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Research Article

RESPIRATORY DISEASE ASSOCIATED WITH BIOMASS SMOKE EXPOSURE IN RURAL WOMEN

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of biomass fuel combustion on pulmonary function tests (PFTs) and comparing the PFTs between biomass users and Liquefied petroleum gas (LPG) users.

Method: 150 healthy non-smoking women were randomly selected within the age group of 21-50 years for this cross-sectional study. The study group comprised of 75 subjects who used biomass fuel for cooking (Biomass users) and 75 age matched subjects who were not exposed to biomass served as the controls (LPG users). . The anthropometric data i.e., age, height, weight, blood pressure, respiratory rate was noted and the subjects pulmonary functions were evaluated using RMS Medspiror.

Result: The lung function parameters were significantly lower in the study group, exposed to biomass fuel than the controls FEV1 ($p<0.001$); FEV1/FVC ($p<0.001$) and PEFR ($p<0.001$), except FVC ($p<0.338$). The evaluation of PFTs suggested the increased risk to the obstructive type of pulmonary disease in biomass users.

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

Keywords: Biomass fuel, Liquefied petroleum gas, Pulmonary function test.

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INTRODUCTION

Biomass fuel (wood, cow dung, and crop residue) accounts for more than one-half of the domestic energy in most developed countries and as much as 95% in developing countries [1]. The adverse health effects of indoor air pollution are often exacerbated by lack of ventilation or by the poor design of stoves that do not have hoods to take smoke out of the living area. As the combustion efficiency of biomass fuel is very low, thus it yields relatively high levels of products of incomplete combustion, such as particulate matter, carbon monoxide, hydrocarbons, oxygenated organics, free radicals, and chlorinated organics which are more damaging to health [2].

Biofuel combustion is associated with the release of increased amounts of pollutants such as sulfur dioxide, nitrogen dioxide, carbon monoxide, total suspended particles (TSP), and polyaromatic hydrocarbons (PAH) [3]. The emission factors for these pollutants from biofuels far exceed those from other commercial fuels such as liquid petroleum gas (LPG) and kerosene. The emission factor for TSP is about 20 times higher for biofuels than for LPG. The concentration of indoor pollutants is significantly higher in kitchens using biofuels compared to those using other fuels [4].

The constituents of biomass smoke are particulate matter of <10 μm in aerodynamic diameter (PM10), carbon monoxide, nitrogen dioxide, sulfur dioxide, formaldehyde, and polycyclic organic matter, including carcinogens (e.g., benzopyrene) [5]. Particles with a diameter smaller than 10 μm (PM10), and particularly those with a diameter smaller than 2.5 μm (PM2.5), can penetrate deeply into the lungs and appear to have the greatest potential for damaging health [6] PAH, azo and amino compounds have also been found to be potentially carcinogenic. Formaldehyde affects the respiratory system causing reduction in vital capacity and chronic bronchitis [7]. Toxic inorganic chemicals are known to cause asphyxiation, stillbirth, infant death, heart disease, and severe acute and chronic lung disease and their mechanisms of cell injury are still unexplained [8].

Epidemiological studies have shown that pulmonary functions are decreased with long-term/short-term exposure to polluted air [9].

Different studies have reported that the biomass smoke produced by the combustion of solid fuels acts as a cause of acute upper and lower respiratory infection [4,10]; chronic bronchitis/obstructive airway disease [6-9]; lung cancer [11]; asthma, pulmonary tuberculosis [11]; and low-birth-weight babies [12].

Therefore, the current study was carried out to evaluate the effects of biomass fuel combustion on pulmonary function tests (PFTs) in the women in and around Patna and comparing the PFTs between biomass fuel users and non-users, i.e., those using clean fuels like LPG.

METHODS

This cross-sectional study was conducted in NMCH, Patna. 150 women were selected for the study from among the woman staff and attendants in NMCH. Out of a total of 150 women, the study group (exposed to Chulla smoke) consisted of 75 women from randomly selected rural background of the age group of 21–50 years, with exposure of 3–4 h/day. 75 women formed the age-matched healthy control group (not exposed to Chula smoke) using LPG.

