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Pulmonary Function in Rural Women Exposed to Biomass Fuel

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Abstract

Background: Majority of women living in rural areas use biomass fuels for production of domestic energy. Biomass fuel combustion causes indoor air pollution when used inside the dwellings. Combustion products may induce various effects on lung function.

Objective: Objective of this study was to compare the pulmonary functions in healthy non smoking rural women using biomass for cooking to those obtained in control group who were not exposed to biomass.

Methods: One hundred healthy non-smoking women were randomly selected within the age of 20-35 years for this study. The study group comprised of 50 subjects who cooked solely in biomass and 50 age matched subjects who were not exposed to biomass served as controls. A standardized respiratory questionnaire was administered to all the subjects and pulmonary function tests were evaluated by using Medspiror.

Results: The lung function parameters were significantly lesser in the study group, exposed to biomass fuel, than the controls FVC ($p<0.01$), $FEF_{25-75\%}$, ($p<0.01$), FEV_1 ($p<0.001$), PEFR ($p<0.01$), FEV1/FVC% ($p>0.05$). The evaluation of PFT suggested both restrictive and early small airway obstructive type of pulmonary disease.

Conclusion: The reduction in the pulmonary function in the biomass exposed women could be due to high exposure of biomass pollutants with inadequate ventilation in cooking area leading to chronic pulmonary disease.

Keywords: Biomass fuel; COPD; Pulmonary function tests; Spirometry

Introduction

According to World Health Report, indoor air pollution is ranked as the 10th of preventable risk factors contributing to the global burden of a disease. Around 1.5-2 million deaths/year are attributed to indoor air pollution, mainly affecting the children under 5 years due to Acute Respiratory Infection (ARI); Chronic obstructive pulmonary disease (COPD) and lung cancer among women. In developing countries, indoor air pollution ranks 4th most important preventable risk factor. India registers 6,00,000 premature deaths/year due to biomass fuel combustion exposure [1]. 50% of the world's population and up to 90% of rural house-holds in developing countries and approximately 80% of rural households in India still rely on unprocessed biomass fuels such as wood, dung, crop residues and coal for production of domestic energy for cooking and heating. The biomass fuels when burned in inefficient stoves and open fire places in closed space with no ventilation, forms an enormous source of indoor air pollution. Biomass fuels are used mostly by poor people; predominantly in rural areas of developing countries due to its easy availability and mostly free of cost when compared to other fuels (LPG, electricity, kerosene stoves). Biomass fuels have low efficiency and produce indoor air pollutants [2]. Biomass combustion produces complex mixture of volatile organic compounds, which are respiratory irritants like: Suspended particulate matter of respirable size (PM<10 μ), carbon monoxide, nitrous oxides, SO_2, aldehydes (e.g. Formaldehyde) and poly aromatic hydrocarbons which are carcinogenic (e.g. Benzopyrene) [3]. PM_{10} has significant adverse effect on health. The mean PM_{10} level for 24 hours exposure is 300-3000 μg/m³ but as high as 30,000 μg/m³ during cooking is observed. The safety standard recommended for 24 hour average PM_{10} exposure is 150 μg/m³. An average of PM_{10} levels is 1000 μg/m³ in India which is 10-70 times above the ambient levels in most of the polluted cities observed worldwide [4]. Globally 50% of the deaths from COPD in developing countries is contributed by biomass exposure and 75% of the women are suffers [5,6].

Domestic cooking is one of the major activities of the rural Indian housewives. Cooking is carried out in an enclosed space with poor ventilation and in inefficient stoves. Women, young girls and children are the most affected group due to long duration exposure of biomass exposure. In developing countries, at the age of 15 years, girls start cooking and spend an average of 4-6 hours daily in kitchen for cooking. Therefore, during her lifetime, she is exposed to the biomass fuel smoke for 30-40 years, equivalent to 60,000 hours of exposure and inhaling 25 million litres of polluted indoor air [7]. The health hazards associated with chronic exposures to biomass combustion products are: Chronic obstructive lung disease, Cor pulmonale caused by pulmonary damage, [8] Acute respiratory infections, particularly in children due to degradation of the respiratory defence mechanisms and low birth weight due to maternal exposure and associated with a range of perinatal and infant ill health [9,10].

The use of Liquefied petroleum gas (LPG) or electricity for cooking is associated with lowest prevalence of abnormal respiratory findings in non-smoking women as compared to that for smoking females. Exposure to biomass combustion products may well play an important role in the etiology of both chronic and acute respiratory disease leading to respiratory morbidity.

Many studies have proven that biomass fuel combustion deteriorates lung function in rural women mainly producing acute and chronic pulmonary disease. There are also studies explaining no

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adverse effects of biomass combustion on lung function [11]. There is also a study indicating association of lung cancer with wood smoke exposure [12,13]. This type of conflicting studies shows that there are different confounding factors affecting the biomass fuel combustion on pulmonary functions. Hence, more studies are needed for stronger scientific evidence.

