A comparative analysis of biomass and clean fuel exposure on pulmonary function during cooking among rural women in Tamilnadu, India

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Abstract:
It is of interest to document data on the comparative analysis of biomass and clean fuel exposure on pulmonary function during cooking among rural women. The study consisted of 100 biomass and 100 LPG fuel using women with no smoking habits and other related illness Parameters such as FVC, FEV₁, FEV₁/FVC, PEFR, FEF₂₅₋₇₅% were obtained using the computerized spirometry to assess the pulmonary function in these subjects. The collected data were analyzed using the Student t-test method and Pearson correlation. The exposure index for biomass fuel users is 69.78±27.25 showing high exposure duration during cooking. The parameters for pulmonary functions significantly declined in FVC (42.34±13.6), FEV₁ (45.55±15.98), PEFR (34.11±14.78) and FEF₂₅₋₇₅% (45.56±23.00) for biomass fuel user. However, this is not true for FEV₁/FVC ratio (107.56±16.9). The increase in PFT suggests the restrictive and obstructive patterns of pulmonary diseases. There was a negative correlation between increased duration of cooking and the value of FEV₁/FVC (r = -0.2961), FEF₂₅₋₇₅% (r = -0.3519) and PEFR (r = -0.2868). Thus, the deformation of pulmonary function due to extended exposure of biomass fuel for...
cooking women in rural Tamilnadu is shown using parameter features such as high exposure index, overcrowded area and improper ventilated houses.

**Keywords:** Biomass Fuel, clean fuel, exposure index, pulmonary function test, restrictive and obstructive disease, spirometry.

**Background**

In the rural regions of developing countries, most people use biomass fuels such as wood, cow dung, crop residues etc. for cooking purpose [1]. People were exposed to air pollution due to smoke from industry and vehicle causing chronic obstructive pulmonary disease in urban areas [2, 3]. The particulate matters (fine or ultra fine) in air vary in size, composition and origin [4]. The particulate material such as gaseous pollutants, organic pollutants and heavy metals etc. progressively changes the indoors environmental [5]. The inhaled pollutants directly enter into the respiratory system and reach the circulation causing deleterious effect on various organs among women and children during cooking [6]. The biomass smoke causes COPD by pulmonary and systematic inflammation using pro-inflammatory agents such as TRP (Transient Potential Receptor) and TLR (Toll-like receptors) and genotoxic effect of oxidative stress [7]. Nowadays 'Biomass exposure index' is used clinically as a tool to analyze the risk of developing the disease and to identify the minimum threshold of exposure. Biomass exposure index' is often used to calculate the minimum threshold of exposure and it is calculated by the average hours spent on cooking per day multiplied by the number of years of cooking [8]. It is known that there is an increase in enormous uncovered health burden such as respiratory and non-respiratory illnesses among the biomass fuel users [9]. Therefore, it is of interest to document data on the comparative analysis of biomass and clean fuel exposure on pulmonary function during cooking among rural women.

**Subjects and Methods:**

**Study design:**

**Selection and description of participants:**

A comparative study between rural biomass fuel user and clean fuel user for cooking was conducted around the Kancheepuram district, Tamilnadu. India. Clinical evaluation was done before doing the Spirometric test. Age (18-55 yrs) and BMI matched healthy women using the biomass fuel group and clean fuel and duration of exposure to cooking for minimum of 5 yrs were included. History of any diseased condition and smoking for the biomass fuel and clean fuel group were excluded. Detailed information about Anthropometry data were collected for the both groups such as Age, Height, Weight and BMI. The ventilation profile or data such as House type, Number of rooms, Placement of kitchen, Type of kitchen, presence or absence of Ventilation, Type of biomass fuel, and Duration of cooking were also collected. Pulmonary Function Test was done for every individual with the help of SPIROMETRY [MODEL: Helios 401, Version: 3.1.85], [10] which is based on European Respiratory standards [11] and assess [12] the Parameters such as FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume in one second), FEV1/FVC ratio, PEFR (Peak Expiratory Flow Rate) and FEF 25-75% were done for the biomass fuel group and clean fuel group.

**Informed consent and ethical approval:**

Written consent was taken in the regional language before collecting the data from each individual for the study purpose. The Institutional Ethical committee approved the study.

**Statistics:**

The student t test used to differentiate the groups at 5% level of significance. The correlation between the duration of exposure and FFT in biomass groups was assessed using the spearman correlation coefficient with 5% level of significance.