The anthropometric data, i.e., age, height, weight, blood pressure, and respiratory rate was noted and the subject's medical history was taken and clinical examination was also being done. Informed and written consent of all the subjects was taken before conducting the study.

The ethical clearance was obtained from the institutional human ethical committee subjects were broadly categorized into three groups.

Asian J Pharm Clin Res, Vol 17, Issue 1, 2024, 76-78

Group I includes women in the age group of 20–30 years. Group II included women in the age group of 31–40 years and Group III included women in the age group of 41–50 years. Females between the age group of 20–50 years. Having 10 years or more than 10 years of exposure to Chula smoke, using biomass fuel wood, cow dung, or crop residue. And using separate enclosed outdoor kitchens with biomass being used for fuel for domestic cooking without any gap in cooking duration were included in the study. Females having <10 years of exposure to Chula smoke and those with respiratory problems and on treatment were excluded. Women on chronic medications or having any chronic or morbid illness or having smoking habits were also excluded. Pregnant women and those using LPG were also not studied.

PFT

The pulmonary functions were evaluated using RMS Medspiror. The subject's age (years), height measured in standing position without shoes in cms, and weight measured in Kg were fed into the machine and the machine automatically gave the normal values corresponding to that age, weight, and height thereby removing these confounding factors. The subjects were instructed to apply mouthpiece closely to the lips and close their nose with the nose clip with her own fingers so as to prevent any leakage of air. The procedure was explained in detail and demonstrated to the subject before the commencement of each test and maximum effort on behalf of the subject was emphasized. This procedure was repeated and the best of three readings were considered for analysis. The parameters measured were forced vital capacity (FVC) (normal value >80% of predicted value), forced expiratory volume in first second (FEV1) (normal value >75–80% of predicted value), ratio of FEV1/FVC (normal value >70% of the predicted value), and peak expiratory flow rate (PEFR) (normal value of about 380–500 L/min or 6–9 L/s).

Statistical analysis

Statistical analysis was done with the SPSS software. An Independent t-test was used for the comparison between the groups and one-way ANOVA followed by *post hoc.* Multiple comparisons were applied for the comparison of age groups within each group and odd ratio was calculated on the basis of PEFR. p<0.05 was considered as significant.

RESULTS

A total of 180 women were approached for assessing the PFTs. Of which only 150 women agreed to PFTs. Further two groups were formed, biomass users and LPG users consisting of 75 women each of the age group of 21–50 years (3–4 h/day exposure). The mean age and BMI of the biomass and LPG users were 36±9.11 and 35±4.77 years; 18.87±1.63 and 23.65±1.37 kg/m^2 respectively. All the subjects were asymptomatic without any respiratory symptoms.

The mean of all the parameters (FVC, FEV1, FEV1/FVC, and PEFR) of biomass and LPG users is shown in Table 1. The lung functions except FVC (p<0.338), reduced significantly (p<0.001) in case of biomass users as compared to LPG users. From Table 2, it is clear that with increasing age and duration of exposure to biomass fuel combustion, the pulmonary functions reduced significantly (except the group I and II of FVC) in biomass users compared to LPG users. Further, Odd's ratio (OR) was calculated to compare the risk of obstructive lung disease in biomass and LPG users on the basis of PEFR (Table 3). OR calculated was 4.45; which was highly significant (p<0.0001). PEFR as one of the main indicators of obstructive lung disease hereby indicates a high risk of developing obstructive disease in biomass users as compared to LPG users.

FVC (p<0.338), reduced significantly (p<0.001) in case of biomass users as compared to LPG users. As shown in Table 2, it is clear that with increasing age and duration of exposure to biomass fuel combustion, the pulmonary functions reduced significantly (except the group I and II of FVC) in biomass users compared to LPG users. Further, OR was calculated to compare the risk of obstructive lung disease in biomass and LPG users on the basis of PEFR (Table 3). OR calculated was 4.45; which was highly significant (p<0.0001). PEFR as one of the main indicators of obstructive lung disease hereby indicates a high risk of developing obstructive disease in biomass users as compared to LPG users.

