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Original article

New anthropometric indices or old ones: Which is the better predictor of body fat?☆

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ABSTRACT

Background: The percent and distribution of body fat are important factors in the pathogenesis of numerous diseases. Our aim was to investigate common anthropometric indices in their relationship with body fat content.
Methods: In a cross-sectional study 1360 healthy individuals (580 men and 780 women) in a cluster sampling, from Ahvaz, Iran, body fat content (using bioelectrical impedance) and anthropometric measurements [weight, waist circumference, a body shape index, abdominal volume index, body adiposity index, conicity, body mass index, hip circumference, waist to hip ratio and waist to height ratio] was obtained. The ROC curve analysis was used to compare each index with body fat percent.
Results: Significant difference was found between men and women in all anthropometric parameters ($p < 0.001$). Women displayed higher percentages in the overweight and obese categories (33.6% vs. 32.9% and 26.4% vs. 22.1%, respectively).
In both men and women, the strongest correlations were seen between body fat percent and BMI, AVI and WHtR ($r > 7.9$ and $p < 0.001$). BMI, WHtR and AVI in men and BAI, BMI and WHtR in women showed the most accuracy for estimating body fat percent, respectively.
Conclusion: All anthropometric parameters could predict body fat percent with relatively good power, however BMI, WHtR and AVI are more powerful predictors. Based on our findings, we suggest using the AVI and WHtR instead of other indexes, as they are better able to assess the accumulation of fat in the abdominal area and are able to more accurately assess body fat percent, which are indicators of chronic disease.

☆ Implication for health policy makers/practice/research/medical education: Older anthropometric indexes such as BMI have remained the most commonly used indexes for estimating disease risk. Recently it has become evident that old anthropometric indices are limited in many aspects for body fat and disease risk estimation. Replacing those indices with better and newer anthropometric indices that do not have the limitations of previous indices will aid in the correct estimation and prediction of disease development and overall body fat percent which itself is an indicator of chronic disease.

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1. Introduction

Obesity defined as excess body fat, is a chronic and complex disease, which has long been recognized as one of the biggest problems in the field of public health. Increase in the prevalence of obesity leads to increased prevalence of obesity related complications such as cardiovascular disease [1], diabetes [2], some types of cancer [3], psoriasis [4], adverse pregnancy outcomes [5], earlier mortality [6] and many other health conditions. Abdominal obesity also known as central obesity is an excess of fat located in the abdominal area [7].

Anthropometry refers to the measurement of the human individual and has been used for identifying and understanding human physical variations. These measurements have simple, easy and effective characteristics that make them the first choice for nutritional evaluations. These indexes include: body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR), waist to height ratio (WHtR), skinfold thickness, dual-energy X-ray absorption (DXA) and hydrostatic densitometry [8,9]. The point that should be considered regarding anthropometric indicators, in addition to their ability in estimating obesity or body fat, is their ability to detect the accumulation of fat in the abdominal area, which according to most studies is the most important factor affecting disease [8].

The negative impact of abdominal obesity on health is well recognized and although there have been tremendous advances in measuring body fat, there is still much debate regarding the most clinically efficient method of body fat assessment.

In this study, we investigated common anthropometric indices regarding body fat content and further compared the available indices in order to better understand the more clinically valid and reliable measure for adiposity.

2. Materials and methods

2.1. Subjects and study protocol

In a descriptive cross-sectional study from 2013 to 2014, the residents of Ahvaz, Iran were considered for inclusion in the study. For selecting the study sample, a cluster sampling technique was used. Twenty six districts in Ahvaz city were considered for the initial clusters. Then, the first digit of the postal codes of the citizens relating to the municipal classification was utilized to choose a random sample from the households in the city. Head – clusters were specified randomly using the list of the residing families and finally the map of each cluster along with its address were marked. The exact locations of the head – clusters in association with their addresses were specified on a map. Overall one thousand and four hundred persons were invited to participate in the study. Only participants who were in an apparently healthy state were enrolled in the study and any participant who had any systemic disease was excluded from the study population. For data gathering, 10 experienced nutritionists were trained for the interview process. Data gathering was done using face to face interviews and study related measurements were done at the participants' doors. All Participants were informed about the purpose and protocol of this study and each participant gave their consent to enter the study.

2.2. Measurements and calculations

All anthropometric measurements were done in the morning, after an overnight fasting condition, at a similar time (9 a.m.), and according to the recommendations of the International Standards for Anthropometric Assessment (ISAK) [10]. Furthermore, all measurements were performed by well – trained researchers to minimize coefficients of variation. Each measurement was made three times and the average value was calculated. Body weight was measured to the nearest 0.1 kg using an electronic scale (Seca 769 scale, Seca GMBH, Hamburg). Height was measured to the nearest 0.5 cm using a stadiometer (Seca 769 scale, Seca GMBH, Hamburg). BMI (Kg/m^2) was calculated as weight (Kg) divided by squared height (m^2). Abdominal waist and hip circumferences were measured using a flexible plastic tape. Waist circumference (WC) was measured at midpoint at the inferior border of the lowest ribs to the superior iliac crest. The measurement was done at the end of a normal expiration while the subject stood upright, with feet together and arms hanging freely at the sides. Hip circumference was measured over no restrictive underwear at the level of the maximum extension of the buttocks posteriorly in a horizontal plane, without compressing the skin.

All anthropometric calculations were done according to the following equations:

$$\text{A body shape index (ABSI)} = \frac{WC}{BMI^{2/3} * height^{1/2}}$$

$$\text{Abdominal volume index (AVI)} = [2(\text{WC})^2 + 0.7(\text{waist/hip})^2]/1000$$

$$\text{Body adiposity index (BAI)} = \frac{Hip}{Height^{1.5}} - 18$$

$$\text{Conicity} = \frac{WC(\text{m})}{0.109\sqrt{\frac{Weight(\text{kg})}{Height(\text{m})}}}$$

Percentage of body fat was obtained by the Tetrapolar Bioelectrical Impedance Analysis (BIA) system (BF-350, Tanita Corp, Tokyo, Japan). Subjects stood on the metal contacts with bare feet and their body fat mass were determined. This measurement was repeated twice, and the average value was calculated and set.

2.3. Statistical analyses

All statistical analysis including the anthropometric calculations were carried out using the Statistical Package for Social Sciences software (SPSS/IBM, Chicago, IL, USA), for windows version 22. All the data were tested for their normal distribution using the Kolmogorov – Smirnov test. Results are displayed as means and standard deviations (SD) and in percentages where appropriate.

Student *t*-test for unpaired data was used to evaluate differences in anthropometric characteristics between two sexes. We categorized the participants according to sex and separately evaluated the existence of significant bivariate correlations among different anthropometric indices using the Pearson correlation coefficient.

The diagnostic accuracy of each of the measurements for estimating abdominal fat was assessed using a receiver operating characteristic (ROC) curve analysis, reporting its sensitivity and specificity, positive predictive value (PPV), negative predictive values (NPV), positive likelihood ratio (PLR), negative likelihood ratio (NLR) and accuracy (Acc), for each of the two sexes separately. In this analysis body fat percent was considered as the continuous variable and other anthropometric variables were compared to body fat percent. A two-tailed p-value of less than 0.05 was considered statistically significant.