicted' value for each of the parameters FVC, FEV1, PEF and FEF_{25-75} of each study group (A-E) was considered for the analysis. A two-way analysis of variance (ANOVA) was carried out to determine statistically significant observations. Those results found to be statistically significant were subjected post hoc analysis for significant individual differences between the groups (A to E) using the Least Square Difference (LSD) test (5).

RESULTS

Subjects in the study groups A to E (smokers and non-smokers) were comparable in terms of age, height and years of work in the petrol stations. The mean number of years spent at work in the petrol station ranged from 0.91±0.37 to 19.6±0.57 for smoking subjects and 1.0±0.0 to 17.7±1.7 years for non-smoking subjects. The spirometry data was found to be normally distributed with respect to each of the parameters studied. The percentage of predicted value for the lung function parameters recorded is as shown in Tables II and III.

The FVC (as a percentage of predicted) was seen to significantly decline in both smokers and non-smokers as the number of years of work in petrol stations increased (F=3.05, P=of 0.025). Smoking, as an independent variable was not found to affect the FVC across the study population. A post-hoc analysis of the effect of increasing years of work, as an independent variable, on FVC revealed significant reduction in FVC with duration of work in both smokers and non-smokers (Group A Vs Group E P=0.005,

TABLE II : Mean percentage of predicted FVC and FEV1 of smoker and non-smoker petrol station workers as per years of work in petrol stations.

Years of work	*FVC*		*FEV1*[$]	
	Smokers (S)	*Non-smokers (NS)*	*Smokers (S)*	*Non-smokers (NS)*
Group A (<2 yr)	93.0±7.09	94.4±5.6	93.5±6.1	96.0±6.4
Group B (2-5 yr)	93.08±18.8	93.1±10.1	91.6±11.7	95.2±16.6
Group C (6-10 yr)	86.3±13.1	89.0±5.2	80.8±14.1	94.6±6.1
GroupD (11-15 yr)	73.2±9.5	90.5±4.9	78.2±10.2	89.0±1.4
Group E (16-20 yr)	71.0±29.3*	77.0±16.9*	65.3±12.7[#]	78.5±17.7[#]

*Significantly lower than Group A (P=0.005) & Group B (P=0.005).
[#]Significantly lower than Group A (P=0.001), Group B (P=0.001) & Group C (P=0.01).
[$]Significant difference between smokers and non-smokers (P=0.01).

TABLE III : Mean percentage of predicted PEF and FEF_{25-75} of the subjects as per years of work.

Years of work	PEF		FEF_{25-75}	
	Smokers (S)	*Non-smokers (NS)*	*Smokers (S)*	*Non-smokers (NS)*
Group A (<2 yr)	90.5±11.3	93.2±18.9	102.3±13.1	104.7±10.3
Group B (2-5 yr)	88.7±7.1	92.5±17.7	83.5±30.5	90.3±25.7
Group C (6-10 yr)	90.7±3.6	93.3±4.0	71.6±18.3	85.5±12.4
Group D (11-15 yr)	83.4±11.9	89.0±4.2	69.2±30.0	78.9±7.0
Group E (16-20 yr)	61.7±37.5*	86.3±7.1*	47.1±14.1#	70.6±22.0#

*Significantly lower than Group A (P=0.002), Group B (P=0.005) and Group C (P=0.01).
#Significantly lower than Group A (P=0.008), Group B (P=0.007) and Group C (P=0.007).

Group B Vs Group E P=0.003). The interaction of smoking and duration of work was not found to significantly affect the FVC (F=0.77, P=0.20).

The FEV1 (as a percentage of predicted) declined significantly with increasing number of years of work in petrol stations in both smokers and non-smokers (F=4.73, P=0.002). Post-hoc analysis for inter group differences in FEV1 revealed highly significant differences in FEV1 with increasing duration of work in petrol pumps (Group A Vs Group E P=0.001, Group B Vs Group E P=0.001, Group C Vs Group E P=0.01). Unlike the FVC, smoking as an independent variable significantly reduced the FEV1 (F=5.44, P=0.023). There was however, no significant interaction between the number of years of work and smoking with respect to the deterioration in the FEV1.

There was no significant difference between the observed mean values of PEF in smokers and non-smokers (P=0.068). The duration of work in petrol stations was found to affect the PEF, with a significant decline evident with increasing years of work in the stations (Group A Vs E P=0.002, Group B Vs E P=0.005, Group C Vs Group E P=0.01). Smoking as an individual variable did not affect the decline in PEF (P=0.064).

The FEF_{25-75} was found to be the most affected pulmonary function parameter. It was also the parameter to show the fastest deterioration with increasing years of work in the petrol stations. The reduction in the FEF_{25-75} with increasing years of work in the petrol stations was highly significant (F=8.86, P=0.0001). The smoking status was not found to be significant as an independent variable in the reduction of FEF_{25-75} across the groups (F=2.282, P=0.137). There was no significant interaction between the years of work in petrol stations and smoking with respect to the deterioration of the FEF_{25-75}. However, unlike the other spirometric parameters, the FEF_{25-75} decreased to less than 70% of predicted in those individuals who were smokers and had worked for more than 11 years in the petrol stations.

