Original Article

Body Mass Index and Body Fat Percentage in Assessment of Obesity Prevalence in Saudi Adults

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Abstract

Objective To assess the obesity prevalence in Saudi adults according to the international standards of body mass index (BMI) and body fat percentage (BF%).

Methods Five hundred and thirty healthy Saudi adults aged 18-72 years (mean 36.91±15.22 years) were enrolled in this study. Their body composition was assessed by bioelectrical impendence analysis with a commercially available body composition analyzer. Standard BMI and BF% values were used to define obesity.

Results The prevalence of underweight, normal underweight, overweight and obesity in Saudi adults according to the BMI criteria (<18.5 kg/m^2, 18.5-24.4 kg/m^2, 25-29.9 kg/m^2, 30 kg/m^2 and above, respectively) was 2.5%, 30.2%, 33.6%, and 33.8%, respectively, whereas the obesity prevalence was 60% (n=318) in Saudi adults according to the BF% criteria (25% for males and 30% for females), which was significantly higher than that according to BMI criteria. However, it was 50.6% (n=268) when the BMI cutoff point was 27.5 kg/m^2, proposed by WHO for the Asian population**.** Kappa analysis showed that the obesity prevalence defined by BMI and BF% was higher in females than in males (k=0.530 vs k=0.418, P<0.0001). The sensitivity and specificity of BMI (30 kg/m^2 and 27.5 kg/m^2) were 54.1% and 96.7% and 76.4% and 88.2%, respectively, for obesity. A lower BMI cutoff point (26.60 kg/m^2) was proposed in this study, which gave the maximum sensitivity (84.3%) and specificity (85.4%), with a moderate kappa agreement (k=0.686). Moreover, the obesity prevalence at this cutoff point (56.4%) was significantly higher than that recommended by WHO.

Conclusion The specificity of BMI for obesity is high and its sensitivity is low in both sexes. Its sensitivity can be increased by changing BMI cutoff to a lower value. The choice of BF% reference is of great influence for the assessment of obesity prevalence according to the BMI.

Key words: Body composition; Obesity; Body mass index; Body fat percentage; Kappa analysis

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INTRODUCTION

The global prevalence of obesity has increased substantially in the past 3 decades and is now estimated to affect over 400 million people[1]. Obesity is closely associated with a number of diseases such as type 2 diabetes, hypertension, coronary artery disease and cancer[2]. Body mass index (BMI) is recommended by WHO as a simple marker to reflect total body fat amount. However, BMI, as compared to weight and height, is just a weight excess index, rather than body fat composition. It was reported that the relation among BMI, body fat percentage (BF%), and

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body fat distribution differs across populations[3]. BMI is widely used as a measure of overweight and obesity, however it underestimates the prevalence of both conditions, defined as an excess of body fat. Given the elevated concentrations of cardio-metabolic risk factors reported herein in non-obese individuals according to BMI and in obese individuals based on body fat, the inclusion of body composition measurements together with morbidity evaluation is desirable in routine medical practice both for diagnosis and decision-making for the most appropriate treatment of obesity[4]. Recognition of different subtypes of obesity has been reported in the literature including metabolically healthy and obese individuals[5]. Although local BMI cutoff points of overweight and obesity have been used in Asian populations to reduce the discrepancy[6-8], the best index of obesity remains inconclusive and needs to be further studied[9]. Kennedy et al. reported that adiposity status is misclassified according to BMI in approximately one-third of women and men, thus care should be taken when BMI is used in scientific research and clinical practice[10-11]. A considerable number of subjects, both males and females, cannot be classified as obese according to their BMI alone. Such a misclassification is undesirable, especially in general practice, thus calling for diagnostic criteria other than BMI alone for obesity. Obesity-associated metabolic risks are greater in Asian people than in European descent populations. The Chinese tend to have a lower BMI but a higher fat volume. WHO suggests that Asian populations have a high risk of type II diabetes and CVD at BMI values lower than those recommended by WHO for overweight and obesity[12]. Therefore, the prevalence of obesity in Saudi adults was compared according to the BMI and BF% criteria.

