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Relationship between Body Mass Index and Body Fat Percentage

Author
Dr Deepa Sanjeev Nair
Associate Professor, Department of Physiology, MIMER Medical College, Talegaon (D), Pune, India
Corresponding Author
Dr Deepa Sanjeev Nair
Associate Professor, Dept of physiology, MIMER Medical College, Talegaon (D), Pune Pin- 410507
Tel. 9326026733, Email: *drdeepasnair@rediffmail.com*

Abstract
Background; *Obesity is a worldwide epidemic. According to the latest reports India is the third most obese country in the world. Obesity is a condition with excess body fat to the extent that health and well-being are adversely affected. As the obesity is associated with increased mortality and morbidity, assessment of obesity is important. Body Mass Index (BMI) is a widely used tool to gauge obesity. There is difference of opinion whether BMI is a reliable indicator of body fat percentage.*
Aim and Objectives: *To assess the correlation between Body Mass index and body fat percentage.*
Material and Methods; *Study was conducted in adult male of age group 35-45 years. Height and weight are measured. BMI is calculated using the formula BMI= Weight (kg)/ Height (m2). The study group is divided in to three according to their BMI. Group I, II and III consists of subjects with BMI less than 25, with BMI between 25-29.9 and BMI above 30 respectively. Fat percentage is assessed by hydro densitometry. Statistical methods ANOCVA, Kruskal – wallis test and correlation analysis is used to compare BMI and fat percentage Result: In my study, I found a correlation between Body mass Index and fat percentage.*
Conclusion: *Body mass index is a fair indicator to assess fat percentage.*
Keywords: *Body mass index, Fat percentage, Hydrodensitometry.*

Introduction

Obesity is a worldwide epidemic. According to the latest reports, India is the third most obese country in the world. Obesity is a condition with excess body fat to the extent that health and well-being are adversely affected[1]. Obesity is a health hazard and is associated with increased mortality and morbidity. Various diseases associated with obesity includes coronary heart disease, hypertension, Type 2 diabetes mellitus. There are also data showing a strong correlation between obesity and endocrine disorders such as ovarian dysfunction, hormone related cancers etc[2]. As obesity is associated with increased morbidity and mortality, the assessment of obesity is very important. Most widely used method to measure obesity is Body mass Index (BMI), which is equal to weight/ height ^{2} [in kg/m^2). Other approaches to measure obesity include anthropometry (skin fold thickness), densitometry [under water weighing], computerised tomography, magnetic resonance imaging etc.

Based on the un equivocal data of substantial morbidity, a BMI of 30 is most commonly used as threshold for obesity in both men and women. Large scale epidemiological studies suggest that metabolic disorders, carcinoma and cardiovascular morbidity begin to rise when BMI is 25 or more suggesting that cut off rate for obesity to be lowered. Some authorities use the term overweight to describe individuals with BMI 25 and 30. A BMI between 25 and 30 should be viewed as medically significant and worthy of therapeutic intervention [3].

Body mass Index is widely used method as it is a simple procedure. There is difference of opinion whether Body Mass index is a true indicator of fat content of the body. Ranasinghe C etal compared body mass index and body fat percentage estimated by bio electrical impedance and found that there is a strong correlation between BMI and body fat percentage measured by bioelectrical impedance[4]. But Meeuwsen S etal, in their study concluded that the relationship between BMI and percentage body fat is not strong[5].

The present study aims to throw some light on the correlation, if there exists one, between body mass index and Percentage body fat.

Aim and Objective

To assess the correlation between Body Mass index and body fat percentage

Material and Methods

The study was conducted on adult male subjects aged between 35-45 years. Subjects selected were apparently healthy with no h/o systemic illness. Procedure was explained to them and written consent was taken.

Body Mass Index Assessment

Height and weight of the subjects were measured by means of SECA balance. The subject was made to stand bare foot against the scale attached to the balance. The posture was corrected, the back was straightened and the external acoustic meatus was aligned with the outer canthus of eye, bringing the head to the Frankfurt plane.. The flat surface was placed over the scalp and the height was read off the scale. The balance was corrected to '0' before taking the weight by using built in correcting device. BMI was calculated using the formula BMI = Weight {kg}/ Height ^{2} [in m^2).

