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Relationship between body mass index, percent body fat, fat weight, and respiratory functions among secondary school teachers in Ibadan North local government area, Ibadan, Nigeria

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Abstract. *Introduction.* Obesity is increasing at an alarming rate and according to World Health Organisation, the number of severely overweight adults is expected to double that of the underweight by 2025. Obesity is no longer concern for the developed countries only, but it is becoming a global phenomenon with prevalence on the rise in many developing countries like Nigeria. Obesity has been found to be associated with impaired respiratory function. The aim of this study was to determine the relationship between body mass index (BMI), percentage body fat (%BF), fat weight (FW) and predicted respiratory function indices. *Material and Method.* Two hundred (100 males and 100 females) randomly selected non smoking secondary school teachers in Ibadan North local government area, Ibadan, with age range between 38 and 62 years voluntarily participated in this study. Expost facto research design was used for this study. BMI, % BF and FW were used as measures of body fat, while predicted forced expiratory volume in 1st second (FEV_1), predicted peak expiratory flow rate (PEFR), predicted forced vital capacity (FVC), breath hold time, respiratory rate and chest expansions were used as measures of respiratory function. The procedure of measurement was explained to each participant before they were allowed to participate in this study. Descriptive statistics of range, mean and standard deviation were used to analyse all the variables measured in this study. Pearson product moment correlation coefficient was used to determine the relationship between body fat indices and predicted respiratory function indices. Alpha level was set at 0.05. *Results.* There was a significant inverse relationship between BMI, %BF, FW and all the respiratory function indices ($p \leq 0.05$) except respiratory rate, which showed a significant direct relationship ($p \leq 0.05$). The mean of measured respiratory function indices (FEV_1, PEFR and FVC) were significantly lower than the predicted values. *Conclusion*. The mass loading effect of excess body fat on the mechanics of the thorax reduces respiratory efficiency.
Key words: *Body mass index, Percent body fat, fat weight, predicted respiratory function indices.*

Introduction

Obesity which has been defined as excess accumulation of body fat results when the energy intake of an individual exceeds energy expenditure, leading to excess fat relative to non-fat tissue (1-4). Obesity tends to run in families (5,6), with a greater likelihood of a child becoming obese, if both parents are obese (7,8) than if one parent is obese. It was suggested that human obesity may be influenced by behaviours that are themselves genetically regulated such as imposition of a feeding pattern with high calorie foods and beverage by the mother on the child early in life (9), which may play major role in a cultural transmission of obesity from one generation to the next rather than genetical. This familial tendency to obesity according to Nguyen, Larson & Johnson et al. (10), relates to energy intake rather than energy expenditure.

According to Kambe, Kimura & Kawamoto et al. (11), pulmonary function is classified as respiratory and non-respiratory function. Respiratory pulmonary function involves the exchange of oxygen and carbon dioxide gas at alveolar units in the lungs (11). The ventilatory muscles are striated skeletal muscles (12) and their in situ function is governed by the same relationship that determines the contractile force of muscles in-vitro. They are distinct functionally from limb skeletal muscles in that they are the only skeletal muscles on which life depends (13). All inspiratory muscles shorten when the lung is inflated above the functional residual capacity. Among these muscles that participate in ventilation, the diaphragm has the greatest capacity for shortening and volume displacement, making it the primary muscle of inspiration (13). Other inspiratory muscles include intercoastal muscles, scalene muscles, which elevate the first two ribs and the sternum, and the sternocleidomastoids, which elevate the sternum during exercise and vigorous breathing. Forced vital capacity (FVC) and forced expiratory volume in 1st second (FEV_1) (14), peak expiratory flow rate (PEFR) (15, 16), vital capacity (17,

