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RESEARCH ARTICLE

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Effect of long term exposure to wood smoke on fasting blood glucose level and body mass index (BMI) among women in Samaru, Zaria

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ABSTRACT

The study is aimed at examining the effect of exposure to wood smoke on blood glucose level and biomarker of obesity among women in Samaru, Zaria. The survey research design was adopted for the study. The sample of the study comprised of 40 women in the study area. The study is designed to involve all the women in community market Ahmadu Bello University, Zaria who use fire wood as a means of daily commercial cooking activities and women in community market Ahmadu Bello University who are not exposed to fire wood smoke. Data collected included age, height, weight, fasting blood glucose level and body mass index and level of education in view of socio economic factors. Wood smoke is a complex mixture of substance produced during the burning of wood. The major emissions from wood stoves are carbon monoxide, organic gases (containing carbon or derived from living organism), particulate matter and nitrogen oxide. Wood smoke contains many organic compounds known to cause cancers (such as benzopyrenes, dibeenzanthracenes and dibenzocarbazole) and other toxic compounds (such as aldehydes, phenols or cresols). The findings of this study show that women exposed to wood smoke had higher mean values of fasting blood sugar than control group, (93.45 ± 2.14) and (76.75 ± 1.39), respectively. They also had higher body mass index (27.21 ± 1.39) as compared with control (22.25 ± 0.62), and higher body weight (67.40 ± 3.3 6) as compared with control (58.90 ± 2.14). In conclusion, this study observed significant increase in blood glucose level, body weight and body mass index. Hence, the findings of the study show that long term exposure to wood smoke causes an increase in blood glucose level, body weight and body mass index. Long term exposure to wood smoke is a potential predisposing factor to obesity and diabetes mellitus.

Key-words: Fasting blood glucose, body weight, body mass index, body height, wood smoke.

INTRODUCTION

This study is aimed at evaluating the effect of wood smoke exposure on fasting blood glucose level and obesity risk parameter (body mass index) among women in Samaru, Zaria.

The use of wood is often considered to be as old as human evolution and wood is the oldest of human fuels. Hence, it is literally true that exposure to wood smoke is as old as humanity itself. Even today, biomass in the form of wood and agricultural wastes is a significant source of direct human energy consumption worldwide. Wood is used in its traditional forms as household heating and cooking fuels in developing countries, and in its modern forms as power-plant fuel, principally in developed countries [1]. Because household use dominates total fuel demand in many

developing countries, particularly in rural areas where half of humanity still lives, it is likely that biomass remains the main source of energy for most of humanity [2].

The percentage of fuel demand (wood) declines with economic development. The increase in use of wood and other biomass fuels in developing nations due to poor economic development are among the factor responsible for the consequent concern about the health effects of air pollution around the world, leading to stricter air pollution regulation and controls. While commercial sources of wood combustion have been subject to some regulation in North America and Europe, there are still important unregulated sources of wood smoke, including household heating stoves and fireplaces. There are also important non-point sources of wood smoke, particularly wild-land fires and intentional burning of agricultural waste [2]. Most households in rural areas and a few in urban areas depend on biomass fuels (wood, dung, and agricultural waste) due to incomplete combustion of the biomass fuels; the resulting smoke contains a range of health-worsening substances that at varying concentrations can cause a serious threat to human health [2].

The sentiment that wood smoke, being a natural substance, must be benign to humans is still sometimes heard. It is now well established, however, that wood-burning stoves and fireplaces as well as wild-land and agricultural fires emit significant quantities of known health-damaging pollutants, including several carcinogenic compounds (e.g., polycyclic aromatic hydrocarbons, benzene, aldehydes, particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO), and other free radicals) [2] due to which cardiovascular, coronary artery diseases, cerebro-vascular diseases and venous thrombo-embolism occurred in people that are exposed [3]. Air pollutant when inhale, affects blood pressure [4]. The improved stove intervention was associated with 3.7mmHg lower systolic blood pressure (SBP) after adjusting for age, body mass index, smoking, second hand tobacco smoke, apparent temperature, season, day of week and time of day [5].