**Table 1:** Descriptive statistics for anthropometric parameter

| Group          | Mean   | SD    | t     | P     |
|---------------|--------|-------|-------|-------|
| Age           |        |       |       |       |
| Biomass fuel  | 39.91  | 8.46  |       |       |
| (100)         |        |       |       |       |
| Clean fuel    | 36.53  | 7.70  | 2.96  | 0.004*|
| (100)         |        |       |       |       |
| Ht (cm)       |        |       |       |       |
| Biomass fuel  | 154.18 | 3.49  | 0.001*|
| (100)         |        |       |       |       |
| Clean fuel    | 155.71 | 2.91  |       |       |
| (100)         |        |       |       |       |
| Wt (Kg)       |        |       |       |       |
| Biomass fuel  | 51.31  | 10.01 |       |       |
| (100)         |        |       |       |       |
| Clean fuel    | 59.41  | 13.38 |       | <0.0001*|
| (100)         |        |       |       |       |
| BMI (Kg/m2)   |        |       |       |       |
| Biomass fuel  | 21.54  | 3.89  |       |       |
| (100)         |        |       |       |       |
| Clean fuel    | 24.48  | 5.37  |       | <0.001*|
| (100)         |        |       |       |       |

Note: * t test used to differentiate the groups at 5% level of significance; Table I shows the mean value and statistically significant difference in age(*p<0.004), height(*p<0.001), weight(*p<0.0001), and BMI(*p<0.0001) were observed between the biomass and the clean fuel group.

**Table 2:** Descriptive statistics for exposure index for biomass and clean fuel group.

| EXPOSURE INDEX | Group | Mean   | SD    | T     | P     |
|---------------|-------|--------|-------|-------|-------|
| (Hr-Yr)       | Biomass fuel | 69.78  | 27.25 | 6.472 | <0.0001*|
Note: * t test used to differentiate the groups at 5% level of significance; In table II shows the mean of exposure index (69.78± 27.25) for duration of cooking is higher in biomass fuel group than clean fuel group (47.85± 20.14) and statistically significant difference (P=0.0001) between the two groups on the exposure index.

Table 3: Descriptive statistics for pulmonary function test by spirometry

| PFT PARAMETER | GROUP          | MEAN    | SD      | T     | P     |
|---------------|----------------|---------|---------|-------|-------|
|               | BIOMASS FUEL   | 42.34   | 13.6362 | 2.64  | 0.009*|
| FVC (%P)      | CLEAN FUEL     | 46.92   | 10.72115| 3.296 | 0.001*|
| FEV1 (%P)     | BIOMASS FUEL   | 45.55   | 15.98508| 1.91  | 0.058 |
|               | CLEAN FUEL     | 52.40   | 13.28324|       |       |
| FEV1/FVC (%P) | BIOMASS FUEL   | 107.56  | 16.91829| 3.57  | 0.0004*|
|               | CLEAN FUEL     | 111.65  | 13.13056|       |       |
| FEF25-75% (%P)| BIOMASS FUEL   | 45.56   | 21.00387| 1.91  | 0.058 |
|               | CLEAN FUEL     | 55.91   | 17.63897|       |       |
| PEFR (%P)     | BIOMASS FUEL   | 34.11   | 14.78594| 3.441 | 0.0007*|
|               | CLEAN FUEL     | 41.28   | 14.68049|       |       |

NOTE: FVC = Forced Vital Capacity; FEV1 = Forced Expiratory Volume in One Second; FEV1/FVC% = Forced Expiratory Ratio; PEFR = Peak Expiratory Flow Rate; FEF25-75% = Forced Expiratory Flow between 25% and 75%. * t test used to differentiate the groups at 5% level of significance; In Table III shows the result of the pulmonary function test of the various parameters between biomass fuel and clean fuel. FVC (%P), FEV1 (%P), FEF25-75% (%P) and PEFR (%P) were statistically significant (P=0.009, P=0.001, P=0.0004, P=0.0007) except FEV1/FVC% was not significant (P=0.058).

Table 4: Correlation of duration of cooking with PFT in biomass and clean fuel

| PFT PARAMETER | BIOMASS FUEL GROUP | CLEAN FUEL GROUP |
|---------------|---------------------|------------------|
|               | r VALUE             | pVALUE           | r VALUE             | pVALUE             |
| FVC(%P)       | -0.0485             | 0.6317           | 0.0829             | 0.4122             |
| FEV1(%P)      | -0.1872             | 0.0622           | 0.04497            | 0.6568             |
| FEV1/FVC(%P)  | -0.2961             | 0.0028†          | -0.06518           | 0.5194             |
| FEF25-75%(%P) | -0.3519             | 0.0003†          | -0.1272            | 0.2071             |
| PEFR(%P)      | -0.2868             | 0.0038†          | -0.1554            | 0.1227             |

Note: †spearman correlation coefficient shows negative correlation with 5% level of significance. In Table IV shows the negative correlation of duration of cooking exposure on pulmonary function parameter of FEV1/FVC (%P), FEF25-75% (%P) and PEFR (%P) were the value of r= -0.2961, r= -0.3519 and r= -0.2868 for biomass fuel group and shows significance (P=0.0028, P=0.0003 and P=0.0038).

