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Impaired Pulmonary Lung Functions in Workers Exposed to Bagasse: Is Obesity an Added Risk?

Yogita S. Khade, Shrilaxmi Bagali,[1] and Manjunatha Aithala[1]
Department of Physiology, NRI Institute of Medical Sciences, Sangivalasa, Vishakhapatnam, Andhra Pradesh, India
[1]Department of Physiology, Shri B. M. Patil Medical College Hospital and Research Centre, BLDE University, Bijapur, Karnataka, India
Address for correspondence: Dr. Yogita S. Khade, Department of Physiology, NRI Institute of Medical Sciences, Sangivalasa, Vishakhapatnam - 531 162, Andhra Pradesh, India. E-mail: moc.liamg@edahkatigoyrd

Abstract

Context:

Effect of obesity and dust exposure on lung functions.

Aim:

To assess the pulmonary functions in asymptomatic, dust-exposed sugarcane factory workers with obesity as an added risk.

Settings and Design:

A cross-sectional study.

Materials and Methods:

The present study was conducted in one of the reputed sugarcane factories in Karnataka. One hundred and fifty asymptomatic male workers working in sugarcane factory were included in the study. Based on exposure to sugarcane dust and body mass index (BMI), subjects were categorized into normal weight (not exposed to sugarcane dust), overweight and obese (not exposed to sugarcane dust), and overweight and obese (exposed to sugarcane dust). Adiposity markers such as waist circumference and hip circumference were measured; waist hip ratio, waist stature ratio, and body fat% were calculated. Lung volumes such as forced vital capacity (FVC in L), forced expiratory volume in 1 s (FEV_1 in L), forced expiratory flow during 25–75% of expiration ($FEF_{25–75\%}$ in L/s), and FEV_1/FVC%, peak expiratory flow rate (PEFR in L/min) were measured by digital spirometer.

Statistical Analysis Used:

Comparison between groups was done by one-way analysis of variance with *post hoc* analysis.

Results:

Significant lower values for FEV_1 in obese and PEFR among overweight and obese exposed to dust compared to overweight and obese not exposed to dust.

Conclusions:

We observed significant decrease in FEV_1(L) in obese workers exposed to dust and significant lower PEFR (L/min) in overweight and obese workers exposed to dust, indicative of obstructive pattern of lung disease as a result of occupation-related sugarcane dust exposure in overweight and obese workers in whom already some lung functions are impaired owing to their BMI status, thus indicating that obesity is an added risk.

Keywords: Body mass index, pulmonary functions, sugarcane factory workers

INTRODUCTION

India is the land of agriculture; sugar industry contributes to about 20% of sugar mills and 15% of sugar production of the world. India is the second largest agro-processing industry, next to Brazil.[1] Occupation-related exposure is a risk factor for acute and chronic respiratory irritation and inflammation with the possibilities of development of atherosclerotic and coronary artery diseases.[2] Organic dust “Bagasse” is the most important one.

Apart from dust, pulmonary functions are also affected by age, gender, and body mass index (BMI). Obesity may influence pulmonary function mechanically by changes in compliance, work of breathing, and the elastic recoil.[3,4]

India ranks third among obese and overweight (11% of adolescent and 20% of all adults) after US and China. Karnataka ranks 12th (male) and 9th (female) in the list of obesity.[5]

No studies have addressed obesity as a risk factor in the development of work-related lung disorders. The aim of the present study is to evaluate the additional impact of exposure to sugarcane dust on lung functions in individuals who already have a possibility of altered lung functions as a result of obesity. Therefore measures can be taken to prevent dust exposure and control weight so that impact of the dust exposure can be minimized.

MATERIALS AND METHODS

The study was conducted on the workers of sugar factory, during January 2013 to March 2013. The permission to carry out the study was sought from the management of sugar factory. Institutional ethical clearance was also obtained. The recording was done in the morning between 9 am and 12 noon.

Totally, 150 workers were included in the study. Sixty (overweight n = 30, obese n = 30) male workers exposed to sugarcane dust with minimum of 5 years exposure were selected for the study. Similarly, 30 age-matched normal weight male individuals, who volunteered and not exposed to dust (office workers), were selected from the same factory and considered as controls. Similarly, 60 (overweight n = 30, obese n = 30) controls not exposed to dust but were overweight and obese were included in the study.

