ORIGINAL ARTICLE

Domestic Cooking Fuel and Lung Functions in Healthy Non-smoking Women

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ABSTRACT

Objective. The objective of this study was to compare the pulmonary functions in healthy non-smoking women who used either biomass or liquified petroleum gas (LPG) as their sole cooking fuel. The effects of passive smoking, ventilation, over crowding and cooking index were also taken into account.

Methodology. The study was conducted over a period of two years from January 1994. One hundred healthy non-smoking women were included 50 cooked solely with biomass and 50 cooked with LPG. A standardised respiratory symptoms questionnaire was administered to all the subjects and spirometry was carried out.

Results. Passive smoking showed no significant difference between the two groups. No statistically significant differences was found in lung functions in the two groups except for the PEFR, which was significantly lower ($P<0.01$) in women using biomass. No correlation was observed between different variables and pulmonary functions. The step-wise multivariate linear regression analysis showed no correlation between cooking fuel and the pulmonary functions.

Conclusion. The absence of the expected adverse effects of biomass on pulmonary functions was possibly due to better ventilation in the kitchens of subjects in the biomass group compared to previous studies.

Key words : *Cooking fuel, Pulmonary function, Non-smoking women, Biomass, Liquified petroleum gas.*

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INTRODUCTION

A majority of the world's population still relies principally on wood, animal dung and crop residues for fuels[1]. Wood stoves create pollutants both indoors and outdoors because they generate: (*i*) suspended particles of respirable size, (*ii*) gases including polycyclic aromatic hydrocarbons[1,2]. Exposure to irritant gases produced during cooking on *Chulha* (indigeneous-cooking stove where biomass is used as a fuel) is considered a primary cause of bronchitis and chronic cor-pulmonale[3,4]. The use of liquified petroleum gas (LPG) for cooking is associated with lowest prevalence of abnormal respiratory findings in non-smoking women

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when compared to men and smoking females[5-7].

Recent rural development has been accompanied by a transition away from traditional biomass fuels to modern fuels (usually kerosene, diesel, liquified petroleum gas, and electricity). Biomass fuel contribution to total energy consumption in India in 1989 was 50%, having declined from 74% in 1972-73 and 66% in 1982-83[8]. This transition in cooking fuel selection allows comparison of pulmonary function tests of individuals who cook with biomass fuels with those who cook with LPG.

MATERIAL AND METHODS

The present study was designed to compare the pulmonary functions in healthy women who used either biomass or LPG as their sole cooking fuel. Study participants were recruited from the female attendants of patients who were seeking medical care at the All India Institute of Medical Sciences Hospital, New Delhi, India. Eligible subject were females between the age group of 30-55 years, life-time non-smokers and who were using either biomass or LPG for cooking for a minimum period of 10 years. All subjects were free of acute or chronic cardiopulmonary disease and spine and chest deformities. Informed consent was taken from all subjects. The questionnaire used for this study was based on the American Thoracic Society Questionnaire and Division of Lung Disease [ATS-DLD], which was developed by the Epidemiology Standardization Project Committee[9].

Details regarding the number of members in the family who were either current or ex-smokers, in particular the smoking habits of the husband, were recorded. Number of persons sleeping per room and the family size were also noted. Type of ventilation in the kitchen, number of windows, presence or absence of chimney in the kitchen and presence or absence of soot deposits in kitchen and other rooms was recorded. Cooking variables included the time spent in hours in household cooking per day and the number of years of cooking. Cooking index was calculated by multiplying the number of hours spent in a day for cooking and the number of years of cooking. The educational status of the subject and the socio-economic status of the family was detailed. Based on the income per month, the subjects were divided into three income groups: *Group- 1*–Low-income group (Rs. <2000/month), *Group-2* – Middle–income group (Rs. >2001-5000/month), *Group-3* – High-income group (Rs. >5001/month). Educational status of the subjects was categorized into illiterate, primary school education, middle school education, and secondary school or college education.

Pulmonary functions were performed using an electronic rolling seal spirometer (PK Morgan, UK). The calibration of the equipment and the procedure adopted during the tests were in accordance with the equipment and procedure requirements of the ATS Snowbird Workshop on the standardization of pulmonary function testing[10]. Peak expiratory flow rates (PEFR) were determined with a calibrated Wright's peak flow meter. Mouth pressures [Maximum Inspiratory Pressure (PImax) and Maximum Expiratory Pressure (PEmax)] were recorded using a mercury manometer. Nose clips were used for this procedure. At least three satisfactory readings were recorded and the highest was taken as the representative value for a given individual.

In this study the predicted values for FVC, FEV_1 and PEFR were calculated by using the equation of Udwadia *et al*[11] [Y= C+(Age in years) Age Coefficient + Standing height in cm (height coefficient)].

Statistical analysis was done with the statistical package SYSTAT. Numeric parameters were analyzed using the student t-test and categorical data was analyzed using Chi-square analysis. The influences of various confounders were analyzed by multivariate regression analysis.

