Comparison between body mass index and percentage of body fat as measured by bioelectrical impedance in Egyptians

Dalia R. AbdelRahman, Hoda Maamoun and Amin R. Soliman

Internal Medicine Department, Division of Nephrology, Cairo University, Cairo, Egypt

Correspondence to Dalia R. AbdelRahman, MD, MSC, Internal Medicine Department, Division of Nephrology, Cairo University, 11439 Cairo, Egypt
Tel: +02 2360 5684;
e-mail: daliaroushdy@hotmail.com

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Background
During the past decade, the number of Egyptians showing overweight and obesity as measured in terms of BMI (kg/m^2) has been documented through different surveys. This increase in adiposity has been associated with metabolic syndromes in Egyptians and with higher fasting insulin concentrations. The purpose of this study was to assess the relationship between BMI and percentage body fat (PBF) in Egyptians and to determine whether this relationship differs between men and women.

Methods
We conducted a cohort study including 152 healthy participants; body fat composition was calculated using the BMI equation and bioelectrical impedance (BEI).

Results
The predicted PBF values based on BMI values between 15 and 50 for women and 18 and 50 for men were analysed, which showed that the trend of predicted PBF values differs in accordance with BMI:

(1) at BMI at least 30, men tended to have higher PBF compared with women;
(2) at BMI at least 35, women tended to have higher PBF compared with men.

Conclusion
The present study has investigated the relationship between PBF and BMI in Egyptians. The results show a significant difference in PBF on the basis of BMI and sex. There are some potential explanations for this difference, including sedentary lifestyles and possible genetic makeup. Similar observations with regard to the mediation of BMI on PBF according to sex have been reported previously.
It is important to emphasize that the PBF values obtained in this study using BMI are estimates determined on the basis of the samples and that significant differences were found only among women.

Keywords:
bioelectrical impedance, body mass index, Egyptians, percentage of body fat

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Introduction

During the past decade, the number of Egyptians showing overweight and obesity as measured in terms of BMI (kg/m^2) has been documented through different surveys. This increase in adiposity has been associated with metabolic syndromes in Egyptians and with higher fasting insulin concentrations. Increased amounts of body fat may constitute a public health concern for this population, because evidence shows that obesity is associated with related conditions such as cardiovascular disease [1] and type 2 diabetes [2].

Body weight adjusted for stature is often used as an alternative to the estimation of adipose tissue mass when evaluating individuals or populations for obesity. Many studies have shown that BMI is a reasonable index of adiposity [3], given that measurements of body weight and stature can be taken in a simple, inexpensive, safe and practical manner, particularly for people with limited access to healthcare. Differences based on ethnicity have been found in the relationship between BMI and percentage body fat (PBF); specifically, at constant BMI, PBF was seen to differ among Asians, African Americans and whites when sex, age, height and weight were controlled for [4,5].

The purpose of this study was to assess the relationship between BMI and PBF in Egyptians and to determine whether this relationship differs between men and women.

Participants and methods

Only those individuals who reported themselves as being healthy were invited to participate in the study; thus, all participants defined themselves as healthy in the questionnaire. Moreover, individuals who had reported

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Table 1 Participant's age, BMI, percentage body fat, smoking status and exercise level by sex

	Age (years)	BMI (kg/m^2)	PBF (%)	Smoking	Exercise
Men (n=64)	43.6 ± 18.1	26 ± 3.2	22.4 ± 7.5	0.32 ± 0.30	0.50 ± 0.5
Women (n=88)	39.9 ± 17.4	29.8 ± 5.1	38.6 ± 8.3	0.17 ± 0.32	0.38 ± 0.5

PBF, percentage body fat.

being malnourished or as having HCV or diabetes in their questionnaire were excluded from the study. History of smoking was taken. Level of exercise per week was reported.

Body composition

BMI was calculated on the basis of weight and height for each participant. Weight was measured to the nearest 0.1 kg and height to the nearest 0.5 cm. Total body fat was measured using bioelectrical impedance (BEI). The body weight value measured on the scale was compared with the BEI-derived weight value.

PBF was then calculated using the equation

$$\text{PBF}=b_1\ \text{ethnicity}+b_2\ \text{smoking}+b_3\ \text{exercise}+b_4\ \text{age}+b_5\ 1/\text{BMI}+b_6\ (1/\text{BMI}\times\text{ethnicity})$$

where smoking = 1 for smokers and 0 for nonsmokers; exercise = 1 for participants who spent at least 4 h/week exercising and 0 for others; 1/BMI is the predictor of PBF measured using BEI; ethnicity factor was regarded as nil because all participants belonged to the same ethnic group. Therefore, this component was removed from the model for the final analysis; age was also removed from the final analysis because no significant difference in the effect of age on the prediction of PBF by inverted BMI was seen.

