Original Article

The validity of the World Health Organisation's obesity body mass index criteria in a Turkish population: a hospital-based study

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Our aim was to determine the relationship between body fat percentage (BF%) and body mass index (BMI) and to evaluate the validity of World Health Organisation's BMI cut-off values for obesity. Adult out-patients (n=909, 249 men, 660 women), mean age; 40.5 ± 14.1 years were included. According to WHO's BMI criteria, 440 subjects were obese (79 men, 361 women). The BF% of participants were measured using a bioelectrical impedance analysis (BIA) system (TANITA). Randomly selected 30 patients were also subjected to the dual-energy X-ray absorptiometry (DEXA) procedure for evaluation of the validity of TANITA measurements. The BF% results obtained by DEXA and TANITA revealed good correlation (r =0.952, p= 0.382). There was a positive correlation between BF% and BMI (p<0.001) for both methods. Cut-off values for BMI were calculated as 28.0 kg/m^2 for women, 28.2 kg/m^2 for men, if obesity was defined as BF ≥ 25% in men, ≥ 35% in women according to WHO's criteria. Using the new cut-off values, the frequency of obesity increased up to 33.9% in our group. The increase was more pronounced in men (67.1% vs 26.6%).The WHO cut-off values underestimated the frequency of obesity in this population. Further studies are warranted for different ethnic groups.

Key Words: obesity, body mass index, body fat percent, bioelectrical impedance analysis, dual energy X-ray absorptiometry, Turkey

INTRODUCTION

Obesity is a rapidly growing global threat against public health.[1,2] The World Health Organisation (WHO) has defined obesity as a condition with excessive fat accumulation in the body, to the extent that health and well-being are adversely affected.[1] The amount of increased body fat (BF) is defined as BF > 25% in males and > 35% in females, corresponding to a body mass index (BMI) of 30 kg/m^2 in Caucasians.[3] In vivo, the amount of BF can be determined by a number of techniques including; underwater weighing (hydrodensitometry), deuterium oxide dilution, dual energy X-ray absorptiometry (DEXA), skinfold thickness measurements (anthropometry), air displacement (bod pod), bioelectrical impedance analysis (BIA), computerized tomography (CT) and magnetic resonance imaging (MRI).[2,4] Most of these techniques have proven their validity in determining BF, but due to their disadvantages in terms of cost and time, BMI defined as body weight divided by height squared (kg/m^2) is regarded as the most suitable indicator for obesity. The WHO recommended BMI cut-off points for overweight and obesity as; ≥ 25 kg/m^2 and ≥ 30 kg/m^2, respectively.[1,3]

Recently, increasing evidence has suggested that the relationship between BMI and body fat percentage (BF%) differs among various ethnic groups.[5-7] Well known examples for this situation are Asians, Blacks and Polynesians.[8] It has been shown that Asians have a higher BF% in lower BMI values compared to Caucasians, while Blacks and Polynesians have a low body fat at any given BMI value compared to Caucasians.[9-11] A committee co-sponsored by the Regional Office for the Western Pacific, WHO, International Association for the Study of Obesity (IASO) and International Obesity Task Force (IOTF) considered this issue and proposed new BMI cut-off values for adult Asians, which suggested normal ranges as 18.5-22.9 kg/m^2 .[12] The aim of the present study was to determine the relationship between BF% and BMI in our study group, and to evaluate the validity of BMI cut-off values for obesity.

MATERIALS AND METHODS

Subjects and research design: A total of 909 Turkish adult out-patients (249 men, 660 women) were included in the study. This study was conducted in accordance with the internationally agreed ethical principles for the conduct of medical research. None of these subjects had a severe chronic illness or a malignancy. Height and weight measurements were done barefoot and with light clothes.

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All of these measurements were done by the same observer with the same equipment during morning hours. After anthropometric measurements, BF% prediction was done by using a foot-to-foot BIA apparatus (Tanita Inc, Tokyo, Japan, Model TBF-300M/300MA). Before testing, subjects were required to adhere to the BIA testing guidelines: 1) not to eat or drink (especially caffeinated products) within 4 h of the test, 2) not to consume alcohol within 48 h of the test, 3) avoid intense exercise within 12 h of the test, 4) if possible not to take diuretics within 7 days of the test, and 5) to empty bladder within 30 min of the test.[13] Subjects were measured while standing erect barefoot on the device's footpads and wearing light clothes. Afterwards to show the validity of BIA, randomly selected 30 patients were subjected to DEXA measurement; one of the reference methods for the prediction of BF%.

Statistical Analysis

Statistical analyses were carried out using SPSS Version 11.0 (SPSS Inc, Chicago, IL, USA). Descriptive statistics were used to present subject characteristics. Linear regression analysis was used to show the relationship between BF% and BMI. The comparison between BIA and DEXA was made by using paired samples *t* test. Statistical significance was reported at the conventional $p<0.05$ level (two-tailed).