The mechanisms proposed to explain the adverse health effects of PM exposure include particle-induced oxidative stress, inflammation and genotoxicity. Several *in-vitro* studies of cultured cells have previously shown that wood smoke PM increased the expression and production of pro-inflammatory cytokines, oxidatively damaged DNA and production of oxidative stress [6]. Chronic inflammation has been suggested to be a mechanism promoting increased insulin resistance in mice with diet induced obesity and whole-body glucose homeostasis was reduced after increased PM exposures [7]. It is hypothetically say that exposure to wood smoke predisposes one to oxidative stress, reduced body glucose homeostasis and possible pancreas inflammation which could promote insulin resistance as seen in mice with diet induced obesity. The association between effect of exposure to domestic wood smoke and blood glucose level in African women has hardly been studied in the rural areas where wood is used as major source of domestic fuel and household heaters.

MATERIALS AND METHODS

1.1 Research Design

The research design used for the study was survey design. This is because it gives easy way to assess the effect of exposure to wood smoke on blood glucose level and body mass index among women in Samaru, Zaria. It is believed that survey design is most common and effective in examining existing issues as this study topic entails.

1.2 Population of Study

The targeted populations of study were the women in Samaru area of Zaria, Kaduna State of Nigeria. The population of the study includes all women who were 18 years and older and have been exposed to wood smoke for at least a period of ten years consistently as the exposed group and women who had never or abstained from wood smoke exposure for a period of ten years in the past as the control group. The target population was 50 women. The sample size was determined using the formula Yamane (1967) [8].

$$N = \frac{N}{1+ N*(e)2}$$

Where
n = the sample size
N = the population size

e = the acceptable sampling error
95% confidence level and p = 0.05 were used.

Hence, a total of 40 respondents were used for the research as the sample size which was selected from a total population of 50 women. The Forty (40) women volunteered to participate in the study. The women were grouped according to the type of domestic fuel used: wood (N = 20) and non-wood fuel (N = 20) group. Non-wood fuel comprised liquefied petroleum gas, electricity and kerosene. All the women who used non-wood fuels had been exposed to biomass fuel at some time, but were currently using mixed sources of fuel. Exclusion criteria included all smokers, pregnant women and women with family history of hypertension and diabetes any respiratory disorder, pulmonary arterial hypertension, diabetes mellitus, and those who underwent recent surgery.

1.3 Sample and Sampling technique

The sample for the study is made up of a total of 40 women from Samaru area (Ahmadu Bello University Community Market) of Zaria, Kaduna State of Nigeria. A volunteer sampling technique was used to select the women who constituted the respondents and subjects for the study. The women were selected from the market which use wood frequently as source of fuel and also from locations in the market where wood is rarely used as source of fuel.

1.4 Data Collection

Questionnaire and scientific instrument were used for data collection. The questionnaire was divided into four parts. Section A, B, C and D. Section A comprises socio-demographic data of the respondents, section B family history, section C habits and physical activities and section D some structured questions revealing issue concerning health condition and health care accessibility of the respondents.

1.5 Data Administration

The research was carried out at the locations selected as sample for the study and the questionnaires were administered to the designated sample of women personally. This was to avoid loss of the questionnaires. Hence, the wait and take method was used to request the respondent to provide information at the point of visit. After which, body weight, height, blood samples for fasting blood glucose level was taken according the method stated below.

Fasting blood glucose

The tip of the middle finger of each of the subjects was cleaned with cotton wool and methylated spirit. The finger was pricked using a blood lancet, the first drop of blood was wiped off with a cotton wool then the second drop of blood was allowed to drop on the glucose strip which was inserted into the glucose meter according to the manufacturer instruction. The blood samples were analyzed using the glucose meter, Accu-chek advantage, Roche Technology, USA.

Body mass index (weight and height)

The women each stood on a weighing scale and their weight were measured and recorded in kilograms. Their height was also measured in meters using a meter rule. Their body mass index (BMI) was then calculated using the formula BMI = $\frac{\text{weight(kg)}}{\text{height(m}^2\text{)}}$.

1.6 Ethical Consideration and Consent

An ethical permit from Ahmadu Bello University Teaching Hospital (ABUTH) Scientific and Health Research Ethics Committee was obtained for the research and also consent forms were issued out to the respondent during the research. This was to make sure that the respondents approved their participation in the research.

1.7 Statistical Analysis

The data obtained was expressed as Mean ± Standard error of mean (SEM) and analyzed by using the student t-test. Probability $P < 0.05$ was considered statistically significant. Statistical package for social science (SPSS) software version 20.0 for Windows computing programme was used for the statistical analysis.

