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*Original Research Article*

# Correlation of BMI, and Pulmonary Function in Nigerian Firefighters

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***Purpose:*** **Obesity as measured by body mass index BMI, is a major health problem, worldwide and of importance is its effect on the respiratory system. It is well known that increases in BMI causes decreases in lung volumes, this study seeks to show the correlation between body mass index (BMI) and lung function indices such as $FEV_1$, FVC, FEV1/FVC, and PEFR, in firefighters who are equally exposed to smoke inhalation and smoking cigarette.** ***Methods:*** **The study is a cross sectional comparison of Nigerian firefighters with at least two years of fire fighting experience. One hundred (100) smoking (cases) firefighters were matched to 101 non-smokers (controls). Information pertaining history and duration of smoking was obtained from each smoker. Information pertaining to a wide range of Body Mass Index (BMI) ($kg/m^2$) was calculated as weight in kilograms (kg) divided by the square of the height in meters (m) i.e. $kg/m^{2,}$ clinical data of Peak expiratory flow rate (PEFR), forced expiratory volume in 1 second ($FEV_1$), forced vital capacity (FVC) and the ratio of the $FEV_1$ to the FVC as a percentage ($FEV_1$/ FVC%) were measured and analyzed for both groups. Wright's peak flow meter, Mechanical Spirometer, non-stretchable metric tape rule. Normographs for predicted $FEV_1$, FVC were used as investigative tools. Setting: Federal Fire Service stations in Lagos, Nigeria between July and August 2002.** ***Results:*** **There were significant linear relationships between BMI and lung function. Results of this study observed, that 43% of the smokers and 38.5% of the non-smokers falls within the normal weight category. Greater part of the remaining, falls within the overweight category (37 of smokers' vs 33 non-smokers. There were more obese fighters in the smoking group when compared with the controls (16vs 8). Only 4 of the smokers were found to be underweight and non amongst the non-smokers (*$P.Value \leq 0.01$*). With increase in value for BMI, the mean $FEV_1$/FVC were lower than the predicted for each age group. PEFR values significantly declined with increasing age. Those in the age group 20 to 29 years had the highest values of PEFR while those in the age range >50years the lowest values in both groups.** ***Conclusion:*** **The study showed that BMI has significant role in affecting the respiratory system as evidenced by the deceased values of lung function parameters, it can therefore, be deduced, even though smoking and smoke inhalation are known contributing factors to decrement in lung function, increase in body mass index is another single factor that has a negative effect on lung function.**

**Keywords:** BMI, Lung Function, Smoking, Firefighters.

## INTRODUCTION

Obesity is acceptable among Nigerians as it signifies evidence of good living, hence accepted culturally and socially as a way of earning respect in the society, and therefore is not usually recognized as a medical problem**.** Although there have been studies on prevalence of obesity in Nigeria, there is a paucity of information on factors associated with it. Establishment of associated factors will be potentially useful in the holistic approach to the prevention of the rising prevalence of obesity and other non-communicable cardiovascular diseases. The aims of this study were to find correlation of body mass index and lung function in smoking and non-smoking firefighters. This is to find if obesity has effect on lung function apart from smoke inhalation and smoking. It is defined[1] as an excess of adipose tissue resulting in body mass index (BMI) ≥30 kg/m.

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Obesity generally results from a chronic imbalance between energy intake and expenditure[1]. Until recently, obesity was considered the direct result of two weight linked behaviors of physical inactivity and chronic ingestion of excess calories. Although these factors are relevant, BMI is the most popular anthropometric index used for the assessment of obesity among individual subjects, which can be compared across populations.

Many studies have obesity to have a high correlation with body fat. Based on measured weight and height, many studies find that lung function, as described by the forced expiratory volume in one second ($FEV_1$) and/or forced vital capacity (FVC), is inversely correlated with general, pulmonary, and cardiovascular mortality and morbidity[1,3,4] PEFR is considered as the simplest index of pulmonary function to assess the ventilatory capacity. It is effort dependent and reflects mainly the calibre of the bronchi and larger bronchioles, which are subjected to reflex bronchoconstriction . $FEV_1$ and FVC at the end of life is a function of lung growth during childhood, peak function in early adulthood, and subsequent decline related to aging and insults such as cigarette smoking, air pollution, and occupational exposures[5,8]. Peak lung function in early adulthood is related to gender, race/ethnicity, cigarette smoking, exposure to environmental tobacco smoke and particulate air pollution [7,9].