Many studies, on the effect of biomass fuel combustion on pulmonary function, were performed across the world but very few studies are conducted in South India. Hence, this study was performed to evaluate the effect of biomass fuel combustion on pulmonary function in biomass exposed women.

Materials and Methods

This study was carried out in Sri Devaraj Urs Medical College, Tamaka, Kolar located 70 kms from the nearest city Bangalore, Karnataka, Southern India.

Study population

Sample size of 100 subjects was taken using convince sampling/ simple random sampling technique. The sample size was determined due to the same procedure and the same cost and duration spent on each subjects in the ratio of one control to one case with considering the sampling error. The study had a power of 80% with the alpha error set at 0.05. The study cases were selected from the secondary random selection of the study units and were prevalent. 50 female attendants of patients admitted to medical ward for non respiratory treatment at the R.L. Jalappa Hospital and Research Centre Kolar were recruited for the study.

The study cases were healthy non smoking women between the ages of 20-35 years using biomass fuel for cooking. The controls were age matched healthy non smoking women using only LPG for cooking. Both the groups were cooking for a minimum period of 5 years with their respective fuels. Subjects with the history of bronchial asthma, pulmonary tuberculosis, pregnancy, cardiac diseases and cancer were excluded from the study. Subjects using mixed fuel were excluded from this study. Ethical clearance was obtained from the institutional human ethical committee. Informed consent was obtained from all the subjects. These subjects were interviewed with a standard respiratory questionnaire based on the American Thoracic Society Questionnaire and the European Respiratory Society (ATS/ERS) [14] which collected information on personal details which included the educational status of the subject and the socioeconomic status of the family. Educational status of the subjects was divided into illiterate and literate. Detailed history of respiratory symptoms, duration of cooking in years, average cooking duration in a day, place of cooking, type of ventilation in the kitchen, number of windows, presence or absence of chimney in the kitchens, presence of soot deposits in kitchen and the type of cooking fuel used were taken as categorical variables. The questionnaire was validated based on the pilot study and with help of co-researchers. The effect of age, weight, height, ventilation status and occupation confounding factors was adjusted as much as possible.

Pulmonary function test

Severe exercise, eating large meal, wearing tight clothes was avoided before performing the test. The subject's age (years), height measured in standing position without shoes in centimetres and weight measured in kilograms were taken as continuous variables.

Both the cases and the controls performed the pulmonary function tests according to ATS/ERS guidelines using Medspiror, PC based Spirometer with flow transducer (Recorders and Medicare Systems). The spirometer was calibrated with a 3 L syringe daily. Pulmonary function tests were carried out in the afternoon hours. The entire FVC procedure was demonstrated satisfactorily to the subjects. Nose clips was attached. The subjects were asked to take maximal inspiration and blow into the mouthpiece as rapidly, forcefully and completely as possible for about atleast 3 seconds. The subjects were verbally encouraged to continue to exhale the air at the end of maneuver to obtain optimal effort. A minimum of 3 acceptable Forced vital capacity (FVC) manoeuvres was performed in the standing position with nose pinched and the best manoeuvre was selected and accepted. The parameters measured were Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), FEV_1/FVC ratio, Peak expiratory flow rate (PEFR) and forced expiratory flow rate ($FEF_{25-75\%}$.)

Statistical analysis

Statistical analysis was done with SPSS software. Students't' test was used to analysis pulmonary functions and independent variables were analyzed by Chi-square test and odds ratio was calculated.

Age, height, weight and duration of exposure were the independent variables, whereas spirometric parameters were the dependent variables.

Results

The mean age, height, weight and Body Mass Index BMI of biomass group and control group is show in table 1.

All the subjects were asymptomatic without any respiratory symptoms. The income of the subjects was divided into three groups: Group 1-low income (Rs.<2000/month), Group 2- middle (Rs.>2001-5000/month), Group 3-High income (Rs.>5001/month)

The educational status of the subjects was divided into illiterate, primary school education, middle school education and secondary school/college education. Biomass group women were illiterate and of low socioeconomic status or middle class. The LPG users were middle and upper middle class. The income and educational status in biomass and control group had a significant difference. The cooking years ranged from 5 to 20 years with an average of 12.2 ± 5.2years per women. The mean duration of cooking was 3.5 ± 1.3 hours per day.

Ventilation in the biomass group cooking area was analyzed using Chi-square test. Thirty seven of the 50 women in biomass group were cooking with both windows and chimneys, three had chimneys but no windows, and 8 of them was cooking with no chimney but had windows. One woman in the biomass group was cooking without any ventilation in the cooking area and one person was cooking outside the house. All the cooking areas had soot deposits on the walls. The LPG group did not complain of any respiratory symptoms whereas the biomass group women complained of lacrimation and running nose in the beginning of the biomass fuel combustion.