RESULTS

Figure 1 shows the mean difference of fasting blood sugar (mg/dL) of women exposed to wood smoke and control group, (93.45 ± 2.14) as compared to control (76.75 ± 1.39). There is statistically significant increase in the fasting blood sugar of women exposed to wood smoke ($P < 0.05$).

Figure 1: Fasting blood sugar of women exposed to wood smoke and control group

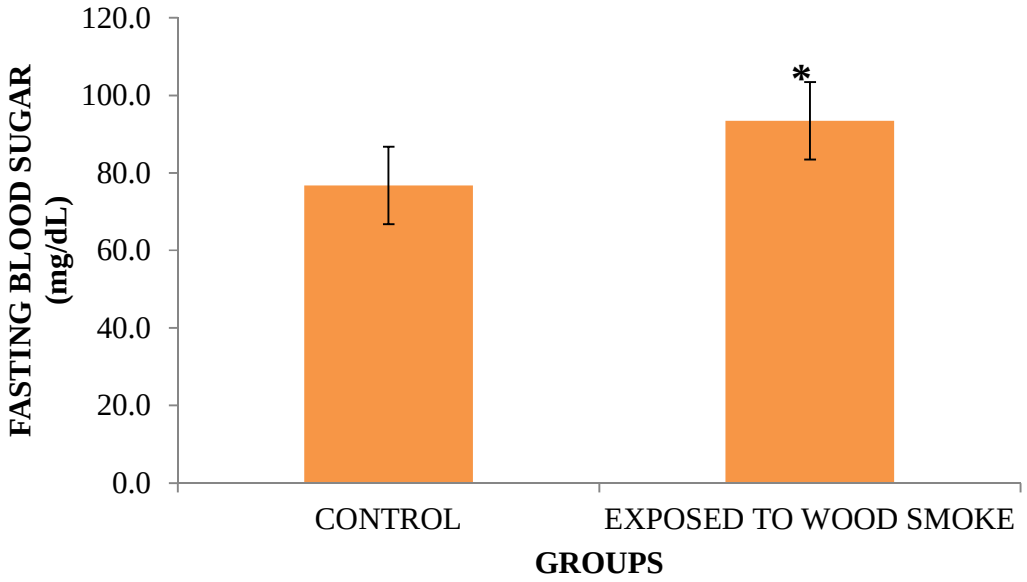

Figure 2 shows significantly higher ($p < 0.05$) value in mean of body weight of women exposed to wood smoke (67.40 ± 3.36) as compared to control (58.90 ±2.14).