18), respiratory rate (19) and breath holding time (18) have been used for the assessment of respiratory function.
Obesity has been found to be associated with health risks. It can affect the thorax, diaphragm and abdominal muscles causing increased respiratory effort and impairment of the gas transport system thereby altering respiratory function even if the lungs are normal (20). Singh, Linstead & Fraser (21), observed a direct positive relationship between body mass index and mortality in the middle aged and old men. Impaired respiratory function and ineffective respiratory muscles was also observed in the obese (22, 23). This influence of obesity on respiratory function has long been recognized and established, but the nature of the relationship and the mechanisms are not yet clear (23, 24). Lazarus, Sparrow & Weiss (24), obtained a significant negative relationship between body mass index (W/H^2) and forced vital capacity in men between 40 and 69 years of age. After adjustment for BMI, sub-scapular skinfold thickness was found to be negatively associated with both FVC and FEV_1 among men aged between 30-59 years (24). In males, FVC had a significant positive relationship with BMI (25). In females a negative relationship was obtained between subscapular skinfold thickness and both FVC and FEV_1 (25). Sanya & Adesina (18), observed a high but inverse relationship between estimated body fat and predicted vital capacity and breath holding time in subjects whose BMI (quetelet) index were above 30 Kg/m^2. These findings were attributed to the restrictive effect of excess adipose tissue located around the thorax and abdomen. Weiner, Waizman & Weiner et al. (22) claimed that morbidly obese subjects are known to have impaired respiratory function and inefficient respiratory muscles. Collins, Hoberty & Walker et al. (26), opined that individuals having upper body obesity have more severely compromised lung function than those with lower body obesity. The aim of this study was to determine relationship between adiposity indices and respiratory function indices among secondary school teachers.

Material and Method

The research design for this study was expost facto design. Ethical approval in compliance with the Helsinki Declaration was sought and obtained from Oyo State Health Management Board Ethical Review Committee before the study was conducted.
Participants. Two hundred (200) non smoking, apparently normal, secondary school teachers selected from 10 secondary schools out of 21 schools in Ibadan north local government area using multistage random sampling technique. Relevant medical history and examination of the cardiovascular and respiratory systems was used in screening those that participated in this study. Non smokers and those that were found to be free from respiratory conditions were allowed to participate in this study after signing the informed consent form.
Procedure for data collection. The following measurements were taken.
Age of participants was recorded in years to the nearest birthday.
Weight: The Seca weighing scale manufactured by Vogel and Halk Gmbh co. Germany was used to measure body weight. The weighing scale is calibrated in Kilogrammes from 0-150kg. It is accurate to the nearest 0.5 kilogrammes. Each participant's weight was measured with light clothing, bare footed, standing erect, looking straight ahead. *Height:* The participants stood erect on the Seca weighing scale platform with feet together. The Seca height scale manufactured by Vogel and Halk Gmbh & company, Germany was used to measure height of participants. The height scale is calibrated in centimetres from 60 200 centimetres. It has measurement precision to the nearest 0.1cm. The height of each participant was measured bare footed, standing erect and looking straight ahead, feet together with heels touching the height meter bar. The horizontal bar of the scale was adjusted to rest on the subjects head without exerting pressure. The scale was read at this level and recorded to the nearest 0.1centimeter. Body mass index was computed with the formulae weight/height^2 with unit of measurement as Kg/m^2.
Respiratory functions. Respiratory rate: Sport timer alarm stopwatch made in United Kingdom was used to determine respiratory rate. It is accurate to the nearest 0.01 seconds. The participants assumed a half lying position on the plinth with right hand placed on the chest. The breathing rate was measured by counting the number of chest excursions in one minute. *Breath holding time.* The breadth holding time was measured by instructing the participants to breathe in gently and maximally and then hold the breath at the end of full inspiration. A small strip piece of paper was held in front of the nose and mouth and a nose clip was applied to prevent breathing through the nose. The participant was timed until the slightest displacement of the paper is noticed. The time taken to hold the breadth was recorded in seconds. The best of three trials was recorded.