MATERIALS AND METHODS

A total of 530 healthy Saudi adults aged 18-72 years (mean 36.91±15.22 years) were enrolled in this study which was approved by College of Medicin Ethics Review Board. Only those who signed the consent form were selected.

Measurement of Anthropometric Index and Body Fat

The body height and weight of each subject wearing light indoor clothes were measured with a scale after overnight fasting. Subjects were not allowed to drink during fasting and were asked to empty their bladders before measuring their body composition. BMI was calculated as the weight in kilograms divided by the square of the height in meters (kg/m^2). All participants underwent body composition analysis. Body composition was assessed by bioelectrical impendence analysis (BIA), with a commercially available body analyzer (InBody3.0, Biospace, Korea). The subject was asked to first wipe the sole of the feet with a wet tissue and then stand over the electrodes of the machine and results were ready in 3-5 min. Parameters recorded included height, body weight, body surface area, BMI, obesity degree, protein mass, muscle mass, fat mass, body fat percentage, fat control, muscle control and fitness scoring based on the target values for ideal body fitness. Segmental analysis can calculate slight differences by sex, age, and race without using empirical estimation. The InBody 3.2 Body Composition Analyzer (BioSpace, Seoul, Korea) is a segmental impedance device measuring the voltage drop in the upper and lower body. The InBody uses eight points of tactile electrodes (contact at the hands and feet) to detect the amount of segmental body water. The technique uses multiple frequencies to measure intracellular and extracellular water separately. The frequency at 50 kHz measures the extracellular water while the frequency above 200 kHz measures the intracellular water.

Definition of Variables and Outcomes

The standard BMI and BF% values were used to define obesity. On the basis of BMI the subjects were categorized divided into underweight group (BMI< 18.5 kg/m^2), normal weight group (BMI 18.5-24.9 kg/m^2), overweight group (BMI 25.0-29.9 kg/m^2), obesity class I group (BMI 30.0-34.9 kg/m^2), obesity class II group (BMI 35.0-39.9 kg/m^2) and extreme obesity class III group (BMI 40.0+ kg/m^2) according to their BMI. The subjects were divided into normal BF% group (BF<25% for men, <35% for women) and high BF% group (BF>25% for men, BF%>35 for women) according to their BF% as previously described[13-16].

Statistical Analysis

Statistical analysis was performed using SPSS for Windows (version 18.0; SPSS Inc., Chicago, IL, USA). Categorical data were expressed as absolute numbers and percentages. Numeric data were summarized with mean, standard deviation (SD), median and range. Different groups were compared by chi-square test for categorical variables and by

Mann-Whitney test for continuous variables. Kappa analysis was performed to study the agreement between the BMI and BF% criteria of obesity with 95% confidence interval (95% CI). McNemar test was used to compare the prevalence of obesity. ROC curve was used to detect obesity and identify new cutoff points with a higher sensitivity (true positive rate) and specificity (true negative rate). Positive predictive values (PPV) and negative predictive values (NPV) were also calculated and compared for proposed and standard BMI cutoffs. Spearman's correlation was determined to see the relation between age, BMI and BF%. *P*≤0.05 was considered statistically significant.

RESULTS

The obesity prevalence and body fat percentage in Saudi adults were assessed by BMI criteria and bioelectrical impendence analysis, respectively. Descriptive characteristics and gender comparison of all subjects included in this study are shown in Table 1. Significant gender difference was observed in height, body surface area, BMI and BF%. The prevalence of underweight, normal weight, overweight, obesity classes I-III was 2.5%, 30.2%, 33.6% and 17.7%, 8.7% and 7.4%, respectively, with an overall obesity prevalence of 33.8% (Figure 1). Spearman's correlation showed that age was positively related with BMI (*r*=0.228, *P*<0.001) and BF% (*r*=0.188, *P*<0.001). The obesity prevalence was 27.8% in males and 46.7% in females according to the BMI criteria (BMI≥30 kg/m^2). The obesity prevalence was significantly higher in females than in males according to the BF% than according to the BMI (60% *vs* 33.8%, 64.7% *vs* 57.9%). These results suggest that the rate of missed diagnosis of BMI for obesity is higher than that of BF% for obesity (Figure 2). Regression analysis showed that BMI was closely related with BF% (*r*=0.824, *P*<0.0001, Figure 3).