The results of air analysis are shown in Table IV. The levels of NOx, SPM and PM_{10} were found to be higher than the maximum permissible levels as per the National Air Quality Standards of India (6).

TABLE IV : Levels of outdoor air pollutants measured at two petrol stations.

Pollutant	Max. Permissible* ($\mu g/m^3$)	Site 1 ($\mu g/m^3$)	Site 2 ($\mu g/m^3$)
Sulphur Dioxide (SO_2)	80	78.54	64.19
Oxides of Nitrogen (NOx)	80	201.88	91.31
PM_{10}	100	294.11	181.97
SPM	200	955.84	448.00

*Indian National Ambient Air Quality Standards.

DISCUSSION

In the present study, the results of dynamic spirometry were found to be within the normal range for most of the subjects when compared to the predicted values. These findings appear contrary to that reported by Singhal et al (1). This is possibly due to the difference of methodology adopted to analyze the spirometric data.

A graphical representation of lung function versus time spent at the petrol stations shows that subjects who had worked for a longer duration at the petrol stations had lower 'percentage of predicted values' for most of the parameters studied. This reduction is not due to increasing age of subjects since each parameter was analysed as a percentage of predicted value, thus catering for the age related decline in spirometric values. It is likely that this decline in lung function is due to the factors such as exposure to air pollutants, fuel vapour inhalation and cigarette smoking. The results of air analysis show that the levels of NOx, SPM and PM_{10} were higher than the maximum permissible levels, supporting the above assumption. Hydrocarbons derived from fuel vapour were not assessed hence, quantification of the amount of fuel vapour inhaled by the subjects cannot be commented on. It was also not possible to carry out urine analysis for the metabolites of benzene and toulene to indicate magnitude of fuel vapour inhalation in the subjects studied.

Automobile exhaust is a complex mixture of different gases and particulate matter. These include oxides of nitrogen (NOx), carbon monoxide, Sulphur dioxide (SO_2), hydrocarbons and particulate matter (PM). Animal studies have demonstrated that exposure to particulate matter combined with exposure to an irritant gas such as NO_2, results in greater damage to the lung than when exposed to either substances individually (7). Particulate matter of the size of 2.5 m and 10m (PM_{10}, $PM_{2.5}$) and NO_2 have been found to be significantly associated with reduced FVC. Similar effects of automobile exhausts on the FVC and FEV1 have been reported in tunnel and bridge workers, traffic wardens and shopkeepers (8–11). Smoking has been reported to accelerate the decline in FEV1 (12, 13).

FEF_{25-75} is considered a fairly good test to identify early small airway disease (14–16). The findings of the present study indicate that small airways probably bear the brunt of the air pollution and fuel vapour related lung injury. This finding is in agreement with most studies on pollution inflicted changes in lung function (10, 17, 18). In combination with particulate pollutants, SO_2 and NO_2 have a greater chance to reach the deeper parts of the lungs. The gaseous pollutants may also alter the properties and concentration of surfactant and may thus contribute to the early closure of small airways. Many terminal bronchioles may be compromised before other pulmonary function tests such as FEV1 are affected (14). Histopathological studies have provided evidence that the small airways are the site of damage in people living in areas of high air pollution (18). An interesting observation in the present study is the failure to demonstrate smoking as an independent variable responsible for the reduction in FEF_{25-75}. This is more so since it is a well-documented fact that cigarette smokers show a reduction in the FEF_{25-75} as one of the earliest changes in lung function (19). These findings seem to suggest that there may be no additive effects of smoking, inhaled fuel vapour and outdoor air pollutants on small airway dysfunction. However, it would be prudent to interpret the results of statistical analysis with caution in this case since the sample size studied is small.

The use of PEF to assess the functional status of the airways following any occupational exposure must be taken with caution. This flow rate is highly effort dependent and within-subject variability has been documented. Its use to assess the effects of occupational exposure on lung function in epidemiological studies is not recommended (14, 19, 20). Thus the findings of the present study, though suggestive of a decline in the PEF with increasing duration of work in petrol stations, are not over emphasized.

The limitation of the present study is the small sample size of subjects, which is not ideal for cross-sectional analysis and thus the statistical significance of the results should be interpreted with caution. We were constrained by the inability to find adequate number of subjects with different time periods spent working in the petrol pumps. Though longitudinal follow up of subjects is the ideal design for such a study, the temporary nature of workforce in petrol stations is a major limiting factor, with many subjects being lost to follow up. The present study can be used as basis for planning longitudinal or cross sectional studies with a larger sample size.

In conclusion, any significant decline in the lung function with time merits attention, despite the fact that the observed values may still be within the normal range, since they indicate likely morbidity in the event of continuing exposure to an offending agent (21, 22). Since most individuals are likely to remain asymptomatic till significant pulmonary damage results, regular monitoring of lung function is desirable. Smoking should be discouraged since cessation of smoking halts the accelerated decline in lung function that may other wise result.

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