Pulmonary Function Tests In Rural Women Exposed To Biomass Fuel

Empreet Mangat[*], Suchet[**], L.S. Dashora[***], Surjit Singh[***], Swati Chouhan[****]

* MSc. student, ** Associate Professor, *** Professor, ****, M.D.student, Department of Physiology, MM Institute of Medical Sciences & Research, Mullana, Ambala, India 133 207.

Abstract: Background: Biomass fuel accounts for more than one-half of the domestic energy in most developed countries and as much as 95% in developing countries. As the combustion efficiency of biomass fuel is very low, it yields relatively high levels of products of incomplete combustion which may induce various harmful effects on the lung function. 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: Three hundred healthy non-smoking women were randomly selected within the age group of 21-50years for this cross-sectional study. The study group comprised of 150 subjects who used biomass fuel for cooking (Biomass users) and 150 age matched subjects who were not exposed to biomass served as the controls (LPG users). A standardized respiratory questionnaire was administered to all the subjects and pulmonary function tests were evaluated by using spiro excel. Result: The lung function parameters were significantly lower 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.

Key Words: Biomass fuel, Liquefied petroleum gas, Pulmonary function test.

Author for correspondence: Dr. Suchet ,Associate Physiology, Department of Physiology, MM Institute of Medical Sciences & Research, Mullana, Ambala, Haryana, India e- mail: suchet.dr@gmail.com

Introduction: Air pollution is generally perceived as an urban problem associated with automobiles and industries. But indoor air pollution emitted from traditional fuels and cooking stoves is a potentially large health threat in rural regions.

Air pollution is either due to gases or particulates. These, individually or in combination can cause respiratory impairment if inhaled in adequate concentration over a long period of time[1]. Inhalation is probably the most important route of exposure in the workplace and is an inescapable route to toxins in the general environment.

Biomass fuel (wood, cow dung, crop residue) accounts for more than one-half of the domestic energy in most developed countries and for as much as 95% in developing countries[2]. 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, like particulate matter, carbon monoxide, hydrocarbons, oxygenated organics, free radicals and chlorinated organics which are more damaging to health[3].

Different studies have reported that the biomass smoke produced by combustion of solid fuels acts as a cause of acute upper and lower respiratory infection[4,5]; chronic bronchitis/obstructive airway disease[6-9]; lung cancer[10] ;asthma, pulmonary tuberculosis[11]; low-birth weight babies[12].

Epidemiological studies have shown that pulmonary functions are decreased with long term/short term exposure to polluted air[13]. Therefore, the current study was carried out to evaluate the effects of biomass fuel combustion on pulmonary function tests in the women of villages in and around Mullana, Ambala (Haryana) and comparing the pulmonary function tests between biomass fuel users and non-users i.e. those using clean fuels like liquefied petroleum gas (LPG).

Material and Method: This cross-sectional study was conducted in Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala, Haryana (India). Out of total 300 women, the study group (exposed to Chula smoke) consisted of 150 women from randomly selected rural background of the age group 21-50yrs, with exposure of 3-4 hours/day. 150 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, 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 as follows:
Group I : Age group 21-30yrs.
Group II : Age group 31-40yrs.
Group III : Age group 41-50yrs.

Inclusion criteria:

- Females between the age group of 21-50 yrs.
- Females having 10yrs or more than 10yrs of exposure to Chula smoke, using biomass fuel wood, cow dung or crop residue.
- Females using separate enclosed outdoor kitchens.
- Females using biomass fuel for domestic cooking without any gap in between cooking duration.

Exclusion criteria:

- Females having less than 10yrs of exposure to Chula smoke.
- Females with respiratory problems and on treatment.
- Any chronic medications.
- Any chronic or morbid illness.
- Smokers.
- Pregnancy.
- LPG users.

