



A COMPARATIVE STUDY OF EFFECT OF DURATION OF COOKING EXPOSURE ON PULMONARY FUNCTION BETWEEN BIOMASS FUEL AND CLEAN FUEL USER AMONG RURAL WOMEN

Sarojini Kaliyaperumal

PhD scholar, PhD Scholar, Department of physiology, Sri Balaji Vidyapeeth University, Puducherry, India

Dr Chitra M*

MD, HOD & Professor, Department of physiology, Shri Sathya Sai Medical College and Research Institute, Chennai and Sri Balaji Vidyapeeth University, Puducherry, Tamil Nadu, India*Corresponding Author

Dr Kannan

MD, HOD & Professor, Department of physiology, Adhiparasakthi Institute of Medical Sciences and Research, Melmaruvathur, Tamilnadu, India

Dr Vinitha Baskaran

MBBS Junior medical consultant, sri sai krupa hospital, Puducherry, India.

ABSTRACT

Background and Objective: In last decade, rural Indian population using the biomass fuels for cooking and heating purpose. Cooking process was done in their houses as indoor or outdoor with overcrowded living area. To evaluate and compare the pulmonary function by spirometry with duration of cooking exposure on biomass fuel and clean fuel user among rural women. **Methods:** A comparative study, 100 biomass fuel users and 100 LPG users were selected under the assessment of non smoking women, any illness or disease condition. The demographic information's were collected and pulmonary function tests were done by computerized spirometry to assess the FVC, FEV1, FEV1/FVC, PEFR, FEF25-75% parameters from the selected females. Collected data were analyzed by Student t test method and Pearson correlation. **Results:** Biomass exposure index for biomass fuel users 69.78±27.25. This illustrates the biomass fuel users have chronically high exposure duration during cooking. The pulmonary functions parameters were significantly decline in FVC(42.34±13.6), FEV1(45.55±15.98), PEFR (34.11±14.78), FEF25-75%(45.56±23.00) except FEV1/FVC ratio(107.56±16.9) for biomass fuel user. The evaluation of PFT suggested restrictive and obstructive pattern of pulmonary diseases. There was significant negative correlation between increased duration of cooking and the value of FEV1/FVC ($r = -0.2961$), FEF25-75($r = -0.3519$), PEFR ($r = -0.2868$). **Interpretations & Conclusions:** The deformation of pulmonary function due to chronic exposure of biomass fuel combustion for cooking women mainly by the higher duration of exposure index, overcrowded area, improper ventilated houses.

KEY WORDS : Biomass Fuel, Exposure Index, Pulmonary Function test, Restrictive and Obstructive Disease, Spirometry.

INTRODUCTION

In developing countries, most of the people extensively using the biomass fuels such as wood, cow dung, crop residue etc for cooking purpose and home heating especially.[1] In urban, most of the people were exposed to air pollution due to smoke from industry and vehicle, unlike the rural people were exposed to biomass smoke which are the major cause for COPD.[2] COPD is the fourth leading cause of death in the world population.^[3]

The particulate matter is refers to an air suspended mixture of solid and liquid particles, which is varying in size, composition and origin.[4] The particulate matter is classified into coarse particles, fine particle and ultra fine particles. The particulate matter contains such as gaseous pollutants, organic pollutants and heavy metals etc progressively changes the indoor environmental.[5] The inhaled pollutants directly enter into the respiratory system and reach the circulation and cause deleterious effect on various organs among women and children during cooking.[6] The biomass smoke can cause COPD via various mechanisms like pulmonary and systematic inflammation through pro-inflammatory agents, which produces by the effect of 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' was calculated by the average hours spent on cooking per day multiplied by the number of years of cooking.[8] Among women, there is an increase in enormous uncovered health burden such as respiratory and non-respiratory illnesses among the biomass fuel users.[9] This study was to compare SPIROMETRIC evaluation

between biomass fuel and clean fuel users among rural women and to correlate between duration of cooking and pulmonary function on women exposed to biomass fuel and clean fuel.

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, 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) 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

*Corresponding Author Dr Chitra M

MD, HOD & Professor, Department of physiology, Shri Sathya Sai Medical College and Research Institute, Chennai and Sri Balaji Vidyapeeth University, Puducherry, Tamil Nadu, India

collecting the data from each individual for the study purpose. The study was approved by Institutional Ethical committee before the initiation of the study.

Statistics:

To evaluate the statistics for the data were subjected, using SPSS 16V software. The student t test used to differentiate the groups at 5% level of significance. The correlation between the duration of exposure and PFT in biomass groups was assessed by using spearman correlation coefficient with 5% level of significance.

RESULTS:

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.

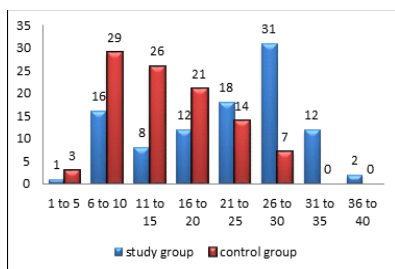
TABLE I: DESCRIPTIVE STATISTICS FOR ANTHROPOMETRIC PARAMETER

	Group	Mean	SD	t	P
Age	Biomass fuel (100)	39.91	8.46	2.96	0.004*
	Clean fuel (100)	36.53	7.70		
Ht (cm)	Biomass fuel (100)	154.18	3.49	3.37	0.001*
	Clean fuel (100)	155.71	2.91		
Wt (Kg)	Biomass fuel (100)	51.31	10.01	4.85	<0.0001*
	Clean fuel (100)	59.41	13.38		
BMI (Kg/m2)	Biomass fuel (100)	21.54	3.89	4.43	<0.0001*
	Clean fuel (100)	24.48	5.37		

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.