Results & Discussion:
The study was conducted on 200 women who were exposed to biomass fuel (n=100) and clean fuel (n=100). The pulmonary function test parameters were recorded and compared between the two groups. The groups were selected with an equal number of participants and the age between 18 – 55years. The rural population in India is still using the unprocessed biomass fuel for cooking in the indoor kitchen as well as an outdoor kitchen. The biomass fuel produces various products that alter the pulmonary functions.
Earlier a study showed a significant decline in FVC, FEV₁, and PEFR caused by irritant gases and particulate matter released by biomass fuel combustion due to hypertrophy of mucosal cells which reflects the deficit in small and large airway function and lung parenchyma [17, 18]. Chronic exposure to biomass smoke may cause an inflammatory reaction in the lungs, as a result of obstructive lung disease and shows some radiological signs of restrictive lung disease such as fibrotic bands, nodular opacities, and perivascular thickening [19, 20]. Similarly, our result was showing a significantly decline in FVC, FEV₁, FEV₁/FVC, PEFR and reduced value in FEV₁/FVC which indicate the pattern of both obstructive and restrictive lung disease. Previous studies showed significant decline in FVC, FEV₁, FEV₁/FVC, FEF₂₅-₇₅% and PEFR with high biomass exposure index for biomass fuel group, which indicates the obstructive pulmonary disease due to chronic exposure of high concentration of the irritable substance and high biomass index as well as scarce ventilation [21, 22, 23]. The minimum threshold of biomass exposure index is 60, which is significant risk to develop chronic bronchitis among women [24]. Similarly, our results show the exposure index (69.78±27.25) which was higher in biomass fuel than clean fuel with a decline in FVC, FEV₁, FEF₂₅-₇₅% and PEFR except for FEV₁/FVC ratio. The exposure index based on the hours per day and for more the 15 years exposure to biomass smoke which cause the adverse respiratory symptom [25]. Similarly our result showed the high exposure index which cause chronic bronchitis among rural women. A negative correlation was observed between lung function parameter (observed PEFR) with exposure index (r = -0.51). This indicates the affect of large airways obstruction caused by irritant gases and particulate matter, which induce hypertrophy of mucosal cells [26]. Similarly in our study shows negative correlation between duration of cooking with pulmonary function parameter of FEF 25-75% (r = -0.3519; p= 0.0003) and PEFR(r = -0.2868; p= 0.0038) for biomass fuel users. It indicates the obstruction in small airways and large airways. Another study showed the negative correlation of FVC, FEV₁, FEV₁/FVC with the duration of exposure in years, [27] similarly our study shows also exhibited a negative correlation of FEV₁/FVC (r = -0.2961; p=0.0028). The effect of quality of life due to chronic biomass fuel exposure and poor ventilation as indicated by the higher exposure index is shown in the data.

Conclusion:
Data shows the deformation of pulmonary function due to extended exposure of biomass fuel for cooking women in rural Tamilnadu is shown using parameter features such as high exposure index, overcrowded area and improper ventilated houses.

References:
[1] Judith T et al. J. Toxicol. Environ. Health 2002 5:269. [PMID: 12162869]
[2] Robert J et al. J Allergy Clin Immunol. 2012 129: 3. [PMID: 22196520]
[3] Sara M et al. Allergy Asthma Proc 2015 36:4. [PMID: 25562549]
[4] Shao-Kun Liu et al. Journal of Thoracic Disease. 2016 8:E41 [PMID: 26904252]
[5] Marilena Kampa, Environmental Pollution 2008 151:1362 [PMID: 17646040]
[6] Arbex MA et al. J Bras Pneumol. 2012 38:643 [PMID: 23147058]
[7] Rafael Silva, Arch Bronconeumol. 2015 51:285. [PMID: 25614376]
[8] Mahesh P A et al. Indian J Med Res 2013 137:87 [PMID: 23481056]
[9] Duncan G et al. Trans R Soc Trop Med Hyg 2008 102:843 [PMID: 18693310]
[10] Salim Uz-Zaman et al. J Clin Diagn Res. 2014 8:BC01 [PMID: 25584206]
[11] Brusasco V et al. European Respiratory Journal. 2005 26:319 [PMID: 16058882]
[12] Rabha R, Women Health. 2019 59:229. [PMID: 30067466]
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