Table 1. Demographic Data about Male and Female Subjects in this Study (*n*=530)

Variables	All Cases		Males (*n*=363)		Females (*n*=167)	
	Mean± SD	Range	Mean±SD	Range	Mean±SD	Range
Age	36.2±14.1	18.0-72.0	38.8±15.6	18-72	36.7±9.5	20-62
Height*	166.9±10.2	42.0-187.0	170.7±7.2	147-187	158.5±10.7	148-173
BSA*	2.8±0.3	2.2-3.5	2.9±0.2	2.2-3.50	2.5±0.3	2.2-2.9
Weight	79.8±20.1	18.3-173.2	79.5±16.2	18.3-135.7	80.5±26.8	36.1-173.2
BMI(kg/m^2)*	28.8±7.8	15.6-67.7	27.4±5.3	15.6-45.9	31.9±10.7	15.6-67.7
BF%*	31.1±11.1	4.0-59.2	26.8±8.0	8.7-51.1	40.4±11.1	4.0-59.2

Note. *Significant difference between males and females groups by Mann-Whitney test (*P*<0.0001).

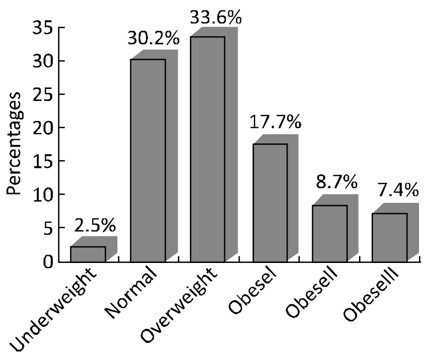

Figure 1. Prevalence of underweight, normal weight, overweight, and obesity in all subjects according to the WHO-recommended standard criteria.

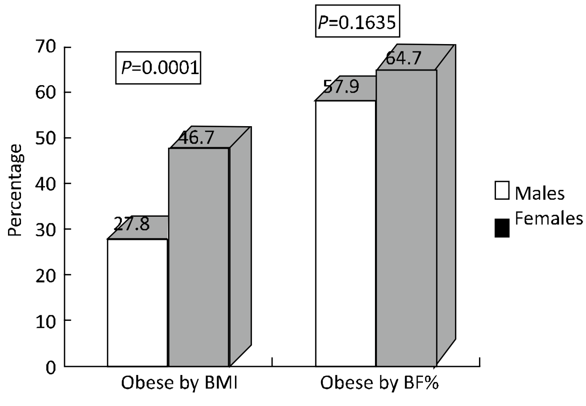

Figure 2. Obesity prevalence in male and female subjects according to the BMI cutoff point and BF% cutoff point.

Kappa analysis showed that BMI was moderately related with BF% (k=0.458, P<0.0001) and the kappa value was higher for females than for males (k=0.530 *vs* k=0.418, P<0.0001).

Considering BF% as our standard criteria, the area under the ROC curves was 0.907 for males and 0.914 for females (Figure 4), indicating that the accuracy of BMI is high in diagnosis of obesity. Nevertheless, the sensitivity and specificity of BMI at a usual cut-off point ≥30 kg/m^2 were 44.76% and 98.69% respectively in males and 67.59% and 91.52% respectively in females. Moreover, the obesity prevalence was 46.7% and 64.7% in females according to the WHO-recommended BMI criteria and BF% criteria. The obesity prevalence was 27.8% and 57.9% in males according to the WHO-recommended BMI criteria and BF% criteria. In both senders McNemar test revealed a significant difference between the two prevalence values (P<0.001). In the present study, the sensitivity and specificity of BMI were 83.81% and 86.27% respectively in males and 83.33% and 83.05% in females respectively, when its cut-off point was 26.60 kg/m^2 in males and 26.75 kg/m^2 in females.