RESULTS

A total of 140 healthy females who met the inclusion criteria were interviewed. Of these, 101 subjects agreed for pulmonary function studies after we explained its purpose. One female was excluded because she could not properly comprehend and perform reproducible pulmonary function test. There were 50 subjects in each of the two groups of fuel usage, *i.e.* biomass and LPG groups. The baseline parameters of the subjects in the two groups are shown in table 1.

Table 1. *Characteristics of subjects in the two groups*

Variables	LPG Group (n=50)	Biomass Group (n=50)
Age (years)^{ns}	38.84 ± 6.95	39.00 ± 7.62
Height (cm)^{ns}	151.18 ± 4.90	149.54 ± 4.90
Weight (kg)*	61.53 ± 9.90	49.59 ± 7.70
BMI**	26.86 ± 4.18	22.12 ± 3.00
No. of persons sleeping per room**	2.26 ± 0.60	3.76 ± 1.70
Passive smoking exposure^{ns}	24%	38%

ns : not significant ($p \leq 0.05$); *: $p<0.01$; **: $p < 0.001$.
Data are mean ± SD except for passive smoking exposure.
LPG=Liquefied petroleum gas; BMI=kg/m^2.

With the alpha error set at 0.05 and using the observed variance in the respiratory laboratory, the study had a power of 80% for detecting significant difference in lung functions, using a two tailed Student's t-test with the available sample size. The two groups are comparable in age and height (p>0.05). Body mass index (BMI) of subjects in the LPG group was significantly higher than in the biomass group. The biomass group had greater over-crowding than the LPG group (p<0.001). Exposure to passive smoking in the two groups was not significantly different. Passive smoking was used as a dichotomous variable (Table 1). The family size of the biomass group was also significantly larger.

Ventilation in the cooking area was analyzed using Chi-square test. Only one woman in the biomass group was cooking with no ventilation. Fourteen of the 50 women studied in the biomass group had at least one window in their kitchen, 17 had both windows and chimney in their kitchen and five cooked in the *verandah*. Forty-two of the 50 women in the biomass group did not feel that there was excessive smoke in their kitchen. None of the subjects in LPG group complained of any respiratory symptoms, but three subjects in the biomass group complained of lacrimation and nasal discharge while cooking.

Table 2. *Comparison of lung functions in the two groups*

Lung Function Tests	LPG Group (n=50)	Biomass Group (n=50)
FVC (L)^{ns}	2.76 ± 0.54	2.79 ± 0.52
FVC% Predicted^{ns}	117.37 ± 18.18	121.21 ± 17.53
FEV_1 (L)^{ns}	2.28 ± 0.43	2.27 ± 0.40
FEV_1 % Predicted^{ns}	81.67 ± 1.59	81.65 ± 1.43
FEV_1 % Percentage Predicted^{ns}	99.45 ± 10.51	100.91 ± 8.03
FEV_1/FVC %^{ns}	82.36 ± 6.13	81.20 ± 8.49
PEFR (L/min)*	368.40 ± 50.20	342.90 ± 54.34
PEFR % Predicted^{ns}	129.90 ± 54.34	123.55 ± 17.68
PI_{max} (cm of water)^{ns}	77.52 ± 20.67	74.52 ± 24.20
PE_{max} (cm of water)^{ns}	89.21 ± 20.67	89.70 ± 21.21

Data are mean ± SD; ns : not significant (p>0.05); * : p<0.05.

There was a significant difference in the income and educational status in the two groups (p<0.001). Women from biomass group were illiterate and belonged to the lower socio-economic status or middle class. In the LPG group, most of the subjects were literate and belonged to middle and higher class families.

Lung functions including forced vital capacity (FVC), forced vital capacity as a percentage of predicted (FVC%), forced expiratory volume in one second (FEV_1), forced expiratory volume in one second per cent predicted (FEV_1% predicted), forced expiratory volume in one second and forced vital capacity ratio as percentage (FEV_1/FVC%), peak expiratory flow rate as a percentage of predicted (PEFR%), maximum inspiratory pressure (PI_{max}), and maximum expiratory pressure (PE_{max}) were not statistically different in the two groups. However, the peak expiratory flow rate (PEFR) in women using LPG was significantly higher than in women using biomass for cooking (p>0.01).

Multivariate Regression Analysis

The correlations among height, age, weight, passive smoking, income, educational status and various parameters of pulmonary functions were not significant.

Step-wise multivariate linear regression analysis was done with lung function indices as dependent variables FEV_1, FVC, FEV_1/FVC ratio, and PEFR. The following models to predict FEV_1, FVC, FEV_1/FVC, and PEFR were obtained.

(*i*) FEV_1=3.05 - 0.08 × Ventilation – 0.07 × Cooking Index - 0.16 × Group.