RESULTS

In total; 909 subjects underwent BIA and 30 subjects underwent BIA+DEXA for BF% prediction. All subjects were apparently healthy and ranged in age from 17-68 years, and in BMI from 16.9-54.8 kg/m^2. Mean age of the patients was 40.5 ± 14.1 years. According to WHO criteria, 440 subjects (79 men, 361 women) were defined as obese. Subject characteristics are summarized in Table 1. According to the data obtained via BIA measurements; the mean BF% of the whole group was 34.6 ± 8.92%, and 34.1 ± 1.60% in the subjects for whom DEXA was also used.. The BF% of the latter group, with DEXA, was 33.6 ± 1.39No statistically significant difference was found between BIA and DEXA methods in the estimation of BF% (r = 0.952, $p = 0.382$).

Mean BMI of the whole group was 30.77 ± 5.95 kg/m^2, and there was a positive correlation between BF% and BMI in the both methods used ($p<0.001$). The BF% distribution of the subjects in relation with their BMI values are shown in Figure 1 and 2. By using linear regression analysis, BMI cut-off points for obesity were calculated according to the WHO BF% criteria. The BMI cut-off values for obesity in this study group were calculated as 28.24 kg/m^2 for men, and 28.02 kg/m^2 for women. The number of obese women rose from 361 to 457 (26.6% increase), and obese men from 79 to 132 (67.1% increase), when these new BMI cut-off values were used. Within the whole group; the number of obese subjects rose from

Table 1. General characteristics of the subjects

	Whole group	Men	Women
Number of subjects (n)	909	249	660
Age±SD (years)	50.5±14.1	52.9±13.3	49.6±14.3
BMI±SD (kg/m^2)	30.8±5.95	29.1±4.87	31.4±6.19
BF%±SD	34.6±8.92	25.9±7.19	37.9±7.08

(SD= standard deviation)

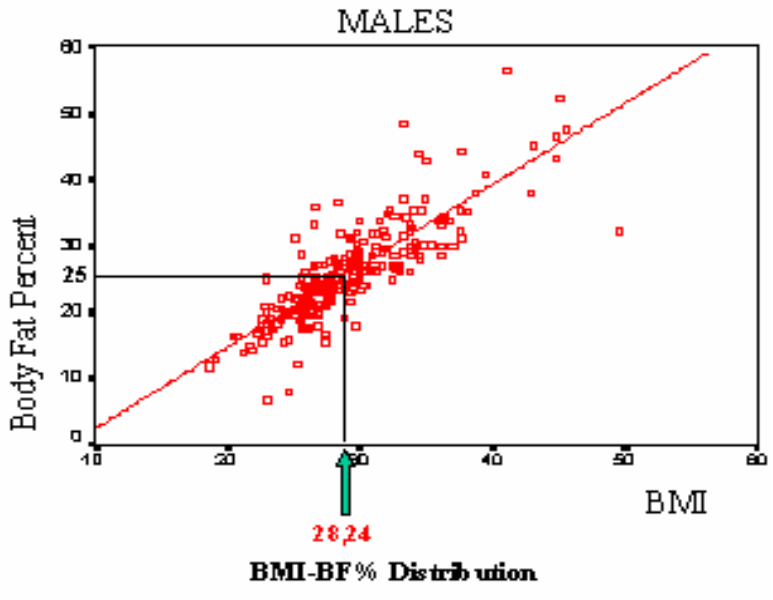

Figure 1. Body fat distribution of male subjects

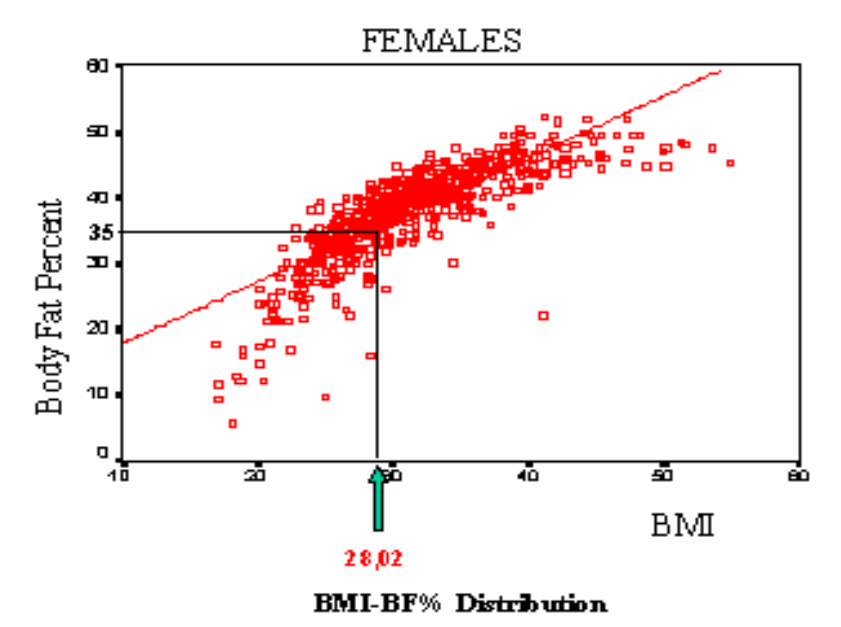

Figure 2. Body fat distribution of female subjects

440 to 589 (33.9% increase).

