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A study of dynamic pulmonary function tests in street cleaners

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ABSTRACT

Background: Street cleaners are exposed to many risk factors such as dust, chemicals, and gases emitted by vehicles and factories, which make them vulnerable to develop certain occupational diseases. The fact that they do not use any protective measures increases their probability of contacting the hazards associated with chronic dust inhalation. **Aims and Objectives:** The objectives of this study were to evaluate the pattern of changes in the dynamic pulmonary function parameters in street cleaners of Shimoga city. **Materials and Methods:** The study has been conducted on 80 subjects, out of which 40 are street cleaners as cases and 40 other group D workers as controls. The dynamic pulmonary function tests such as forced vital capacity (FVC) in liters and forced expiratory volume in 1st sec (FEV_1) were recorded. Furthermore, the percentage of FVC expired in 1st second (FEV_1/FVC %), peak expiratory flow rate (PEFR), and forced mid expiratory flow rate ($FEF_{25-75\%}$) in liters per second were recorded for each of the subjects in standing position. **Results:** A significant reduction in the pulmonary functions of street cleaners was noted compared to controls. The results indicated fall in the parameters such as FEV_1, FEV_1/FVC %, PEFR, and mid expiratory flow rate, which suggest an obstructive pattern in the lung functions and points toward the development of Chronic Obstructive Pulmonary Disease. **Conclusion:** The study, hence, concludes that street sweeping and cleaning as an Occupation has adverse effects on the lungs. Periodic screening for the pulmonary functions of the workers at risk should be undertaken by spirometry which is a simple, non-invasive, and cost-effective method to identify the disease process at an early asymptomatic stage.

Key words: Chronic obstructive pulmonary disease; Lungs; Pulmonary function tests; Spirometry; Sweepers

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INTRODUCTION

Street cleaners play an essential role in maintaining the health and hygiene within the cities. Street cleaners are exposed to different types of risk factors such as dust, chemicals, and gases emitted by vehicles and factories, which make them prone to develop certain occupational diseases.[1]

Chronic inhalation of dust and gases impairs the lung function and might cause lung disorders. Sweeping of the streets is accompanied with exposure to dust, because dust is raised in the surrounding atmosphere during sweeping with brooms and by vehicular movement as well as other human activities. Street cleaners are chronically exposed to dust and by not using any precautionary measures are likely to get affected by conditions that adversely affect their lung functions.[2]

The dust raised by sweeping with a broom acts as one of the major contributor to the overall atmospheric pollution and the gases emitted by the vehicles produce ultra-fine dust particles in an urban environment. Exposure to dust has

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long been associated with varying degrees of obstructive and restrictive respiratory diseases.[3] Street sweepers have increased risk of occupational asthma and self-reported Chronic Obstructive Pulmonary Disease (COPD).[4]

Technical regulations protecting the health of sweepers in most developing countries are rarely found; similarly, precautions (e.g., wearing protective masks) are rarely taken by these workers during their working hours. They dry sweep on roads for several hours a day and are thus exposed to large amounts of dust, predisposing them to the development of respiratory illnesses and COPD.[5]

Working with an intention to provide a clean environment for us, they ultimately succumb to these health hazards. But till now, very little attention has been paid to the health of these workers chronically exposed to the dangers in the process of street sweeping.

Hence, the following study is undertaken to know the impact of these hazards on the respiratory functions of this underprivileged and low socioeconomic section of the society.

Aims and objectives

The aim of this study was to evaluate the pattern of changes in the dynamic pulmonary function parameters in street cleaners of Shimoga city.

MATERIALS AND METHODS

Study design

This study was comparative cross-sectional study.

Study setting

Study was conducted in the city of Shimoga in Karnataka.

Study participants

The sample size for the study was 80, out of which 40 were cases (or the study group) and 40 controls.

Sample size was calculated using a similar previous study[3] as a pilot study and taking standard deviation of 0.5 in each group with a power of 90% and a significance level of 1%.

Inclusion criteria

The study group involved street cleaners of either sex who have been working as street cleaners for more than 2 years. For the control group, group D workers, other than sweepers were selected as their socioeconomic status closely matched with that of the study group.

Both the study and control group were selected from the same geographical area, living in a similar locality with similar socioeconomic status. The subjects were limited to an age group of 30–50 years, to avoid other age-related comorbidities. Written informed consent was taken before the study.

