ORIGINAL ARTICLE

OUR EXPERIENCES WITH HUMAN BODY COMPOSITION ESTIMATIONS; LOW DISCRIMINATORY POWER OF BODY MASS INDEX TO SEGREGATE BODY FATNESS

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ABSTRACT

Body mass index, though globally a very popular and frequently used surrogate measure of body fatness, has come under some scrutiny and serious criticism in recent years for its inability to reflect the same. This is particularly disconcerting with health risks involved in cardiometabolic diseases associated with obesity. Therefore, it is suggested that actual measurement of body fat levels be used and there are simple and easier techniques available. The measurements of body volume index in replacing body mass index may provide better information on human body composition for future research.

Keywords: *Body mass index, body fat, body volume index, cardiometabolic diseases, health risks*

INTRODUCTION

Body Mass Index (BMI), also known as Quetelet's index was first described in 1832 by Lambert Adolphe Jacques Quetelet which was based on the observation that body weight was proportional to the squared height in adults with normal body frames[1]. BMI is a popular and often used proxy, numeric measure of body fat mass and is believed to reflect body fat reasonably well irrespective of age, sex and ethnicity. BMI is also believed to correlate well with changes in lean body mass (LBM) in certain age groups[2]. It is extensively employed in metabolic, nutritional and epidemiologic studies and has been strongly recommended for individual use in clinical practice[3,4]. It provided a way of classifying human subjects as undernourished (UN), normal (N) and overweight/obese (Ow/Ob) individuals to indicate their nutritional status is universal. Garrow& Webster [5] have shown that BMI gives a satisfactory measure of body fatness in obese subjects. However, it has come under criticism for its global application as a predictor of fat mass in different ethnic groups, population groups and particularly with regard to cardiometabolic risks in obesity. The reason being BMI cannot predict the metabolic consequences and health risks associated with obesity and some regard actual assessment of body fat as a better measure of fitness or risk levels in such conditions[6].

Hence, the objectives of this communication were designed as follows:

- To record BMI and classify the subjects into undernourished (UN), normal (N) and overweight/obese (Ow/Ob) groups on the basis of BMI.
- To measure body fat using an automated body composition analyzer.
- To compare the distribution of subjects in each nutritional group based on BMI linked body fatness and on the basis of body fat levels as suggested in the body composition analyzer instruction manual.
- To assess the correlation between BMI body fatness.

MATERIAL AND METHODS

BMI and body fat were measured in different studies of our own at several times involving 648 preclinical medical students of both sexes in medical schools. They were age matched. Body composition analyzer (Model HBF -36, Karada Scan – Bioelectrical Impedance principle – Omron, Japan) was used for body fat measurement. The subjects were segregated into UN, N and Ow/Ob category based on i) BMI for Asian population and BMI for Caucasians by WHO[4] and ii) on body fat levels as recommended by the body composition analyzer manufacturer. Table 1 gives further details.

The data obtained were analysed for comparison between distribution of subjects in different nutritional groups based on BMI and body fat percent values. SPSS version 17.0 was used for statistical analysis. The descriptive analysis provided the mean ±SD values of the variables. Cross-tabulations were used for testing the distribution of subjects. $p<0.5$ was considered significant.

Table 1. Body mass index (BMI) and body fat% based grouping of subjects as undernourished (UN), normal (N) and overweight/obese (Ow/Ob)

Variable	**BMI Asians**	**BMI Caucasians**	**Body fat%**	
Group			Male	Female
Undernourished (UN)	<18.5	>18.5	5-10	5-20
Normal (N)	18.5 – 22.9	18.5-25	10-20	20-30
Overweight/Obese (Ow/Ob)	>23	>25	25-50	30-50

RESULTS

The mean age of the subjects in this study was 20.0±1.6 years. The body weight of normal BMI subjects was 58.4±1.2 kg in the male and 52.5±0.8 kg in the female while the UN subjects had 49.3±0.5 kg (male) and 42.0±1.0 kg (female). The ow/ob males had a body weight of 79.3±1.3 kg while the female had a body weight of 70.2±1.2 kg. BMI related body fat and the body fat level based distribution of subjects is shown in Table 2 and 3 respectively. Table 4 exclusively shows the distribution of subjects on BMI basis and body fat levels in each category of UN N and Ow/Ob subjects. There was no good relationship between the distribution of subjects when compared on the basis of BMI and body fat levels. The results revealed that frequency distribution of UN, N and OW/Ob subjects were different based on BMI and body fat criteria, particularly in the UN group (40 vs. 20 in male; 54 vs. 18 in female). Though, the distribution was somewhat closer in the Ow/Ob group (e.g. 90 vs. 85 in male; 100 vs. 117 in female) and the N group (168 vs. 193 in male; 196 vs. 215 in female) on certain criteria, it was still different (Table 4).