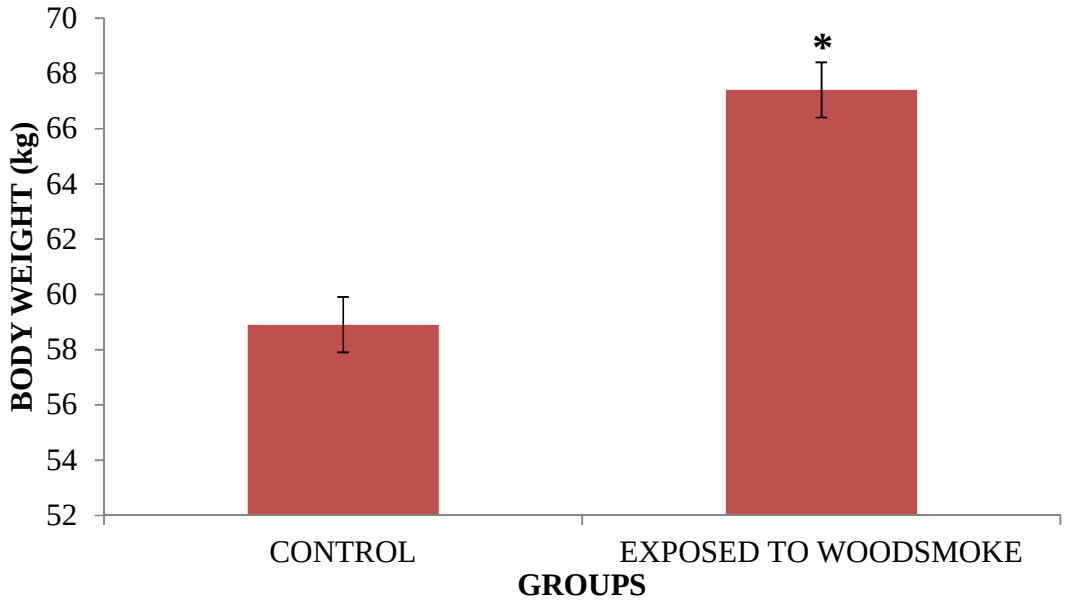

Figure 2: Body weight of women exposed to wood smoke and control group

Figure 3 shows the mean value difference in body height of women exposed to wood smoke (1.58 ± 0.02) and control group (1.62 ± 0.01). This result is not statistically significant, $p > 0.05$.

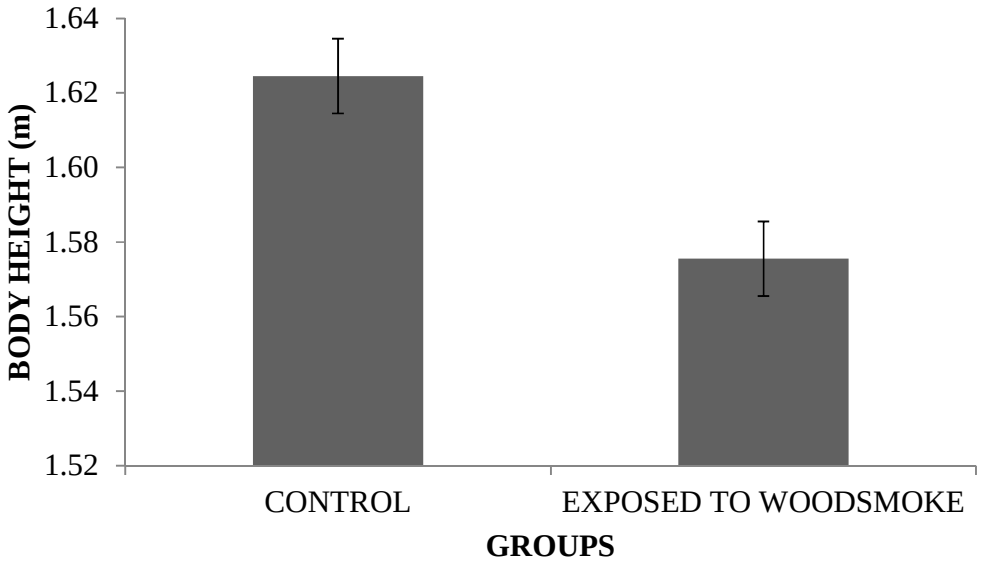

Figure 3: The body height of women exposed to wood smoke and control group

Figure 4 shows the mean of body mass index of women exposed to wood smoke (27.21 ± 1.39), is higher when compared to the control group (22.25 ± 0.62) which is significantly differ ($p < 0.05$).