Pulmonary function Test: Pulmonary function tests were performed using computerized spirometer, spiroexcel (Medicaid systems Chandigarh). It has a turbine flow meter and the range for flow measurement was 0-3L/sec. Range for volume measurement is 0-10L/sec.
Initially the subjects were made to sit comfortably and breathe in and out normally to familiarize themselves with the equipment. The subjects were then asked to inhale to their maximum capacity and then forcefully blow out into the sensor (nose clipped) as hard as and for as long as possible. 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), Peak expiratory flow rate- PEFR (normal value of about 380-500L/min or 6-9L/sec).

Statistical analysis: Statistical analysis was done with the SPSS software. Independent t-test was used for the comparison between the groups and One Way ANOVA followed by Post Hoc Multiple comparisons was applied for comparison of age groups within each group and odd ratio was calculated on the basis of PEFR. $p<0.05$ was considered as significant.

Result: A total of 310 women were approached from the villages in and around Mullana, Ambala, Haryana for assessing the pulmonary function tests. Of which only 300 women agreed to pulmonary function tests. Further two groups were formed, Biomass users and LPG users consisting of 150 women each of the age group of 21-50 years (3-4hours/day exposure). The mean age and BMI of the Biomass and LPG users was 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 table1. The lung functions except

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

Parameters	Biomass users	LPG users	p-value
FVC(L)	1.7±0.52	1.89±0.16	p<0.338
FEV1(L)	1.34±0.41	1.78±0.13	p<0.001
FEV1/FVC (%)	79.88±11.2	85.24±2.99	p<0.001
PEFR (L/sec)	2.36±1.07	9.16±1.24	p<0.001

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

Parameters	Groups	Biomass Users	LPG Users	p-value
FVC (L)	I	1.85±0.46	1.91±0.16	p<0.33
	II	1.77±0.5	1.86±0.15	p<0.24
	III	1.48±0.52	1.88±0.16	p<0.001
FEV1 (L)	I	1.45±0.36	1.79±0.13	p<0.001
	II	1.34±0.4	1.79±0.13	p<0.001
	III	1.24±0.46	1.76±0.13	p<0.001
FEV1/ FVC	I	83.61±9.05	96.1±1.74	p<0.001
	II	79.57±11.22	96.1±1.74	p<0.001
	III	76.45±12.15	93.5±4.07	p<0.001
PEFR (L/sec)	I	2.8±1.14	9.29±1.24	p<0.001
	II	2.43±1.23	9.29±0.12	p<0.001
	III	1.85±0.46	8.9±1.22	p<0.001

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

Study Population	Obstructive Type	Normal Pulmonary Function	Total
Biomass users	67	83	150
LPG users	23	127	150
Total	90	210	300

OR = 4.45 CHI-SQ = 30.73 P<0.0001 (HS)

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 high risk of developing obstructive disease in biomass users as compared to LPG users.

Discussion: The effect of biomass fuel on pulmonary functions in current study showed that, Forced Expiratory Volume in one second (FEV1), FEV1/FVC, Peak Expiratory Flow Rate (PEFR) values in the biomass group were significantly decreased (p<0.001) when compared to that of LPG groups. The decrease in the 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 pulmonary function tests was highly significant and could be due to obstruction of airways during expiration. The FEV1/FVC ratio in biomass group was below the normal which indicates 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 Odd's ratio (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. Studies conducted in early 1980s found a higher occurrence of chronic bronchitis and cor pulmonale in rural women exposed to chulas fuelled with cow dung cakes and firewoods.

Few studies have suggested a link between indoor air pollution from the use of solid fuels and tuberculosis[11, 14].Desai and colleagues[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 5-14years and 1.2 for

persons older than 15years. 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.

The 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: The healthy non-smoking women using biomass fuel for cooking had sub clinical respiratory impairment, identified by pulmonary function tests, which are sensitive and simple tests to identify early respiratory impairments. Indoor pollutants liberated from incomplete biomass fuel combustion may be risk factor for pulmonary diseases like COPD.

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