Exclusion criteria

Subjects suffering from known cardiorespiratory diseases such as bronchial asthma, tuberculosis, and cardiac failure were also excluded from the study. Individuals with severe spino-skeletal abnormalities, morbid obesity, and chronic smokers were excluded from the study.

Ethics

All the procedures followed were in accordance with the ethical standards.

Ethical clearance

Ethical clearance has been obtained on November 23, 2012 from the Institutional (Human) Ethical Committee, Shimoga Institute of Medical Sciences, Shimoga, Karnataka.

Equipment used for the study

1. Digital Spirometer: RMS Helios-401.[6] (Copyright © 2006 by Recorders and Medicare Systems Pvt. Ltd.) was used to record the pulmonary function test values in the subjects.
2. Other instruments such as Weighing machine, Measuring tape, Stethoscope, and Sphygmomanometer were used to record the anthropometrics and vitals.

Statistical analysis

Descriptive statistics such as mean and standard deviation and inferential statistics applying the unpaired t-test was done. All values presented as Mean ± Standard Deviation. Comparison of mean values of parameters between case and control group made by unpaired "t"-test. "P<0.05" taken as significant.

Clinical examination

Clinical examination included a general inspection and systemic examination of Cardiovascular, Respiratory, Alimentary, and Nervous systems.

Pulmonary function tests

Pulmonary functions of all the subjects were tested using a computerised Digital Spirometer: RMS Helios-401.[6] The relevant pulmonary function tests were done on the cases and controls comfortably standing in an upright position. During the tests, the subjects were adequately motivated to do the manoeuvre at their optimum level, and also, a nose clip was applied to avoid leakage of the air.

Before doing the FVC manoeuvre, the subjects were instructed first to breathe in deeply to their full capacity. The subjects, then, placed the transducer to the mouth and forcefully expelled the air from their lungs as quickly and as maximally as possible.

One single expiratory effort gave reading about many parameters. The parameters such as Forced Vital capacity (FVC), Forced Expiratory Volume in the first second (FEV_1), Percentage of FVC forcefully expelled in the first second (FEV_1/FVC %), Forced mid-Expiratory Flow Rate ($FEF_{25-75\%}$), and Peak Expiratory Flow Rate (PEFR) are measured in the study.

RESULTS

This study was a case–control type of research performed between two groups which included 40 street cleaners as cases and 40 other group D workers as controls, with individuals of both the sexes.

Since the majority of street cleaners were female, in the study, 75% of subjects examined were female, and 25% of them were male. The proportion of males and females selected for the control group were the same. This type of gender matching was necessary to eliminate the bias due to mismatch in the mean values of pulmonary functions, as most of the absolute values will be physiologically higher in males than in the female counterpart.

Anthropometric parameters, such as age, sex, height, weight, and ethnicity, have a direct correlation with pulmonary function test values. Attempts were made to select the control group which closely matched with the study group in terms of age, height and weight, which also led to the matching of the body mass index and body surface area between the two groups. There was no statistically significant variation between the two groups in terms of age, height, weight, body surface area and body mass index (Table 1). Hence, the two groups were correctly "Matched" in terms of the anthropometric variables.

Pulmonary function tests

Initially, a comparison was made for the physiologically predicted pulmonary function test values between the study and the control group which showed no significant difference between the two groups since the two groups were adequately "Matched."

Table 1: Comparison of the anthropometric variables between the cases and control group

Anthropometric variable	Cases	Controls	P-value
Age (Years)	38.33±5.43	38.03±6.06	0.81623*
Height (cm)	160.83±8.98	160.60±8.27	0.90747*
Weight (kg)	61.05±10.80	60.65±10.50	0.95787*
Body surface area (sq.m)	1.64±0.18	1.63±0.17	0.86182*
Body mass index (kg/m^2)	23.49±2.94	23.43±3.17	0.92298*

*P>0.05, Hence not statistically significant

Subsequently, Comparison was made for the actual performed pulmonary function test values delivered by the subjects (Table 2). The results are as follows.

FVC was lesser in the study group than the controls, but the difference was not statistically significant (Figure 1). This result could explain the fact that there is very minimal, if any, restrictive type of lung disease in the street cleaners. This result may suggest a gradual deterioration of the lung function of the subjects with chronic exposure.[2]

Next, when we compared the FEV_1, it showed a statistically significant variation ($p < 0.05$), the mean values being lower in the study group (Figure 1).