The whole study population was divided into:

Group A: Normal weight controls, BMI = (18.5–22.9 kg/m^2)

Group B: Overweight controls, BMI = (23–24.9 kg/m^2)

Group C: Obese controls, BMI = (≥25.0 kg/m^2)

Group D: Overweight and exposed to sugarcane dust (cases), BMI = (23–24.9 kg/m^2)

Group E: Obese and exposed to sugarcane dust (cases), BMI = (≥25.0 kg/m^2)

As the study was done regarding exposure to dust with obesity as a risk factor, normal weight and exposed to dust is not included. Only those workers who were exposed to dry and moldy bagasse in the factory were included in the study (Groups D and E).

All the workers (age >25 years) included in this study were apparently healthy, nonsmokers, nondiabetics, and not suffering from any respiratory, cardiovascular, and congenital diseases.

Anthropometric parameters

Height, weight, waist circumference (WC), hip circumference (HC) were measured.

The following parameters were used for assessment of obesity:

1. Body mass index:BMI was calculated with the following formula:

2. Waist circumference: WC cut-offs were taken as >90 cm for male and >80 cm for female to define abdominal obesity.[6]
3. Waist/hip ratio (WHR):For the assessment of abdominal obesity, WHR was calculated as follows:

   The WHR of >0.80 for female and >0.90 for male is taken as obese.[7]

4. Waist/stature ratio (WSR):The WSR was estimated from the following formula:

   The cut-off for assessment of obesity was 0.5 for both sexes.[8]

5. Percent body fat:Upper limit of percent body fat defining obesity is still debatable. Percent body fat was defined as indicative of obesity, if it was >25% in male and >30% in female.[9] It is estimated by the following formula:

   Body fat % = (1.20×BMI)+(0.23×Age)−(10.8×Sex)−5.4

Sex: 1 for males and 0 for females.

Recording of pulmonary functions

Various lung volumes and capacities were recorded using Spiropac (MEDICAID). The subjects were informed regarding the procedure and demonstrated by investigator. The readings were taken in a comfortable upright sitting position. The readings were recorded in the morning between 9 am and 12 noon.

Forced vital capacity (FVC, L), forced expiratory volume in first second (FEV_1, L/min), FEV_1/FVC%, forced expiratory flow at 25–75% ($FEF_{25–75\%}$ L/s) of FVC, and peak expiratory flow rate (PEFR, L/min) of the subjects of all groups were recorded.

Statistical analysis

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 16. Data were expressed as mean ± SD. Comparison between groups was done using one-way analysis of variance with *post hoc* analysis.

RESULTS

All the five groups were age-matched. As expected, height, weight, BMI, body fat %, WC, HC, WHR, and WSR were significantly different between the five groups [Table 1]. Significant differences in FVC, FEV_1, FEV_1/FVC%, and PEFR were observed [Table 2 and Figures Figures11–4]. No significant changes observed with $FEF_{25–75\%}$. Comparison between the groups was done by *post hoc* analysis.

DISCUSSION

Pulmonary function test (PFT) is a basic and essential test for diagnosis, assessment of pulmonary dysfunction, pulmonary diseases, and treatment effects. It is a known fact that pulmonary functions vary according to the physical characteristics, including age, height, body weight, and altitude (hypoxia or low ambient pressure).[10,11]

Bagasse, a byproduct of sugarcane crushing, is an organic dust containing high concentrations of bioaerosols, such as bacteria, actinomycetes, and fungi of plant and animal origin. Size varies from 0.5 to 3 microns, which are called as respirable dust, to which sugar factory workers are exposed by virtue of their occupation.[12]

Obesity is a serious nutritional problem in the world and a source of multiple comorbid conditions in metabolic and cardiopulmonary disorders. It offers mechanical obstruction to the movements of the body and the respiratory system.

The PFTs assess respiratory efficiency. We found significant changes in FVC, FEV_1, FEV_1/FVC%, and PEFR. The findings of our study are in contrast to findings of Gascon *et al*. In their study all subjects had BMI above 25, suggesting general obesity. The PFTs parameters such as FEV_1, FVC, and FEV_1/FVC were recorded before and during the harvesting season; however, Bagasse exposure did not seem to affect the ventilator lung function parameters in their subjects.[13]

FVC: It is the vital capacity performed with expiration being as forceful as possible that is forced after maximal inspiration. FVC is affected by age, sex, body build, occupation, etc., Our study demonstrates significantly lower FVC in obese and overweight workers compared to normal weight. We observed no significant difference in FVC among overweight/obese workers not exposed to dust and overweight/obese workers exposed to dust (Group B vs. Group D and Group C vs. Group E). Hence in the present study decrease in FVC is probably due to obesity and not due to occupational dust exposure as shown in Figure 1. The results of our study are in contrast with the results of Patil *et al*. in which there is significant decline in FVC in Bagasse exposed workers.[14] Findings of our study collaborate with a 6-year follow-up study at Canada.[15] Similar study at Canada showed significant linear relationship between BMI and vital capacity.[16] The significant decrease in FVC in overweight and obese workers may be due to elevated diaphragm, mediastinal fat deposition, interfering with the movements of the chest, decreased compliance, and marked thoracic kyphosis.[17]