In addition, lung function is decreased by excess body fatness after adjusting for other factors such as age, height, race, sex, asthma and smoking status in populations that are at risk for reduced lung function [10,19] obesity impacts on many areas of clinical medicine, including pulmonary medicine, where it is debated if obesity is linked to asthma,[4,5] or whether the obesity, due to its effect of decreasing lung volumes and increasing airway resistance,[6,10] causes symptoms that simply mimic asthma.[11,12,14] Therefore, it is important to understand the relationship between body mass index (BMI) and lung function in people who have occupational exposure to smoke and also habit of smoking cigarettes.

Several previous studies[7] [10,13] [16] have reported that increased body weight decreases lung volumes, they included subjects with coexisting morbidities such as cardiovascular disease,[17,18,19] or they were conducted with the subjects in the supine position. Despite the different study populations, there is general agreement that obesity, even morbid obesity, has relatively little effect on vital capacity (VC) or total lung capacity (TLC). That's why we chose to the study the lung function in firefighters who have occupational exposure and correlate it with various degrees of BMI

## METHODOLOGY

The study was a cross-sectional case-control study conducted at the federal fire service stations in Lagos. Population consisted of active male and who were on the alert list of the federal fire service stations. Informed consent was also obtained from the subjects. Included in the study was Smoking as cases and non-smoking firefighters as controls. All were actively involved in fire fighting for at least two years. Excluded were those with Heart disease, congestive heart failure and thoracic cage abnormality such as scoliosis, kyphoscoliosis, pectus carinatum, pectus excavatum, and those who refused to consent.

Information pertaining to, history and duration of smoking in pack years were also obtained. Height was measured to within 0.1 cm using a stadiometer. Weight was measured in kilograms to within 0.5 kg with subjects wearing light clothing using a portable bathroom weighing scale (HANA BR-9012). Body Mass Index (BMI) ($kg/m^2$) was calculated as weight in kilograms (kg) divided by the square of the height in meters (m) i.e. $kg/m^2$. Subjects with BMI < $18.5kg/m^2$ were classified as underweight and those with BMI between 18.5 and 24.9 $kg/m^2$ were classified as having normal weight. Those with BMI of 25.0-29.9 $kg/m^2$ and ≥ $30.0kg/m^2$ were classified as overweight and obese respectively.

Pulmonary functions as a measure of $FEV_1$and FVC were obtained using a mechanical spirometer attached to vilograph. PEFR was measured with a Wright's peak flow meter. All tests were performed with the subjects comfortably seated upright. Three Spirometric readings and PEFR manoeuvres were made by each subject, and the highest value was recorded, since this parameter requires maximum effort. A minimum of three and maximum of eight maximal performances were recorded until the results were reproducible. Using the predicted equation by Patrick and Femi-Pearse[12] for adult Nigerians aged 17–60 years, predicted values for $FEV_1$ and FVC were calculated for each patient and used to assess normalcy of ventilatory function and the pattern of ventilatory defect.

An obstructive ventilatory defect was described when the $FEV_1$ was markedly reduced compared to the FVC, such that the $FEV_1$/FVC% was reduced to less than 70%. Values of $FEV_1$/FVC ratio, expressed as percentage were used to determine presence of airway obstruction. However, $FEV_1$/FVC ratio declines as a normal process of aging, a ratio under 70% was defined to suggest evident airway obstruction. The values for each subject were compared with the predicted normal for age and height[12].

## DATA ANALYSIS

Statistical software Epi info (Version 6) was used for data entry, validation and analysis. The measure of central tendency and dispersion were computed for all quantitative variables e.g. PEFR, FVC, $FEV_1$, body mass index (BMI), and data on smoking. Variability in these figures was expressed as standard deviation. Mean and standard deviation were computed for all continuous variables and comparison was done using Student's t-test. Frequencies were generated for categorical variables and compared with the chi square test. Multiple linear regression and correlation analysis was utilized for the determinants of pulmonary function; $p< 0.01$ was accepted as significant.

## RESULTS

Results of this study observed, that 43% of the smokers and 38.5% of the non-smokers fall within the normal weight category. Greater part of the remaining, fall within the overweight category (37 of smokers' vs 33 non smokers). There are more obese fighters in the smoking group when compared with the controls (16vs 8). Only 4 of the smokers were found to be underweight and non amongst the non smokers (*P.Value ≤ 0.01*). The distribution of the BMI is shown in table 1.