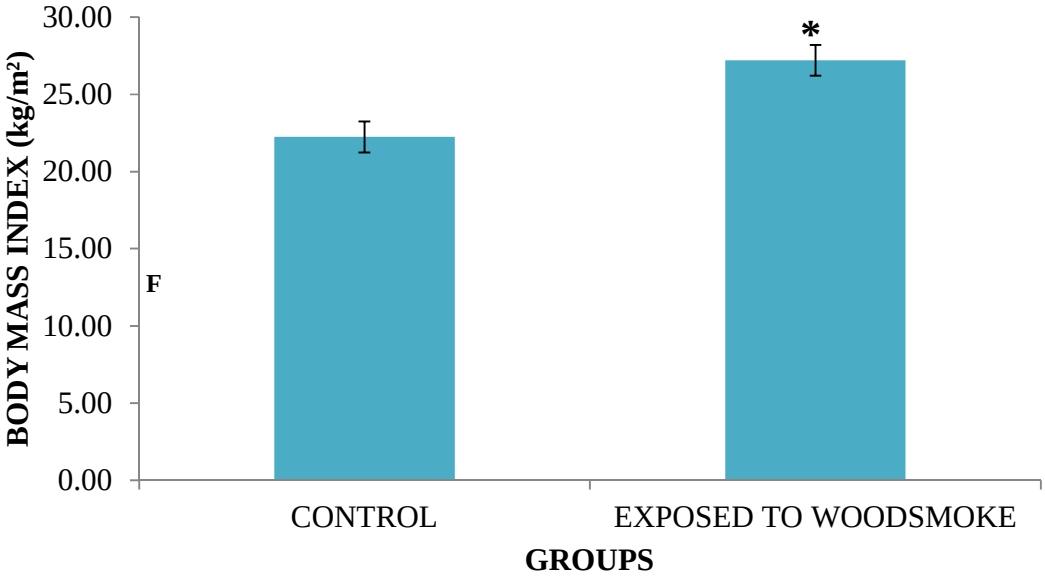

Figure 4: The body mass index of women exposed to wood smoke and control group

DISCUSSION

The present study is based on studying the effects of wood smoke on health status of the users of wood fuel. The adverse effects of the toxicants in wood smoke are common in all the developing countries. The findings of this study show anthropometric indices of control and wood users groups. Both groups differed significantly in fasting

blood glucose level, weight and BMI but not in height. Wood fuel users were found to be heavier and had higher weight and BMI. BMI has been associated with socio-economic status. Based on this study women who use wood fuels are of lower class, with less income and lower educational achievements. Women in this study were mainly cooks, causal workers with low income, when compared with women that used mixed fuels, who are in a higher socio-economic status with higher educational achievements and better pay, and therefore can afford more refined fuels than wood. This finding disagrees with previous report by Akor-Dewu *et al*. (2012) [9], they found that weight and BMI were significantly higher in mixed fuel users. As supposed, the control group who are high earned individual and relatively sedentary to have high body weight and BMI, in contrast, the exposed group was found to have high body weight and BMI. This could be ascribed to the effect of oxidative stress generated from wood smoke causing production of pro-inflammatory substances, disruption in the leptin regulation in the body resulting in gradually weight gain, relating to previous report by Pearson *et al.* 2010 [10], who report that exposure to high levels of air pollution causes increase in adipose inflammation and insulin resistance in mice. A growing body of epidemiology and laboratory-based literature connects air pollution, particularly PM2.5 and deterioration of cardiovascular health among other health conditions. Over expression of tumor necrosis factor alpha (TNF-α) in adipose tissue of rodents and humans provided the first clear link between obesity, diabetes and chronic inflammation. In the inflammatory hypothesis, large adipocytes infiltrated by macrophages produced TNF-α and interleukin-6 (IL-6) in obese individuals [11]. These cytokines decrease lipolysis in adipose tissue, inhibited insulin receptor signaling through different pathways and inhibited a differentiation of pre-adipocytes to mature adipocytes all of which finally led to insulin resistance.

Findings from this study also shows that wood fuels users had higher mean values of fasting blood sugar than the control group; but the mean values fell within the normal physiological range. The result differed significantly. The finding of the present study agrees with the result of study conducted on the effects of occupational exposure to wood Smoke in *Tandoor* Occupants in Pakistan [12]. Pearson *et al*. (2010) [10], suggest that for every $10\mu g/m^3$increase in PM 2.5, there could be a resulting increase of 10,000 diagnosed cases of diabetes or overall increase diabetes prevalence of $1\%/10\mu g/m^3$. Exposure to higher levels of air pollution exaggerates adipose inflammation and insulin resistance in a mouse model of diet-induced obesity. In diabetic patients, plasma inflammatory makers increase in response to higher PM2.5 exposure [10]. Sun *et al*. (2009) [7], demonstrated that the whole-body glucose homeostasis was reduced with PM2.5 exposure and suggested chronic inflammation to be a mechanism promoting increase insulin resistance in mice with diet-induced obesity after PM2.5 exposure. In endocrine hypothesis, adipocytes secrete adipokines such as leptin and adiponectin, which act at both the local and systemic (endocrine) level [13]. Similarly, O'Neil *et al*. (2007) [14], found that obese diabetic patients demonstrated a greater inflammatory response than non-obese diabetic patient upon exposure to pollutant. Taken together this study suggests that obesity probably play a critical permissive role in priming the body for pollution-induced inflammation and disordered metabolism.

CONCLUSION

In conclusion, this study observed significant increase in blood glucose level, body weight and body mass index but no significant different in height in the exposed group when compared to the control group. Hence, the findings of the study show that exposure to wood smoke causes an increase in blood glucose level, body weight and body mass index which could be a potential factor for developing and cofounding the lingering diabetes in our society.

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