FEV_1 and FEV_1/FVC%

FEV_1 is defined as the volume of air expired in 1 s, while performing FVC. In our study we observed significantly lower FEV_1 in obese workers exposed to dust compared to obese workers not exposed to dust (Group C vs. Group E). Hence occupation related dust exposure significantly reduced FEV1 in obese workers as in Figure 2. The decline in FEV_1 is a convenient standard against which we can measure marked declines in subjects with the history of chronic obstructive pulmonary disease or in subjects exposed to environmental pollutants. FEV_1 is known to be reduced in both central and peripheral airway obstruction and reduced lung volume.

The significant decrease in FEV_1 is due to repeated attacks of exposure to dust, destroys respiratory tissue inducing a chronic spreading fibrosis, which destroys alveoli as well as bronchioles as a result of allergic alveolitis. Inflammatory responses and destruction of alveoli causes decreased diffusion capacity of the alveolocapillary membrane, resulting in hypoxia and the associated hyperapnea that give rise to decrease in $PaCO_2$(carbon dioxide tension in alveolar air), which also induces constriction of bronchial muscles. Hypoxia leads to release of leukotrienes and chemokines from eosinophils resulting in broncho-constriction. The walls of bronchioles may be thickened by lymphocytic infiltration and the lumen may be obstructed by granulation tissue.[18]

FEV_1/FVC% is defined as the forced expiratory volume expired over 1 s to FVC percentage ratio. FEV_1/FVC% is slightly higher in overweight and obese workers compared to normal weight workers irrespective of sugarcane dust exposure. In Group B, the difference in FEV_1/FVC% in comparison with Group A is statistically significant. This is indicative of restrictive pattern as a result of obesity as per Figure 3.

$FEF_{25–75\%}$(L/s): No significant difference in $FEF_{25–75\%}$(L/s) was observed across groups.

PEFR: PEFR is a fairly good indicator of bronchial hyper-responsiveness.[19] The PEFR values are affected by various factors, such as sex, body surface area, obesity, physical activity, posture, environment, and racial differences.[20,21] We observed significantly lower PEFR in overweight and obese dust exposed workers compared to their unexposed counterparts as evident in Figure 4. No significant differences were observed between normal weight, overweight, and obese workers. Hence the decreased PEFR can be attributed to occupation-related dust exposure. The reduction in PEFR may be because of the mechanism already explained for obstructive lesion (FEV_1/FVC%). The reduction in PEFR in workers might be due to inflammatory changes in the respiratory tract, which lead to an increased airway resistance and physically impeding the normal lung function as a result of the dust exposure with additional risk of obesity.

Ugheoke *et al*. (2006) assessed pulmonary functions in workers exposed to sawdust and observed that sawdust exposure ultimately results in airway remodeling and lung dysfunction, and this leads to increased airway resistance that manifests as lower peak flow rate value in the wood workers compared to the controls.[22] The decrease in the PEFR observed in the workers is in conformity with the reports of Okwari *et al*. (2005).[23]

CONCLUSION

To summarize, we observed significant decrease in FVC in overweight and obese workers irrespective of dust exposure, indicative of decreased compliance of chest wall. FEV_1/FVC% is slightly elevated in overweight and obese workers and again this is irrespective of dust exposure. This indicates a restrictive pattern in overweight and obese workers as a result of rising BMI. We also observed significant decrease in FEV_1(L) in obese workers exposed to sugarcane dust and significant lower PEFR (L/min) in overweight and obese workers exposed to sugarcane dust. The decrease of FEV_1(L) and PEFR (L/min) observed is indicative of obstructive pattern of lung disease as a result of occupation-related sugarcane dust exposure in overweight and obese workers in whom already some lung functions are impaired owing to their BMI status, indicating that obesity is an added risk.

Limitations of the study

Small sample size. Females were not included in the study, to study for the possible influence of sex on pulmonary functions and the associated occupational dust exposure. Other household variables such as cooking system usually used in these workers' home (gas, wood, or any other) were not evaluated.

Future prospective

Comparison between different factories and sugarcane factory. Effect of sugarcane dust on hematological parameters. Chemical nature of the dust can be evaluated. Study between production of sulfur-free sugar and normal sugar can be done.

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Conflicts of interest

There are no conflicts of interest.

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