The study group were divided in to three according to their BMI. Group I, II and III, subjects with BMI less than 25, with BMI 25-29.9 and BMI above 30 respectively.

Calculation of fat Content

The fat content was calculated by hydro densitometry with the help of the immersion tank. Immersion tank was locally fabricated. The metallic tank was made up of iron and has got a height of 200 cm, length 125 cm and breadth of 125 cm. Water can be pumped in to the tank and the water level inside can be measured by means of a connecting tube and a scale attached to it. The scale has got measurement in centimetre on one side and inches on the other side. Least count of the scale is 1 mm. The tank was calibrated by pouring known amount of water. The iron tank is provided with a ladder through which the person can climb up in the tank and then get immersed in the water .There are provisions for adjusting the temperature of the water through a relay system which maintain the temperature in the immersion tank close to the mean skin temperature of subjects , which is 35 degree C initial level of water tank was noted. Then the subject was asked to submerge their body completely after exhaling maximally and then holding their position for a few seconds until the water level after submersion had stabilized and noted. The water displacement was calculated from the difference between two water levels. From this body density was calculated as body mass/ volume. Assuming that the density of fat and fat free mass is known, the proportion of each constituent may be calculated from measurement of body density [6]

Percentage of fat = [(4.95/d)-4.5] × 100

Results

The study has been carried out in 45 healthy male volunteers with BMI. Study group were divided in to 3 according to BMI

Group	BMI	No. of subjects
I	<25	15
II	25-29.9	15
III	>30	15

Variable in the study

Age

Mean age of the subjects in group I was 39.00+ 4.488 years and that of group II and group III were 37.69 + 4.316 yrs and 40.80+3.726 yrs respectively. There was no significant difference in the age. (Table1)

Height

Mean heights of group I, II, and III were 1.699 + 0.049 m, 1.674 + 0.036m and 1.677 + 0.037 m respectively. There were no significant differences in the height (Table-2)

Weight

Analysis of the weight showed a significant difference ($p<0,05$) with mean values being 69.267+4.992Kg, 79.438+ 3.346 Kg and 87. 233 + 2.840 kg in group I, II and III respectively (Table 1)

The statistical method, ANOVA was used to analyse anthropometric parameters viz, age, height and weight.

Body Density

The mean values in the group I, II and III were 1.055 + 0.009g/cm3, 1.037 + 0.005 g/cm3 and 1.028= 0.004 g/cm3. Body density tend to decrease with increase in BMI and it was statistically significant ($p < 0.0050$ (Table 2)

Fat percentage

Mean fat percentage values obtained in group I, II and III were 19.197 + 4.210%, 27.316+ 2.207 and 31.344 + 1.953% respectively. Fat content showed a significant increase with increase in BMI ($p< 0.05$) (Table 2)

Kruskal – Wallis test was used to analyze body density and fat percentage.

Table-1 Anthropometric analysis among different BMI groups

Variable	Group-1 (n=15)	Group –II (n=15)	Group III (n=15)	P value
Age (yrs)	39.00 + 4.488	37.69 + 4.316	40.80 + 3.726	0.130 (NS)
Height (m)	1.699 + 0.049	1.674 + 0.036	1.677 + 0.037	0.187 (NS)
Weight (kg)	69.267 + 4.992	79.438 + 3.346	87. 233 + 2.840	0.000 (S)

Values are mean + SD in rows; n= no. Of subjects: NS = not significant
Statistical method used: ANOVA: Significant (S) at $p < 0.05$

Table 2 Analysis of Body density and Fat percentage among different BMI groups

variable	Group-1 (n=15)	Group –II (n=15)	Group III (n=15)	P value
Density (g/cm3)	1.055 + 0.009	1.037 + 0.005	1.028 + 0.004	0.000 (S)
Fat %	19.197 + 4.210	27.316 + 2.207	31.344 + 1.953	0.000 (S)