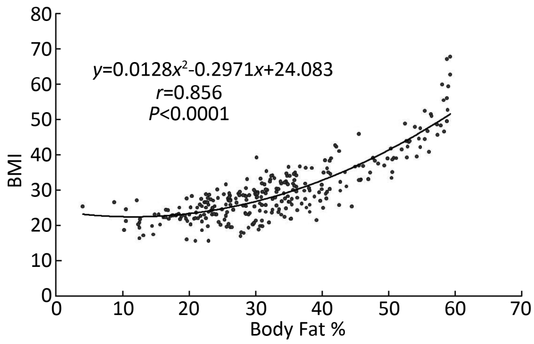

Figure 3. Regression analysis showing relation between BMI and BF% in all subjects.

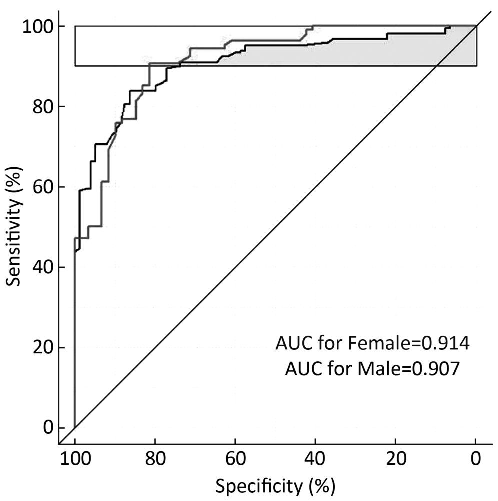

Figure 4. ROC curve showing sensitivity and specificity of BMI at different cutoff points and area under AUC for males and females.

Figure 5 shows scatter plot of BMI (kg/m^2) and BF% in males (Figure 5A) and females (Figure 5B). With lower cutoff points, the number of false negative decreased and the true positive cases could be increased. When the BMI cutoff point was offset at 26.75 kg/m^2, the obesity prevalence went up to 59.9% in females, closer to that according to the BF%. McNemar test revealed no significant difference in

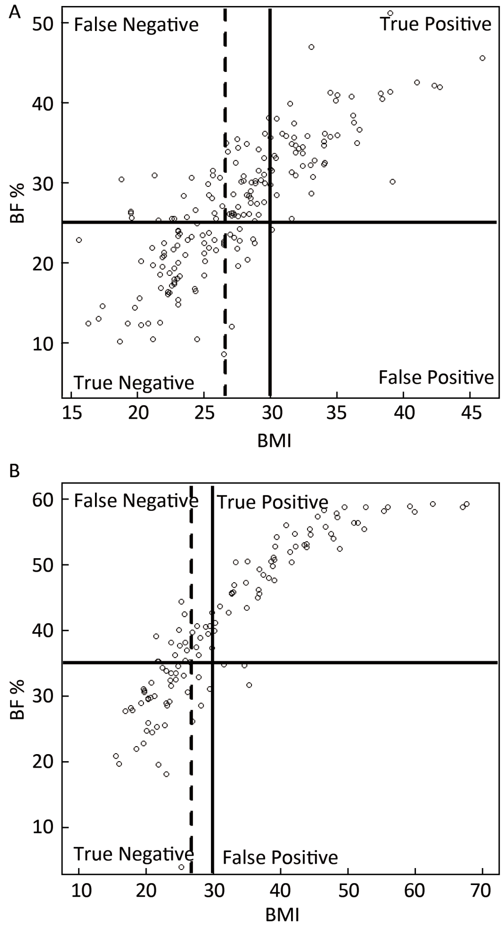

Figure 5. Scatter plot of body mass index *vs* body fat percentage in males (A) and females (B). *x* axis reference line denotes the BMI cutoff for obesity by BMI classification system, *y* axis reference lines denote BF% cutoffs for obesity in males and females, and dashed lines indicate proposed cut-offs.

the obesity prevalence according to the two criteria (P=0.185). When the BMI cutoff point was set at 26.60 kg/m^2, the obesity prevalence increased to 54.3% in males, nearer to that according to the BF%. McNemar test showed no significant difference in the obesity prevalence according to the two criteria (P=0.105).