Comparison of the lung function parameters and BMI for smoking and non smoking firefighters are shown in table 2 A and B respectively. For both groups the mean FEV1/FVC lower than the predicted for each age group. PEFR values significantly declined with increasing age. Those in the age group 20 to 29 years had the highest values of PEFR while those in the age range >50years the lowest values in both groups.

**Table 1** Frequency distribution of the international classification of body mass index in the study population

| BMI | SMOKERS | FREQUENCY | NON-SMOKERS | FREQUENCY | P-VALUE |
|---|---|---|---|---|---|
| <18.5 kg/m$^2$ | 21.406±3.40 | 4 | 0 | 0 | 0.002** |
| 18.5-24.5kg/m$^2$ | 22.00±2.5 | 43 | 23.68±4.01 | 39 | 0.068 |
| 25-29 kg/m$^2$ | 24.00±0.223 | 37 | 22.44±0.512 | 33 | 0.521 |
| >30 kg/m$^2$ | 23.56±1.348 | 16 | 20.373±1.760 | 8 | 0.379 |

**P. Value ≤0.01is significant

**Table 2** Age groups variables of, BMI, and lung parameters in the study population

**A**. SMOKING FIRE FIGHTERS.

| *AGE GROUP* | *FREQ* | *MEAN FEV1(l)±std* | *MEAN FVC(l)±std* | *MEAN PEFR(l/m)±std* | *MEAN FEV1/FVC test(%)±std* | *MEAN FEV1/FVC pred.(%)±std* | *MEAN ±SD OF BMI* |
|---|---|---|---|---|---|---|---|
| 20-29 | 2 | 3.6 ±.35 | 4.5±.53 | 520± 28 | 81± 2 | 83.3± .4 | 21.407±3.358 |
| 30-39 | 40 | 2.8±.8 | 3.75±.60 | 538± 74 | 77±6 | 80± 2 | 25.00±1.437 |
| 40-49 | 43 | 2.4±.51 | 3.23±.57 | 511± 90 | 76± 6 | 78.3± 3 | 26.00±1.641 |
| 50-59 | 15 | 2.2± .45 | 3.0 ±.45 | 486±110 | 71±9 | 76±3 | 22.100±1.53 |

**B.** NON SMOKING FIRE FIGHTERS.

| *AGE GROUP* | *FREQ* | *MEAN FEV1(l)±std* | *MEAN FVC(l)±std* | *MEAN PEFR(l/m)±std* | *MEAN FEV1/FVC test(%)±std* | *MEAN FEV1/FVC pred.(%)±std* | *MEAN ±SD OF BMI* |
|---|---|---|---|---|---|---|---|
| 20-29 | 5 | 2.5±.17 | 3.54±.36 | 502±67 | 72± 8 | 81± .8 | 31.967±2.73 |
| 30-39 | 40 | 2.7±.6 | 3.75±.82 | 535± 74 | 74±5 | 8l±3 | 22.879±1.32 |
| 40-49 | 45 | 2.32±.51 | 3.25±.63 | 496± 33 | 7l± 6 | 78± 3 | 26.86±1.701 |
| 50-59 | 11 | 2.25±.45 | 3.3 ±.75 | 480±96 | 69±4 | 75±3 | 26.92±1.68 |

**C.** OVERALL MEAN OF PULMONARY FUNCTION PARAMETERS AND BMI

| *VARIABLES* | *SMOKERS* | *NON-SMOKERS* | P. Value** |
|---|---|---|---|
| BMI | 21.874±2 | 22.877±1 | 0.22 |
| FEV1(L) | 2.6 | 2.5 | 0.19 |
| FCV(L) | 3.4 | 3.56 | 0.9 |
| FEV1/FVCtest(%) | 76 | 72 | 0.55 |
| PEFR(L/M) | 520 | 511 | 0.55 |
| FEV1/FVCpred.(%) | 78.6 | 78.7 | 0.74 |

**P.Value ≤0.01is significant

The overall mean body mass indices for smoking and non-smoking firefighters were within the normal range, however, the respective lung function parameters were all decreased, with values suggesting airway obstruction in both groups. The mean FEV1/FVC ratio for each group was lower than the mean predicted. This is shown in table 2 C.