All analyses were performed using the linear regression option of SPSS (SPSS Inc., Chicago, Illinois, USA).

Results

Descriptive characteristics, including age, sex, smoking, PBF and exercise, are shown in Table 1. The results from the regression model used in the equation are summarized in Table 2. When PBF was predicted using BMI, the results were used to estimate the trends of predicted PBF at a BMI range of 15–50 for women and 18–50 for men. This estimation was made at consistent values of exercise level, smoking status and age.

Data are represented as $X \pm$ SD. Smoking is coded as 1 for smokers and as 0 for nonsmokers. Exercise is coded as 1 for participants who spent at least 4 h/week exercising and as 0 for others.

For both sexes, the average values for the following parameters were used: for exercise, 0.5 ± 0.5 for men and 0.38 ± 0.5 for women; for smoking, 0.32 ± 0.32 for men and 0.17 ± 0.32 for women; and for age, 43.6 ± 18.1 for men and 39.9 ± 17.4 for women.

Table 2 Results of percentage body fat from the equation compared with results from bioelectric impedance using regression analysis

	Equation	BEI	P-value
Age	0.058	0.112	0.001*
Exercise	−1.285	−1.933	0.01*
Smoking	0.094	0.343	0.54
Men	76.96	60.77	0.04*
Women	78.23	64.17	0.05
INVBMI	−1105.6	64.17–1084.4	0.01*

INVBMI = 1/BMI.
BEI, bioelectric impedance.
*P-value < 0.05 is significant.

Analysis of the predicted PBF values based on BMI values between 15 and 50 for women and 18 and 50 for men showed that the trend of predicted PBF values differs according to BMI:

(1) at BMI at least 30, men tended to have higher PBF compared with women;
(2) at BMI at least 35, women tended to have higher PBF compared with men.

Discussion

The present study has investigated the relationship between PBF and BMI in Egyptians. The results showed significant difference in PBF on the basis of BMI and sex. There are some potential explanations for this difference, including sedentary lifestyles and possible genetic make-up. Similar observations regarding the mediation of BMI on PBF according to sex have been reported previously [6,7]. It is important to emphasize that PBF values obtained in this study using BMI are estimates determined on the basis of our sample and that significant differences were found only among women.

To assess the sensitivity of the results, we tested the multiple regression models without excluding those persons who met the exclusion criteria described previously. The results obtained were consistent across the conditions summarized in Table 2.

Certain aspects of the model deserve further discussion. These include: the use of INVBMI as a predictor; the inclusion of smokers in the sample; and the inclusion of exercisers in the sample. The prediction model used in this study was developed on the basis of linear multiple regression; thus, it is advisable to maximize the linearity of the predictor variable before using the model.

The study investigated the predictive ability of PBF using BMI in the general public. It is a known fact that a

substantial portion of the Egyptian population uses tobacco. This fact supports the inclusion of smokers in our sample, with a statistical adjustment for the effect of smoking as a covariable. According to the centers for Disease Control and Prevention in the USA, the prevalence of cigarette smoking among adults ranges from 13.9 to 31.5%, depending on the state of residence. In our study, 19% of the participants were smokers. Similarly, exercise level was used as a covariable in the prediction equation, because 23% of participants in the sample reported exercising for at least 4 h/week.

We measured PBF using the BEI method, which is a well-validated tool for the measurement of body fat. The use of BEI to quantify the outcome variable reduced biases that might have resulted from measurement errors. However, the statistical analyses were limited because of the noninclusion of other possible confounders that might have influenced the relationship between BMI and PBF, such as menopausal status, hormone use, or dietary habits and by the arbitrary selection of 4 h/week as a cutoff level for exercise.

An important issue to be considered when interpreting the results of this study in Egyptians is their ethnic background. Members of this group carry the cultural and genetic background of mixed populations with different combinations of European, Arabian and African ancestry. These populations are highly admixed in Egypt. Therefore, dividing Egyptians into subgroups on the basis of genetic, cultural and dietary similarities would provide a more accurate research tool and deserves further exploration. Nevertheless, this investigation supports the importance of using prediction equations for determining PBF as a tool for studying obesity in epidemiological and public health applications. BMI can be used by the general public to assess a person's risk for chronic diseases and illnesses, as it can be calculated easily and is therefore accessible to lay persons. Reducing the risk of obesity-related comorbidites by empowering at-risk individuals to self-assess their risk should be a priority of public health and of educational leaders.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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