FEV_1 and FVC : FEV_1 and FVC were measured with Computerised Battery operated Micro Spirometer. The switch on the machine is set at the blow position. The subject is instructed to breathe in until the lung is completely full. The lips are sealed around the mouthpiece and the subject exhales through the mouth maximally and as fast as possible until air cannot be pushed out anymore. Once this manoeuvre is completed, the FEV_I measurement will be displayed and is recorded to the nearest 0.01Litres. To obtain measurement for Forced Vital Capacity (FVC) the micro spirometer is switched to the VIEW position, the FVC appears on the screen. It is then recorded to the nearest 0.01Litres. The best of three trials was recorded.
Peak expiratory flow rate: Mini Wright Peak Flow meter was used to measure peak expiratory flow rate (PEFR). In standing position participants held the peak flow meter in his hand, he takes a deep inspiration. He expires with the mouth piece placed in the mouth without air leakage and then blows out forcefully into the mini-wright peak flow meter. The best of three trials was recorded to the nearest 10 L /min. Predicted values of FEV_1, FVC and PEFR were determined using lung function calculator included with the Computerised Battery operated Micro Spirometer.
Percent body fat. Omron body fat monitor was used to measure percent body fat and fat weight. With participants in standing, feet slightly apart while he wraps the middle finger around the electrode grooves of the handle of the instrument with the thumb and index finger securely grasping the upper portion of the electrode. Subject wraps the ring and little finger around the lower portion of the electrode. After the input of weight, height, age and gender into Omron body fat monitor. The subject presses the palm firmly against the electrode. With the elbows straight, two upper limbs at 90 degrees. The researcher presses start button and fat weight and percent fat is displayed on the monitor and read off from the instrument.
Chest expansion: Chest expansion was measured with an inelastic tape measure applied round the chest wall at the sternal angle anteriorly and at the inferior angle of the two scapulae bones. Participant was instructed to breathe out gently and maximally. The circumference was measured. The participant was instructed to breathe in gently and maximally. The circumference of the chest is measured again. The difference between these two measurements was recorded as the chest expansion.
Data Analysis. Descriptive statistics of Range, Mean and Standard Deviation was used to analyse age, weight, height, forced expiratory volume at 1st second (FEV_I), peak expiratory flow rate (PEFR), forced vital capacity (FVC) and their predicted values, respiratory rate, breath holding time, chest excursion, percent body fat, body mass index and fat weight. Inferential statistics of Pearson product moment correlation coefficient (r) was used to determine relationship between adiposity indices (BMI, % BF and FW) and the respiratory function indices. All hypotheses were tested at 0.05 alpha level.

Results

Two hundred participants who were secondary school teachers from 10 selected secondary schools in Ibadan North Local government Area voluntarily participated in this study. Table 1 shows the summary of (mean, standard deviation and range) for all the variables measured.

Table 1. Physical characteristics of participants (n=200)

Parameters	Range	X ± S.D.
Age (Years)	38.00-62.00	39.52±7.24
Height (m)	1.45-1.92	1.63±0.08
Weight (Kg)	49.00-112.00	76.96±13.95
BMI (Kg/m^2)	18.81-42.87	29.04± 5.84
Percent body fat (% BF)	6.80- 49.10	30.68±9.49
FEV_1 (L)	0.55- 4.12	2.24± 0.73
PEFR (L/min)	150.00- 590.00	354.84±80.07
FVC L	0.92- 4.71	2.44±0.73
Predicted FEV_1 (L)	1.90- 4.80	3.14±0.50
Predicted PEFR (L/min)	321.00- 632.00	454.42±69.42
Predicted FVC (L)	2.20- 5.80	3.69±0.66
Breadth holding time (secs)	19.18- 80.38	44.97±12.92
Respiratory rate (per min)	11.00-23.00	14.94±2.39
Chest Expansion (cm)	2.20- 8.50	4.89±1.55

Table 2 shows comparison between some of the respiratory function indices and their predicted values. This table shows significantly lower FEV_1, PEFR, and FVC than the predicted values. Table 3 shows the relationship between BMI, % BF, FW and respiratory function indices ($predfev_1$, predpefr, predfvc, breadth hold time, respiratory rate and chest expansion).