Values are mean + SD in rows; n= no. Of subjects: NS = not significant
Statistical method used: Kruskal – Wallis test: Significant (S) at $p < 0.05$

Table- 3 Correlation between BMI and body density and fat percentage (n=45)

BMI (Kg/m2)	Density (g/cm3)	Fat %
Pearson correlation	- 0.876	0.879
P value	0.000 (S)	0.000 (S)

Values are mean + SD in rows; n= no. Of subjects: NS = not significant
Test used: Correlation analysis: Significant (S) at $p < 0.01$

Discussion

Obesity, a state of excess adipose tissue mass, is an increasing medical challenge in affluent societies. The increase in prevalence in obesity may be attributed to fast food and sedentary life style. The distribution of adipose tissue in different anatomic depot also has substantial morbidity. As the obesity is a predisposing factor

for various diseases, the assessment of obesity is becoming important. Assessment method should be accurate so that appropriate intervention can be done to reduce the risk.

Most commonly used tool for gauging obesity is Body Mass Index as it is the simplest method. Here I am trying to assess whether BMI reflects the fat content of the individual. There are studies which suggest the existence of correlation between BMI and body fat percentage(4). Some studies suggest that relationship between BMI and percentage body fat is not strong (5). Both of these studies they used bio electrical impedance to measure body fat.

Hydrostatic weighing procedure to estimate body density is considered by many to be the criterion method under carefully controlled condition with maximum subjects compliance. It is highly reliable[7]. Ward A etal also suggested that body fat measurement by underwater weighing and volume displacement is reliable[8].

Submersion technique (Hydrodensitometry) is based on the Archimedean principle that a solid object submerged in water subject to a buoyant force that is equal to the weight of the water displaced by the object or the loss in weight of water when it is weighed while submerged in the water. Traditionally the measurement of body volume requires complete submergence under water. Volume is measured either directly by water displacement or calculated as difference between the weight of the subject under water and in the air, the correction must be done for the volume of air and in the gut. Human body generally has a density close to that of water (i.e, 1.0 g/cm^3). Individual deviations from this value are mainly due to the amount of fat in the body. Because fat is less dense than water, the lower the body density, the greater the amount of body fat. Behnke was the first to show that this method could be used to deduce the percentage of weight that is from body density. Human body density generally varies between 1.08 g/cm^3 (very lean), and 1.03 g/cm^3 (moderately obese). Obese subjects will have body densities < 1.03 g/cm^3 and severely obese people may have densities < 1.00 g/cm^3[9].

A limitation of the measurement of body volume by submersion method is that the accurate measurement requires active participation and effort by the subject being measured. Many obese patients find this procedure difficult and frightening and some systems are unable to accommodate obese subjects. These problems can be minimised by careful attention to the design of the tank, but this method is still acceptable to a significant no. of subjects (80. It is not feasible to measure the amount of air and gas in the stomach and intestinal tract, and a fixed value (100 ml) is usually assumed. [9].

Hydrodensitometry of obese subjects may present special problems. Obesity is often associated with respiratory problems and reduced lung function, which may make it more difficult to obtain accurate measurement of residual lung volume. Despite these limitations, high level of precision can be achieved in most obese subjects with under water weighing.

Age and gender are two factors which affect the body fat distribution[10,11]. Taking this in to consideration, selected study group in this study, were males in the age group 35-45 years. So the final results were not affected by the age and gender.

In my study, I got a significant correlation between BMI and density as well as BMI and fat content. This study suggests that BMI is a relatively accurate assessment of fat content in adults males.

Conclusion

Obesity, a state of excess adipose tissue mass, is a health hazard and detriment to the well being of the individual. As it is associated with increased mortality and morbidity, assessment of fat content is important. In my study, I compared BMI and fat content measured by hydrodensitometry and found that there is a significant correlation between BMI and fat percentage. BMI is a fairly accurate method for fat content in adult males.

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Department of Physiology, AFMC, Pune

Dr. D. K. Dubey, Department of Physiology, Institute of aerospace medicine Bangalore

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