Table 2. Body mass index (BMI) based body fat% in undernourished (UN), normal (N) and overweight/obese (Ow/Ob) subjects.

	Body fat %	**n**	**Body fat %**	**n**
Asian BMI	Male		Female	
<18.5 (UN)	13.2±2.6	40	23.5±1.9	54
18.5 – 22.9 (N)	15.0 ± 3.7	168	27.7±3.2	196
>23 (OW/Ob)	23.7±3.1	90	33.6±3.8	100
Caucasian BMI				
>18.5 (UN)	13.2±2.6	40	23.5±1.9	56
18.5-25 (N)	16.8±4.5	213	28.6±3.4	241
>25 (OW/Ob)	25.0±3.9	45	35.8±3.9	53

(Values are mean ± SD); n=number of subjects in each group

Table 3. Body fat% in undernourished (UN), normal (N) and overweight/obese (Ow/Ob) based on the recommendations of the body composition analyser manufacturer.

Body fat % range			**Male**	**n**	**Female**	**n**
	Male	**Female**				
UN	5-10	5-20	9.38±1.0	20	18.4±1.1	18
N	10-20	20-30	14.7±2.8	193	26.6±2.6	215
OW/Ob	25-50	30-50	24.3±3.5	85	33.6±3.4	117

(Values are mean ± SD); n=number of subjects in each group

Table 4. Distribution of subjects in undernourished (UN), normal (N) and overweight/obese (Ow/Ob) groups based on body mass index (BMI) and body fat% as per the recommendation of the body composition anlyser (BCA) manufacturer.

	Male			Female		
Group	Asian BMI	Caucasian BMI	BCA manufacturer	Asian BMI	Caucasian BMI	BCA manufacturer
UN	40	40	20	54	54	18
N	168	213	193	196	243	215
Ow/Ob	90	45	85	100	53	117

DISCUSSION

BMI and waist circumference (WC) are two common parameters very closely related to metabolic and cardiovascular risks and BMI is the cornerstone of the current classification system for obesity. Several studies claimed that BMI may provide misleading information on the association between adiposity and BMI with cardiovascular diseases and mortality[7-10]. However, it is also shown that the accuracy of BMI in determining the degree of obesity or the body fat levels is limited, particularly for men and elderly individuals in the intermediate BMI ranges as it is unable to differentiate adipose tissue from lean body mass[11]. Moreover, BMI do not allow for differentiating the gender, age or ethnicity, athletes, weight loss with and without exercise, physical training, and special clinical circumstances[12,13]. Even in normal subjects at any given value of BMI, there is a wide range of body fat as % of body weight. For example, in men, BMI showed a better correlation with lean mass than with body fat%, while in women it correlated better with body fat% than with lean mass[11] and therefore, may incorrectly classify the healthy, muscular men and women with different body shapes and heights as being overweight or obese. A study by Frankenfield *et al* [12] has shown that 30% of men and 46% of women with a BMI below 30 kg/m^2 had obesity levels of body fat. Such anomalies are well pointed out in another article by Muralidhara[14]. In such situations it becomes important to note that overweight people had a similar relative risk of mortality to normal weight individuals while underweight and obese people had higher death rate. It also has been noted that patients with coronary artery disease with normal BMI were at higher risk from cardiovascular disease than people with higher BMI which suggests that BMI is not a good measure for assessing the risk of heart attack, stroke or death [7-10].

In conclusion, our present data and findings from other studies strongly suggest the lack of strong discriminatory power of BMI to reflect the body fatness. Although, BMI is a simple indicator of body fat, simplicity that mislead will not be beneficial. BMI may not be useful for individual diagnosis. Therefore, additional anthropometric measures to support BMI findings or an actual measurement of body fat would be a better option. It should be noted that with the available methods, measurement of body composition has become easy, fast and economical both for clinical and population studies in particular. Therefore, in future, a shift from BMI measurements to actual body composition measurements is to be considered since the latter can predict obesity-related risks better than does BMI, WC, waist-to-hip ratio (WHR) or other measures of body fat distribution [15,16]. Actual measurements of body composition are equally important and relevant in nutritional studies too. It is good news that efforts are heading in that direction and Body Volume Index (BVI) may yet replace BMI in the near future[17].

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