Table 2. Comparison between measured and predicted respiratory function indices using independent 't' test (n=200)

	Measured variables X ± SD	Predicted variables X ± SD	t	p value
FEV_1	2.24±0.73	3.14±0.50	-19.33	0.000
PEFR	354.83±80.07	454.42±69.42	-16.16	0.000
FVC	2.44±0.48	3.69±0.46	-27.50	0.000

Table 3. Relationship between BMI, percent body fat, fat weight and respiratory function indices using Pearson's product moment correlation coefficient

	$predfev_1$	fev_1	predpefr	pefr	predfvc	fvc	bhold	rrate	chestexp
Body mass index (Kg/m^2)	-0.329	-0.497	-0.197	-0.486	-0.303	-0.514	-0.514	0.716	-0.597
p value	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
Percent body fat (%)	-0.487	-0.562	-0.422	-0.534	-0.474	-0.614	-0.510	0.682	-0.778
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fat weight (Kg)	-0.305	-0.508	-0.241	-0.504	-0.294	-0.558	-0.534	0.719	-0.700
p value	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000

$predfev_1$ = predicted forced expiratory volume; bhold = breadth hold; predpefr = predicted peak expiratory flow rate; rrate = espiratory Rate;predfvc = predicted forced vital capacity; chestexp = chest expansion; predfer = predicted forced expiratory ratio; fev_1 = forced expiratory volume in 1st second; pefr = peak expiratory flow rate; fvc = forced vital capacity; predfer = predicted forced expiratory ratio

Discussion

The result of this study showed significant inverse relationship between BMI, % BF, FW and respiratory function indices ($predfev_1$, predpefr, predfvc, fev_1, pefr, fvc breadth hold time and chest expansion) except respiratory rate that has significant direct relationship.

The obese is at high risk of pulmonary complications (22, 27) with impaired respiratory function and inefficient respiratory muscles (28), leading to decreased lung volumes and respiratory muscle performance. According to Deane & Thomson (29), mechanical restriction by fat is the cause of the respiratory impairment, which exists in both sexes though with different pattern (25, 30).

In agreement with this study, Sanya & Adesina (18), observed an inverse relationship between predicted vital capacity, breadth holding time and BMI with BMI above 30 kg/m and from this it can be implied that increased adiposity level is associated with decrease in vital capacity and breadth holding time as observed in this study. Collins, Hoberty & Walker et al (26) in a study on the effect of body fat distribution on pulmonary function test with a group of normal and mildly obese individuals observed a significant inverse relationship between BMI and FVC, % BF and FEV_1, which is in agreement with the result of this study. Koziel, Ulijaszek & Szklarska et al (25) obtained a significant positive relationship between FVC and BMI in males, which contradicts the outcome of this study. Wannamethee, Shaper & Whincup (30), obtained in elderly men between 60 and 79 years of age a significant inverse relationship between FVC and BMI. Fat weight (FW) and % BF were significantly inversely related to FEV_1, and FVC in the study, which is in agreement with the result of this study. It is believed that with accumulation of body fat, the muscles get infiltrated with fat thereby making them flabby and weak. The amount of tension such muscles can generate is reduced, thereby leading to reduced chest expansion and hence reduced respiratory function. Restriction effect of accumulated fat in the thorax has also been implicated in respiratory inefficiency caused by obesity.

Conclusion

This study was able to reveal an inverse relationship between body fat and respiratory function indices except respiratory rate which had direct correlation. As body fat increases respiratory function declines. Habits that encourage body fat accumulation should be discouraged to maintain an efficient respiratory function and adequate level of physical fitness.

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