The present study shows conclusively that exposure to non-industrial dust can be sufficient to cause a moderate degree of airflow obstruction without clinical signs as defined by Fraser et al.[7]

Comparison of the Percentage of FEV_1/FVC %, which is considered the hallmark for diagnosis of airway obstruction[8] revealed a highly significant variation ($P<0.01$) (Figure 2). These highly substantial variations clearly explain the predominantly obstructive nature of the disease. Therefore, it can be concluded that the occupation of street cleaning is associated with an increased risk for developing COPD. This result is similar to the findings of Johncy et al., who showed a highly significant reduction in FEV_1 of Sweepers, with a percentage decline of about 15% when compared with non-sweepers.[9]

PEFR was compared to assess any change in the maximal attainable expiratory airflow in the sweepers, and the results

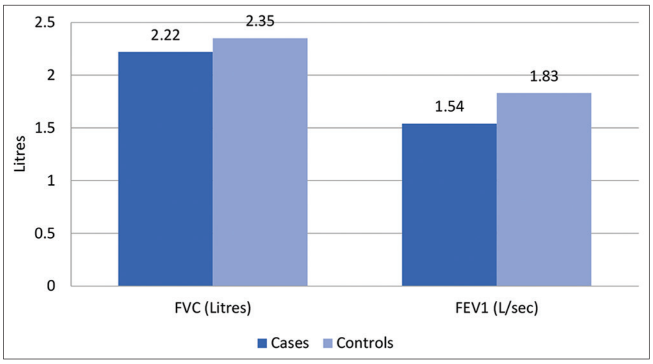

Figure 1: Comparison of performed FVC and FEV_1 values between case and control group

Table 2: Comparison of dynamic pulmonary function test values between case and control group

S. No.	Pulmonary function test	Cases	Controls	P-value
1.	Forced Vital Capacity in Litres	2.22±0.58	2.35±0.46	0.25076#
2.	Forced Expiratory Volume in 1st Sec in Litres	1.54±0.47	1.83±0.54	0.01136*
3.	% of FVC Expelled in First Second in Percentage	69.39±9.23	77.38±13.23	0.00253**
4.	Peak Expiratory Flow Rate in Litres/Second	5.05±1.28	5.92±1.88	0.01863*
5.	Forced Mid Expiratory Flow Rate 25–75% in Litres/Second	2.26±0.55	2.70±0.90	0.01153*

#P>0.05:Not statistically significant,*P<0.05:Significant,**P<0.01:Highly significant

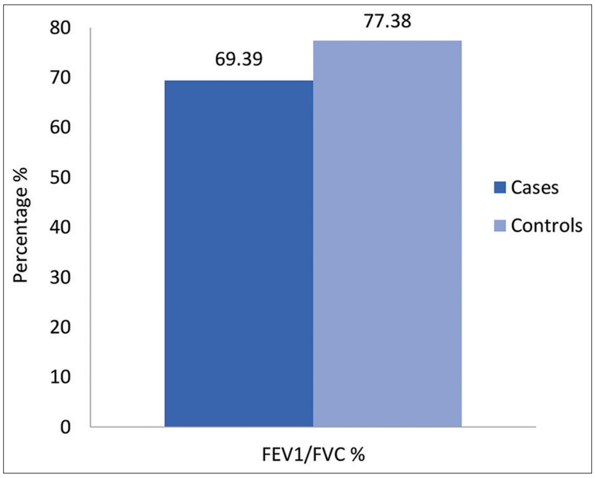

Figure 2: Comparison of performed FEV_1/FVC % between case and control group

came out to be statistically significant (P<0.05) (Figure 3). This statistically significant value indicates a substantial reduction in the maximum attainable expiratory airflow rates in the cases. These results obtained are similar to the study done by Johncy et al.,[9] and Ajay et al.,[10] who showed a decrease in the level of PEFR in sweepers compared to control group.