DISCUSSION

Calculating BMI as a measure of body fatness is cheap, simple to perform and appropriate for large population-based studies. However, the degree of body fatness is more predictive for risk estimation when compared with the degree of excess weight. There are many reference methods for determining BF% like hydrodensitometry, deuterium oxide dilution and DEXA. Additionally, some studies reported that foot-to-foot BIA can also be accepted as a valid measurement method in the assessment of BF%, but this topic is still contraversial.[14,15] In our study, a foot-to-foot BIA apparatus was used to determine BF% due to its inexpensiveness and easiness, furthermore, to show the validity of this method, 30 randomly selected patients were also subjected to DEXA. The data obtained from DEXA results revealed that; if appropriate BIA testing guidelines were used, foot-to-foot BIA measurement results would be valuable in determining BF%.

Many studies have proven that the relationship between BMI and BF% differs among various ethnic groups.[2, 5-11, 16-19] The use of reliable cut-off points for obesity is very important in order to detect the correct prevalence of obesity and establish consequent public health policies for every population. From that point of view, in the present study, we felt it would be of great value to determine the relationship between BF% and BMI in our study group consisting of 909 subjects; a large number that might be appreciated. Our results showed that WHO's BMI cut-off point for obesity underestimates the frequency of obesity in this study group. As a matter of fact, we might propose that the subjects in this study had lower BMI values for the same amount of body fat when compared with Caucasians. In his report, Rose G. claimed that lowering the BMI cut-off point from 30 to 27 kg/m^2 could increase the prevalence of obesity as much as 14% in a population. [20] We detected a 33.9% increase in this study, although the subjects included might not be regarded as representative of Turkish population. The difference might well be attributed to the general characteristics of our study group. In a cross-sectional, population based survey which included 24788 Turkish subjects, by using the WHO BMI criteria for obesity, Satman *et al*, reported the general prevalence of obesity as 22.3% in our country.[21] In our study; the percentage of obese subjects according to WHO criteria was 48.4% and the mean BMI value of the whole group was 30.8 ± 5.95 kg/m^2. Therefore, we could claim that the number of overweight subjects in this study group might be greater within the whole study population, as well as obese subjects, when the new cut-off values were used. Besides, this increase was more evident in men compared with women (67.1% vs 26.6%). It might not be right to take this roughly as a gender difference, as this finding might probably be related to the general characteristics of our study group, as well.

As far as we concern, this is the first study which questiones the validity of the traditional WHO BMI criteria for obesity, and the relationship between BMI and BF% in a Turkish population. Considering the study findings; it seems necessary to rearrange the BMI cut-off values for our population. Larger population-based, cross sectional studies are required to determine these cut-off values for various ethnic groups.

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世界衛生組織的肥胖身體質量指數標準在一個土耳其族群的效度：一個醫院的研究

我們的目的評估體脂肪百分比(BF%)及身體質量指數(BMI)之間的相關性，以評量世界衛生組織(WHO)針對肥胖所訂定的 BMI 切點之效度。門診成人病患（n=909，249 名男性、660 名女性)，平均年齡 40.5 ± 14.1 歲參與研究。依據 WHO 的 BMI 標準，440 研究對象為肥胖（79 名男性、361 名女性）。採用生物電阻分析(BIA)系統(TANITA)評估參與者的 BF%。隨機選取 30 名病人，同時採用雙能量 X 光吸收儀(DEXA)以評估 TANITA 測量的效度。DEXA 及 TANITA 所得的 BF%結果顯示好的相關(r=0.952, p=0.382)。兩種方法測得的 BF%及 BMI 之間均為正相關(p<0.001)。若依據 WHO 的肥胖標準，男性為 BF≥25%，女性為≥35%，則計算出來的女性 BMI 切點為 28.0 kg/m^2、男性為 28.2 kg/m^2。採用新的切點，我們的族群肥胖率增至 33.9%。男性的增加較明顯 (67.1% vs. 26.6%)。WHO 切點對會低估該族群的肥胖率。對不同的種族，進一步的研究是必要的。

關鍵字：肥胖、身體質量指數、體脂肪百分比、生物阻抗分析、雙能量 X 光吸收儀、土耳其。