The data were compared according to WHO international standard criteria, the WHO-recommended cutoff point of 27.5 for the Asians and the present study-proposed cutoff point of 26.6 kg/m^2 for sensitivity, specificity, agreement rate, positive predictive value and negative predictive value for obesity diagnosis. The obesity prevalence in this study was 33.8%, 50.6%, and 56.4% respectively at the WHO-recommended cutoff values of 30 kg/m^2, 27.5 kg/m^2, and 26.6 kg/m^2 (P<0.001, Table 2), suggesting that the true obesity prevalence in Saudi adults is lower than 27.5 kg/m^2.

Table 2. Sensitivity, Specificity, Agreement Rate, Positive, and Negative Predictive Value of the Two Criteria (n=530)

	Cut-off Point (kg/m^2)		
	30	27.5	26.6
Sensitivity (%)	54.1	76.4	84.3
Specificity (%)	96.7	88.2	85.4
Positive Predictive Value (%)	96.1	90.7	89.6
Negative Predictive Value (%)	58.4	71.4	78.4
Kappa Values	0.458	0.622	0.686
Prevalence (%)	33.8	50.6	56.4*

Note. $^*P$<0.001 by McNemar test.

DISCUSSION

The obesity prevalence in Saudi adults was assessed by body mass index and body fat percentage in this study, indicating that the specificity is high and the sensitivity is low at the usual cutoff point of obesity (≥30 kg/m^2). When the BMI cutoff point was decreased to 26.60 kg/m^2 in males and to 26.75 kg/m^2 in females, its maximum sensitivity and specificity were 83.81% and 86.27% respectively in males, and 83.33% and 83.05% respectively in females. When the WHO obesity cutoff was set at 27.5 kg/m^2 for the Asians, the obesity prevalence was lower than that in this study (50.6% *vs* 56.4%, P<0.001), which is closer to the findings in previous reports[17-20]. It was reported that the obesity prevalence detected by BMI and BIA methods was 18.3% and 15.5% in Iranian women[21], which was lower than that in this study. It has been shown that the obesity frequency is higher in men than in women (67.1% *vs* 26.6%)[22].

Shea et al.[23] recently reported that the obesity prevalence is similar in metabolically healthy individuals and obese subjects among the Singaporeans[24]. Several consistent relations exist regarding adipocytokines and body composition[25]. However, further study is needed on such relations in youth, especially at extremes of adiposity such as overweight and anorexics.

In present clinical practice, BMI is usually considered a surrogate marker of excess adiposity in terms of overweight and obesity[26-27]. However, an ideal alternative is to use actual measures of fatness rather than BMI. BIA is a widely used technique for body-composition measurement due to its safety, accuracy, reliability, and low cost as compared to other body composition methods. Although BIA is an easy and valid method of body fat measurement, yet it has some limitations when compared with DXA[28]. This bias, however, depends on the degree of adiposity. BIA overestimates BF% in lean subjects and underestimates BF% in overweight or obese subjects. Although reference methods, such as DXA, can provide accurate results, they are costly and often inaccessible to the public[29], thus not practicable for use with a large sample size. Moreover, in most situations, BIA and other field methods (e.g. waist circumference) are the only techniques available for body composition measurement. If properly used, by BIA body composition can be measured quickly, easily, and inexpensively in healthy populations with values comparable to those measured by densitometry[30]. This study is an effort to assess the obesity prevalence in Saudi adults according to the international standards of BMI and BF%. The limitation of this study is the relatively small sample size. Further study on a larger population size is under progress to get a true picture of obesity in the Saudi population.

In conclusion, the specificity of BMI is high for obesity diagnosis and its sensitivity is low in both sexes. The BMI cutoff points should be reduced when its sensitivity is to be increased. The choice of BF% reference in assessment of BMI greatly influences the outcome of studies.

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