Finally, we compared the Mid Expiratory Flow Rate ($FEF_{25\%-75\%}$) (Figure 3). This rate is the mean flow rate of the middle half of the FVC, that is, after the first 25% of the FVC has been expired upto 75% of the FVC exhaled, hence denoted as $FEF_{(25–75\%)}$. The results revealed a significant reduction (P<0.05) in the sweepers, pointing toward a more substantial damage to the smaller airways. This parameter ($FEF_{25–75\%}$) is considered to be specifically sensitive to the changes in the lower airways. $FEF_{25–75\%}$ is a marker for the early allergic or inflammatory involvement of the small airways in subjects with allergic diseases and no asthma.[11,12]

$FEF_{25–75\%}$ gives a more sensitive way to assess the early detection, severity, and progression of asthma, contrary to the conventional FEV-index that currently constitutes the only specific clinical criteria to fulfil this role.[11,12]

Hence, there was a statistically significant variation in all the performed pulmonary function test values in cases

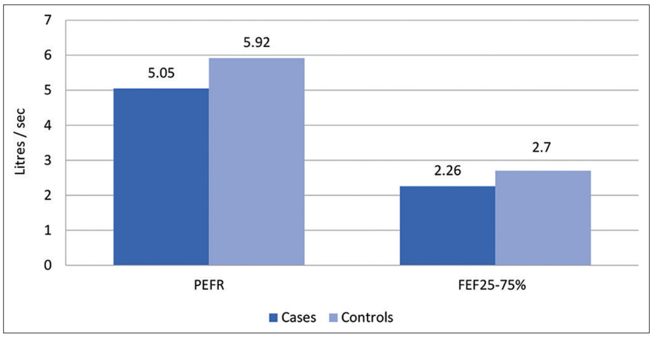

Figure 3: Comparison of performed PEFR and $FEF_{25–t75\%}$ between cases and control group

except FVC, which too shows some difference but not statistically significant.

DISCUSSION

Street cleaners continuously have exposure to the dust while sweeping the roads. The dust raised by street sweeping consists of a complex mixture of soil, sand particles, dirt, motor vehicle tear and wear particles, bio-aerosols, plant particles, etc.[13,14]

The occupation-related lung diseases in street cleaners are most likely due to the deposition of harmful airborne dust particles that are inhaled during sweeping.

The reduction in the Dynamic Pulmonary Functions noted in the cases of our study, mainly the FEV_1 and PEFR can be partially explained by loss of lung elastic recoil pressure, which reduces the force which is required to drive air out of the lungs. This loss of adjustable recoil pressure is attributed to microscopic enlargement of air spaces rather than to grossly visible emphysema.[15]

Our results indicated a gradual development of obstruction in the small airways of the lungs. It is at this point, before the development of frank COPD, that removal of these workers from an environment harmful to them, as well as the adoption of other preventive measures, irreversible lung damage may be avoided.[9]

In the present study, none of the street cleaners were using any protective measures like a mask to protect them from dust inhalation. A few street cleaners used to cover their nose with a cloth as a precautionary measure, but this habit was too infrequent.

This study confirms that the prolonged and continued exposure to non-industrial dust is the main factor for the development of the COPD among the street cleaners, as evident by the obstructive spirometric patterns.

There are a lot of strategies that can be suggested to prevent the development of irreversible lung disease in this vulnerable population.

First, the use of respiratory protection like face-mask can substantially reduce the dust entry into the lungs during sweeping. The use of long-handled brooms too can reduce the amount of exposure to dust.[1] Employing the personnel in other jobs and limiting their hours of street sweeping will be helpful by minimizing the duration of exposure to dust.

Furthermore, making the streets wet by watering them before sweeping will considerably reduce the dust raised from the ground in the process of sweeping. Several studies have considered water flushing as a method able to reduce the dust load deposited on street surfaces.[8]

Automatisation of street cleaning, like the use of newer machines which simultaneously moisten the road and sweep it and collect the dust, should be considered. Another new technique that is suggested is the use of a modified regenerative-air vacuum sweeper followed by a washer, which is shown to be effective at removing the sources of road dust particles.[16]

Finally, the municipality can tie up locally with a medical college or a hospital and ensure periodic screening for the pulmonary functions of the workers at risk. Government agencies can arrange for early diagnosis and treatment. The society can organize NGO's who can also help by equipping the sweepers with face masks and other protective gadgets.

Limitations of the study

The study results cannot be generalized as the study was conducted at one center.

CONCLUSION

The study, hence, concludes that street cleaning as an occupation has adverse effects on the lungs. If the abnormalities are detected early by periodic screening and if further exposure to dust is prevented, irreversible damage to the lungs may be avoided. We also conclude that spirometry is an easy, simple, cheap, portable, and effective non-invasive technique for regular periodic screening of the street cleaners.

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MA- Concept and design, acquisition and interpretation of data; **SSKG**- Statistical Analysis and interpretation of data; **DSR**- Review of the literature and Drafting the manuscript; **JF**- Revising for important intellectual content and Analysis; **MLM**- Final approval of the version to be published.

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