Among 50 subjects in biomass group (study group), 27(54%) subjects had normal pulmonary function tests, were as 23(46%) subjects had abnormal pulmonary function test mainly of early small airway obstruction. In the biomass group (control group), 35 subjects

VariabTable 1les	LPG group	Biomass group
Age (years)	25.5 ± 5.73	23.7 ± 5.18
Height (cms)	155.7 ± 5.3	157.8 ± 6.7
Weight (kgs)	50 ± 7.2	54 ± 8.4
BMI	19.3 ± 2.6	20.7 ± 3.3

Table 1: Profile of the LPG and Biomass group.

Study population	Obstructive type	Normal pulmonary function	Odds ratio
Biomass group	23	27	2.19*
LPG group	14	36	

Table 2: Comparison of risk of abnormal lung function in the Biomass and LPG group.

Parameters	LPG Group (n=50)	Biomass Group (n=50)	P value
FVC% predicted	107.18 ± 11.91 (103.8-110.6)	100.60 ± 10.36 (97.66- 103.5)	<0.01
FEV_1% predicted	114.6 ± 11.9 (111.2- 118)	106.8 ± 11.7 (103.5- 110.1)	<0.01
$FEF_{25-75\%}$% predicted	78.8 ± 16.5 (74.11- 83.49)	70.1 ± 15.7 (65.7- 74.62)	<0.01
FEV1/FVC%	87.49 ± 4.72	86.27 ± 5.71	>0.05

Data presented as mean% (confidence intervals)

Table 3: Distribution of pulmonary function values of the biomass exposed women and LPG group.

pulmonary function tests was normal and 14 subjects had obstructive disease and the observed percentage predicted values of FVC, FEV_1 were above 80%, FEV_1/FVC above 80%, PEFR and $FEF_{25-75\%}$ above 70%.

The risk was calculated between the biomass group and the control group for the spirometric parameters by odds ratio. OR value>1 suggests positive relationship between exposure and risk of abnormal PFT.OR value <1indicates a negative relationship and OR value equal to 1 indicates no relationship between exposure and risk (Tables 2 and 3).

Discussion

The present study was undertaken to evaluate the effect of biomass fuel combustion on pulmonary function tests. In this study the effect of biomass fuel on pulmonary function showed that, Forced vital capacity% predicted (FVC), forced expiratory volume in one second% predicted (FEV_1), flow expiratory flow rate 25-75% predicted ($FEF_{25-75\%}$), Peak Expiatory Flow Rate% predicted (PEFR) values in the biomass group were statistically decreased ($p<0.01$) when compared to that of LPG groups The decrease in lung function in biomass fuel users may be due to the chronic inhalation of particulate matter and toxic gases emitted during biomass combustion leading to inflammatory changes. FVC reduction could be due to the changes in the lungs by the chronic irritation of biomass combustion products. PEFR and FEV_1 reduction in the pulmonary function can be due to the obstruction of airways during expiration.$FEF_{25-75\%}$ reduction shows that there is narrowing of the small airways due to chronic inflammation. The FEV_1/FVC% ratio in biomass group was above normal which indicated restrictive type of lung disorder, but was not statistically significant. These findings of the present study was similar to the observation of Kiraz et al. [15], Reddy et al. [11], Turaclar UT et al. [16], Albalak et al. [17], Ekici et al. [18].

Restrictive and obstructive patterns of respiratory impairments were observed in our study. All the subjects in the study group used wood for their domestic purpose. Analyzing the type of ventilation in the kitchens of households using biomass for cooking, it was found that almost all the households had one or the other type of ventilation in the form of windows or chimneys except for one subject whose kitchen had no windows or chimney but in this study ventilation of these households does seem to influence the pulmonary function. This may be due to inadequate ventilation [11].

The present study shows a significant relation between biomass fuel combustion (mainly wood) and decrease in lung function. This could be due to exposure to high concentration of respiratory irritants emitted during biomass fuel combustion and poor ventilation. Thus decline in lung function in biomass fuel exposed women can be avoided by improving adequate ventilation in the kitchens or by using cleaner fuels [19].

Confounding factors like working in the farms, cooking usually done in morning and evening, exact cooking time, duration of fuel used and comparison with non fuel users was the limitation of this study [20].

Conclusion

This study shows that healthy non smoking women using biomass fuel (especially wood) for cooking had sub clinical respiratory impairment mainly in early small airway obstruction. This could be identified by pulmonary function tests, which are sensitive and simple tests to identify early respiratory impairment as compared to history and physical examination. The adverse effect of biomass fuel on lung function could be due to exposure of high concentration of pollutants liberated by biomass fuel combustion and inadequate ventilation. Hence educating women, improving ventilation, outdoor cooking and by using clean fuels may prevent the adverse effects of biomass fuel combustion to on lungs.

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