Table 1: Comparison of PFT values of biomass-exposed women and LPG users exposed

Parameters	Biomass users	LPG users	p-value
FVC (L)	1.79±0.63	1.89±0.15	p<0.338
FEV1/L	1.41±0.45	1.71±0.16	p<0.001
FEV1/FVC (%)	80.78±11.2	86.24±2.6	p<0.001
PEFR (L/s)	2.56±1.07	9.16±1.54	p<0.001

PFT: Pulmonary function test, LPG: Liquid petroleum gas, FVC: Forced vital capacity, FEV1: Forced expiratory volume in first second, PEFR: Peak expiratory flow rate

Table 2: PFT values in different age groups of Biomass and LPG users

Parameters	Groups	Biomass Users	LPG Users	p-value
FVC (L)	1	1.79±0.46	1.89±0.16	p<0.33
	11	1.87±0.51	1.85±0.15	p<0.24
	111	1.44±0.52	1.88±0.16	p<0.001
FEV1	1	1.44±0.36	1.78±0.13	p<0.001
	11	1.37±0.4	1.76±0.13	p<0.001
	111	1.32±0.46	1.75±0.13	p<0.001
FEV1/FVC	1	84.61±9.05	95.1±1.74	p<0.001
	11	78.57±11.22	96.1±1.74	p<0.001
	111	77.45±12.15	93.5±4.07	p<0.001
PEFR (L/s)	1	2.7±1.14	9.39±1.24	p<0.001
	11	2.33±1.23	9.21±0.12	p<0.001
	111	1.88±0.46	9.1±1.22	p<0.001

PFT: Pulmonary function test, LPG: Liquid petroleum gas, FVC: Forced vital capacity, FEV1: Forced expiratory volume in first second, PEFR: Peak expiratory flow rate

Table 3: Risk of obstructive lung disease in biomass and LPG users

Study population	Obstructive type	Normal pulmonary function	Total
Biomass users	31	44	75
LPG users	14	61	75
Total	45	105	150

LPG: Liquid petroleum gas, OR=4.45, Chi-square=30.73, p<0.0001 (HS)

of obstructive lung disease hereby indicates a high risk of developing obstructive disease in biomass users as compared to LPG users.

DISCUSSION

The effect of biomass fuel on pulmonary functions in the current study showed that FEV1, FEV1/FVC, PEFR values in the biomass group were significantly decreased (p<0.001) 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 was reduced in biomass users as compared to LPG users but not significantly which could be due to minor changes in the lungs by the chronic irritation of biomass combustion products. FEV1 and PEFR reduction in the PFTs was highly significant and could be due to obstruction of airways during expiration. The FEV1/FVC ratio in the biomass group was below the normal which indicates a high risk of obstructive type of lung disorder, which was highly significant. The risk was calculated between biomass and LPG users on the basis of PEFR by OR (OR=4.45), which was highly significant (<0.0001). Many earlier studies also showed association of exposure to biomass fuel (wood, cow dung cake, and crop residue) with higher levels of indoor air pollution and with increased incidence of pulmonary diseases [3,14]. Studies conducted in the early 1980s found a higher occurrence of chronic bronchitis and cor pulmonale in rural women exposed to chulhas fuelled with cow dung cakes and firewood. Few studies have suggested a link between indoor air pollution from the use of solid fuels and tuberculosis [11,14]. Desai *et al.* [15] taking into account various studies have estimated that exposure to solid fuel smoke exacerbates asthma with a relative risk of 1.6 for children between 5 and 14 years and 1.2 for persons older than 15 years. The adverse health effects of indoor air pollution are often exacerbated by the lack of ventilation in homes using biomass fuel and poor design of stoves that do not have hoods to take smoke out of kitchens present study showed a significant relationship between biomass fuel combustion 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 household ventilation, by improvement in stoves and change of the fuel type for cooking and heating.

CONCLUSION

This study shows that healthy nonsmoking women using biomass fuel (especially wood) for cooking had sub-clinical respiratory impairment mainly in early small airway obstruction. This could be identified by PFTs, 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 using clean fuels may prevent the adverse effects of biomass fuel combustion on the lungs.

CONFLICT OF INTEREST

None.

SOURCE OF FUNDING

Self.

ETHICAL CLEARANCE

Taken.

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