GRAPH 1: FREQUENCY DISTRIBUTION OF DURATION OF COOKING IN YEARS FOR BIOMASS FUEL GROUP AND CLEAN FUEL GROUP



NOTE: this shows more number of people using the biomass fuel for cooking.

Graph 1 clearly shows the details of the number of persons exposed to cooking in years for biomass fuel and clean fuel group.

TABLE II: DESCRIPTIVE STATISTICS FOR EXPOSURE INDEX FOR BIOMASS AND CLEAN FUEL GROUP.

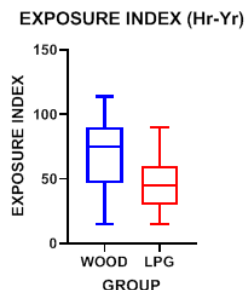
EXPOSURE INDEX (Hr-Yr)	Group	Mean	SD	t	P
	Biomass fuel (100)	69.78	27.25	6.472	<0.0001*
Clean fuel (100)	47.85	20.14			

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.

GRAPH 2: BOX PLOT DIAGRAM FOR EXPOSURE INDEX IN HOURS-YEARS FOR BIOMASS FUEL GROUP AND CLEAN FUEL GROUP



In graph 2, box plot graph shows the higher median value for the biomass fuel group than the clean fuel group. The value between Q1 and Q3 for the biomass fuel group was higher than the clean fuel group.

TABLE III: DESCRIPTIVE STATISTICS FOR PUMONARY FUNCTION TEST BY SPIROMETRY

PFT PARAMETER	GROUP	MEAN	SD	t	P
FVC (%P)	BIOMASS FUEL	42.34	13.63612	2.64	0.009*
	CLEAN FUEL	46.92	10.72115		
FEV1 (%P)	BIOMASS FUEL	45.55	15.98508	3.296	0.001*
	CLEAN FUEL	52.40	13.28324		
FEV1/FVC (%P)	BIOMASS FUEL	107.56	16.91829	1.91	0.058
	CLEAN FUEL	111.65	13.13056		
FEF25-75 (%P)	BIOMASS FUEL	45.56	23.00387	3.57	0.0004*
	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; FEF 25-75% = 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%P was not significant (P=0.058).

TABLE IV: CORRELATION OF DURATION OF COOKING WITH PFT IN BIOMASS AND CLEAN FUEL

PFT PARAMETER	BIOMASS FUEL GROUP		CLEAN FUEL GROUP	
	r VALUE	pVALUE	rVALUE	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 $P = 0.0038$).

DISCUSSION:

In India, mostly the rural population 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 among rural women.

Previous studies have shown a significant decline in FVC, FEV1, and PEFR except FEV1/FVC ratio among biomass fuel exposure among those who used an indoor kitchen without a window for more than 20 years and the author showed the value of FVC was reduced more than that in FEV1 and FEV1/FVC ratio was normal, which indicated parenchymal restrictive lung disease.^[13] Similarly in our study FVC, FEV1, PEFR and FEF25-75% were statistically reduced in biomass fuel users except FEV1/FVC ratio.

FEF 25-75% is a more sensitive indicator and used as a potential diagnostic tool for the early detection of small airway function. The particulate matter (PM_{2.5}µm) can easily penetrate the lungs, which affects the small airway and lung parenchyma.^[14,15] Similarly, in our study, there was a significant decline in FEF25-75%, which indicates early small airway obstruction.

A study reports showed a significant decline in PEFR with increasing duration of exposure due to chronic exposure to biomass fumes in poor ventilation of indoor kitchen which causes inflammation of airways among women.^[16] Similarly, we also observed in our study a significant decline in PEFR among rural women who were prolonged exposed to biomass smoke, which indicates large airway obstruction.

Earlier a study showed a decline in FVC, FEV1, FEV1/FVC, FEF25-75% 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, FEF25-75%, 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, FEF25-7% and PEFR with high biomass exposure index (85.68±3.69) 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, FEF25-7% and PEFR except for FEV1/FVC ratio. The exposure index based on the hours per day and years exposed to the biomass smoke. In a study showed the association between the spending 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 ($r = -0.2961$; $p = 0.0028$).

Our study group population though asymptomatic, was observed to have decline in pulmonary function which may affect the quality of life due to chronic biomass fuel exposure and poor ventilation as indicated by the higher exposure index.

In conclusion rural India, the population using the unprocessed biomass fuel, which was burnt in traditional stoves such as pit, three pieces of brick, or a U-shaped construction in the indoor or outdoor kitchen due to lack of knowledge about the hazardous impact of biomass fuel, most accessible sources of energy and a low monthly income. In our study the biomass fuel users have significantly decreased in pulmonary function FVC, FEV1, PEFR, FEF25-75% expect FEV1/FVC ratio with an increase in the duration of exposure during cooking, which indicates biomass fuel combustion cause obstructive and restrictive pulmonary disease mainly due to exposure to high concentration of respiratory irritants emitted during biomass fuel combustion, poor ventilation and overcrowded area of the living room. There is a need to know the knowledge about the risk factors of pulmonary disease and to conduct various intervention programs to provide a better quality of life among the rural population in India. This study is recommended for future researchers to extend their research.

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