## DISCUSSION

In this study, majority of the fire fighters studied were overweight. It seems to contradict the common expectoration if we consider the nature of the work and strain they are exposed. Firefighting is a strenuous job that requires a lot of energy expenditure. A close look at the result showed only the younger firefighters were overweight and majority with the high BMI belong to non-smoking groups which contradicts the numerous cross-sectional studies which indicated that body weight, or body mass index (BMI; in kg/m2), is lower in cigarette smokers than in non-smokers[5,6,8.] Underweight fire firefighters were, however, only seen amongst those that smoke and non was found in the non smoking group. Another awkward observation was the twice number of obese smoking fighters compared to the non smokers. This finding explains why the relation between smoking and obesity is incompletely understood. On the one hand, nicotine acutely increases energy expenditure (EE) [6, 8, 10] and could reduce appetite, which likely explains why smokers tend to have lower body weight than do nonsmokers and why smoking cessation is frequently followed by weight gain[6,9, 18.]

Moreover, a belief popular among both smokers and nonsmokers is that smoking is an efficient way to control body weight[17]. On the other hand, studies indicate that heavy smokers (ie, those smoking a greater number of cigarettes/d) have greater body weight than do light smokers [8,9,10,18] and that there is a clustering of smoking, obesity, and lower socioeconomic status. Finally, there is increasing evidence that smoking affects body fat distribution and that it is associated with central obesity and insulin resistance[18,19,]. Given the metabolic effect of smoking, it is expected that the greater the number of cigarettes smoked, the lower the smoker's body weight.

However, cross-sectional studies indicate that heavy smoking could be associated with a greater risk of obesity[9, 10, 18,20] this is in agreement with this study were older fire fighters who had smoked for a longer duration were found to belong to obese category. The question of why heavy smokers tend to have greater body weight than light smokers or nonsmokers remains unanswered. One explanation could be that heavy smokers are more likely to adopt behaviors favoring weight gain (eg, low physical activity, unhealthy diet, and high alcohol intake) than light smokers or nonsmokers. Smokers eat less fruit and vegetables, adopt unhealthy patterns of nutrient intake[22,24], drink more alcohol[24, 31,32], and engage in less physical activity than do nonsmokers[34, 35]. A strong clustering of risk behaviors have been identified (ie, low physical activity, low intakes of fruit and vegetables, and high alcohol intake) that correlated with the level of cigarette consumption[36].

There were associations between lung function, BMI, As hypothesized. Overall, FVC, FEV and PEFR were generally decreased in both smoking and non smoking fire fighters. Because greater number of the fire fighters were overweight suggest that increase in body mass indices of these fire fighters studied most have equally influenced the decreased in lung function parameters apart from smoking and smoke inhalation. High mean BMI was observed i the younger and older non smoking fires compared to the smoking group during the study. Furthermore, our results suggested a clear decline in either FVC or FEV1 such that the decline in FEV1/FVC follows an exponential drop from the younger age group 20-29 to the 50-59 in both groups, However the high Mean BMI corresponds with the lowers values of FEV1/FVC in both, suggesting an additional effect of increasing BMI on the lung function apart from smoke inhalation. This is in agreement with earlier studies. [34, 36,] The finding of a decrease in lung function with increasing baseline BMI is in agreement with several cross-sectional studies that found associations of FVC and $FEV_1$ with BMI[40,41] and other longitudinal studies that found that weight gain is associated with more rapid loss of lung function[43].

The PEFR, though effort dependent is equally affected. The present study showed an increase in mean PEFR values up to 40 years and decrease in mean PEFR values with increasing age after 40 years in both smokers and nonsmokers. This could be due to the strength of chest muscle contraction which improves with age in the younger age group and decreases as the age advances. These findings are in agreement with the findings of other studies[38,42,43,44] Mean PEFR values were consistently lower among smokers than nonsmokers in all age groups in view of the above findings and possible explanation, it can be deduce, even though smoking and smoke inhalation are known contributing factors to decrement in lung function, increase in body mass index is another single factor that has negative effect on lung function. Hence the inverse relationship of BMI and lung function.

## CONCLUSION

The study showed that BMI has a significant role in affecting the respiratory system as evidenced by the deceased values of lung function parameters, it can therefore, be deduced, even though smoking and smoke inhalation are known contributing factors to decrement in lung function, increase in body mass index is another single factor that has a negative effect on lung function.

Smoking firefighters had a greater degree of pulmonary function decline than that of non-smoking taking age groups into consideration. However, there are difficulties in measuring a firefighter's working environment. Nevertheless, prevention of respiratory diseases and the early management on pulmonary function by consistent and strict pulmonary function tests and measurement of BMI on firefighters are needed.

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## COMPETING INTEREST

The authors declare that they have no competing interests.

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