The multiple regression analysis for predicting FEV_1 from type of ventilation, cooking index, and group (Biomass *vs* LPG) variables yielded an R square value of 0.135. In other words 13.5% of the variation in FEV_1 values is accounted for by variation in the three-predictor variables.

(*ii*) FVC= 3.80 - 6.46 × Ventilation - 7.72 × Cooking Index - 6.96 × Passive Smoking - 0.19 × Group.

This model yielded an R square value of 0.085.

(*iii*) FEV_1/FVC = 88.59 - 0.72 × Ventilation - 3.55 × Cooking Index - 2.37 × Passive Smoking - 0.34 × Group.

This yielded an R square value of 0.047.

(*iv*) PEFR= 373.88 - 7.90 × Ventilation - 023 × Cooking Index - 8.79 × Passive Smoking - 13.75 × Group.

This model yielded an R square value of 0.088.

Thus, none of the models had a satisfactory predictive capacity.

DISCUSSION

Smoke from fires in huts has been implicated in chronic respiratory disease in India, Nepal, and New Guinea[12-14]. An increased incidence of chronic bronchitis, lung cancer, and acute respiratory infections has been attributed to cooking with biomass fuel[15-19]. Malik[12] from Chandigarh reported that exposure to fumes of biomass could result in impairment of ventilatory function. The amount and concentration of particulate matter and other toxic gases emitted during biomass combustion while cooking in houses are more than those emitted during LPG combustion[20].

During the last two decades, there has been a gradual trend away from the usage of biomass fuel. No study has compared the lung functions in subjects using LPG and biomass for cooking, although studies suggest that using LPG is less hazardous. One study[21] conducted in North India compared the lung functions of women using LPG and kerosene and reported that peak expiratory flow rate was not statistically different in the two groups. Another study from the same centre[22] on 3701 women using different types of cooking fuels found that women using mixed fuel experienced more respiratory symptoms (16.7%), followed by biomass (12.6%), stove (11.4%) and LPG (9.9%), users. Symptoms of chronic bronchitis in women using *chulha* were significantly higher than in LPG users. Other studies[6, 7] have compared lung functions in non-smoking women using LPG and electric stoves and found no significant difference in FEV_1 and respiratory symptoms in both categories of women. Based on the previous observations made on biomass and LPG, we hypothesized that lung functions would be lower in women using biomass.

The failure to dectect a negative effect of biomass combustion on lung function in our study was unexpected. To limit any confounding variable in interpreting early changes in lung function, we included only healthy asymptomatic non-smoking women. Lung functions including FEV_1 were used to study any change in respiratory status. We believe that selection criteria that eliminated significant pulmonary impairment that had already occurred was appropriate, but could have attenuated the expected results of biomass combustion. Like-wise we have no data to support that indoor pollution from biomass affects all individuals equally. If there is a genetic predisposition in responding to the smoke generated by burning biomass, we may have inadvertently excluded some susceptible individuals.

We feel that the reason for the absence of a significant difference in lung function in the two groups occurred because of low exposure to biomass fuel pollutants due to improved ventilation and outdoor cooking. On analyzing the type of ventilation in the kitchens of households using biomass for cooking, it was found that except for one subject (whose kitchen had no windows), all the others had some form of ventilation in their kitchens. Also 13 out of 50 women in this group cooked outdoors and five subjects used verandahs for cooking. In the remaining households, the kitchens were well ventilated with at least one to two windows in the kitchen and the *chulha* used for cooking was situated close to or next to the windows. Proper ventilation and outdoor cooking will decrease the severity of exposure to smoke. All the women in LPG group had adequate ventilation in their kitchens. We were unable to accurately reconstruct the degree of ventilation in earlier studies that have found adverse pulmonary effects from biomass combustion products. Woolcock and Blackburn[23] in their report on chronic lung disease in the Papua New Guinea Highlands suggested that crowding around fires in unventilated thatched huts was responsible for chronic bronchitis. Qureshi[24] looked at domestic smoke pollution and the prevalence of chronic bronchitis in rural Kashmir. In the *Gujjar* community, who usually live in single room huts and cook with wood, the prevalence of chronic bronchitis was 4.8% with good ventilation compared to 23.6% where ventilation was poor. The higher prevalence of chronic bronchitis in *Gujjar* females was attributed to domestic smoke, poor housing conditions, over crowding and low socio-economic status.

Use of biomass fuel with poor ventilation contributes to chronic bronchitis. Good ventilation diminishes the adverse effect on lung functions. Possible confounding effects of room heating fuels on lung function tests did not apply in these women. Exposure to passive cigarette smoking had no statistically significant effect. In developing countries biomass fuel is used for cooking. Cheap alternatives are not available. Improving ventilation in the kitchens of women using biomass fuel may prevent adverse effects on lung function. This effect of ventilation on biomass cooking needs to be confirmed using prospective cohort studies.

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