



Applied nutritional investigation

Comparison of new adiposity indices for the prediction of body fat in hospitalized patients



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ABSTRACT

Objective: To measure the accuracy of the body mass index (BMI), BMI adjusted for fat mass (BMIfat), body adiposity index (BAI), BAI for the Fels Longitudinal Study sample, Clínica Universidad de Navarra-Body Adiposity Estimator, and fat mass index and to compare the accuracy to that of bioelectrical impedance and dual-energy x-ray absorptiometry (DXA) in a sample of the Brazilian population.

Methods: A cross-sectional study conducted on 240 hospitalized patients, 43 (18%) male and 197 (83%) female. Mean patient ages were 53.0 ± 13.3 y for males and 53.49 ± 14.0 y for females. All subjects underwent anthropometric evaluation, bioelectrical impedance, and DXA, which permitted the calculation of the indices. The level of significance was set at $P < 0.05$ in the statistical analyses.

Results: Mean subject age (y), weight (kg), and height (cm) were 53.0 ± 13.3 and 53.4 ± 14.0 ; 72.8 ± 14.9 and 67.6 ± 14.0 ; and 171.0 ± 8.0 and 157.0 ± 7.0 for men and women, respectively. Excess weight was detected in 67.4% and 66% according to the BMI, in 30% and 69.5% according to the BMIfat, and in 51% and 38% according to the BAI for men and women, respectively. Pearson correlation revealed that BMIfat clearly showed a better correlation ($r = 0.67$) with DXA than the remaining tools. The Clínica Universidad de Navarra-Body Adiposity Estimator was the only body adiposity parameter that was significantly higher in men compared to women.

Conclusion: The results suggest that BMIfat is the index best related to the prediction of body fat and that the BAI did not exceed the limits of the BMI. Further studies of this type are needed to strengthen the present findings.

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Introduction

Currently, obesity is a pandemic disorder that is not restricted to developed countries. In 2014, a Brazilian survey indicated that 50.8% of all Brazilians are overweight and 17.5% are obese [1]. Also, the Brazilian population is rapidly undergoing an aging process, meaning nutritional and demographic transitions are occurring concomitantly. According to projections of the Brazilian Institute of Geographic and statistics, by 2050 the mean age of Brazilian people will be 81.29 y [2]. Thus, it is reasonable to assume that the population profile in Brazil is changing to one with increased and redistributed fat mass and decreased lean mass. The ominous combination of body weight gain, at the

expense of increased adiposity that is more concentrated in the visceral compartment, signal the emergence of an unhealthy aged population. On this basis, the development of more accessible and accurate tools to estimate body composition is a crucial element to initiate an assertive nutritional approach.

The most frequently used index is the body mass index (BMI), proposed by Quetelet in 1842 [3]. However, the BMI has considerable limitations because it does not differentiate fat from lean mass content nor assess fat distribution. Other indices have been proposed to extract those points not captured by the BMI. The BMI adjusted for fat mass (BMIfat) was proposed by Mialich et al. and applied to a sample of the Brazilian population [4,5]. The body adiposity index (BAI) was created by Bergman et al. for Mexican-American individuals and uses hip circumference and height as the anthropometric parameters [6]. In 2012, Johnson et al. adjusted the BAI using 626

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European-American adults and created the Adiposity Index for the Fels Longitudinal Study sample (BAIfels) [7]. Lara et al., using a group of 40 Caucasian individuals, developed the Clínica Universidad the Navarra-body adiposity estimator (CUNBAE) based on three variables involved in a complex expression of BMI, age, and sex [8] (Table 1).

The bioelectrical impedance (BIA) technique has largely been used during the last decades in clinical practice and clinical investigation. It is easy to operate, has low cost, and is portable, all of which are attractive features specially designed for field research. However, several factors interfere with BIA assessment, including hydration and feeding/fasting status; more importantly, BIA is not able to indicate fat distribution. Among the most accurate and sensitive methods for the quantitative evaluation of body fat is dual-energy x ray absorptiometry (DXA), which is currently considered to be the gold standard for the analysis of body composition [11]. Although several tools are available for the assessment of nutritional status, it is of fundamental importance to test their accuracy for their target population, especially for application to different ethnic groups because ethnic origin, like age and sex, influences body composition.

The objective of the present study was to expand comparative analyses of the accuracy of methods like adiposity indices and BIA for predicting body fat and to compare their values to those obtained by DXA as the gold standard method for the analysis of body composition.

Materials and methods

Subjects

The study was conducted with 240 Brazilian subjects of both sexes (females/males = 387/114), comprising patients from the University Hospital, Ribeirão Preto Medical School, University of São Paulo (USP). Exclusion criteria were as follows: age <17 y amputated or immobilized limbs; inability to walk; being bedridden; edema and/or ascites; receiving intravenous hydration; or any procedure that might impair the measurements. Also excluded were subjects wearing a cardiac pacemaker, an aneurysm clip, or metal implants of any type (metal wires, plates, or screws) and patients who could not communicate. Participation was voluntary, and each subject was assessed only once during the study by a group of trained examiners. The study was approved by the Research Ethics Committee of the University Hospital, and all subjects gave written informed consent to participate (Protocol no 1955/2010).

Anthropometric evaluation

Each subject underwent anthropometric measurements by the same trained examiner, including weight and height and waist, arm, and hip circumference. Weight was measured with a model BC-558 electronic scale, Ironman Segmental Body Composition Monitor (Tanita Corp., Tokyo, Japan) with a maximum capacity of 150 kg and 0.01 kg precision; subjects were weighed while barefoot and

wearing light clothing and no accessories. Height was measured with a 2-meter anthropometer, with the subject barefoot and standing straight with neck and head aligned with the trunk [12]. Circumferences were measured with an inextensible measuring tape with 0.1 cm divisions according to the anatomic points standardized by Lohman et al. [13].

Bioelectrical impedance

Fat-free mass and fat mass were measured with the BC-558 Ironman Segmental Body Composition Monitor, which is tetrapolar equipment that performs unifrequency analyses. The measured values include total and segmental body fat percentage, body water, total and segmental muscle mass, physique rating, bone mass, visceral fat rating with healthy range, basal metabolic rate, and metabolic age. For this examination, the subjects were wearing light clothing and no socks, and care was taken to verify that their heels were correctly aligned with the electrodes of the measuring platform. The subjects were instructed to fast for at least 5 h, to avoid vigorous physical activity during the last 12 h, to urinate 30 min before the examination, and to abstain from alcoholic or caffeine-containing beverages for 24 h before the examination. During the examination, the subjects continuously held retractile levers that acted with the foot electrodes to form a 90° angle between the base of the electrode and the rod linked to the equipment. After this measurement, which lasted about 30 s, the display automatically showed the final result of body composition.

Dual-energy x ray absorptiometry

The examination was performed with the subject lying in the dorsal decubitus position on a table so the source and the detector would pass through the body at a relatively low speed of 1 cm/s. The equipment used in this study was a 4500 W Hologic scanner (Hologic 4500 W, Waltham, MA, USA), which permitted reconstruction of the image of the underlying tissues and quantified mineral, bone, total fat mass, and fat-free mass content using specialized software.

Adiposity indices

The BMI was determined as weight/height² [3]. The nutritional status was classified according to the cut-off points proposed by the World Health Organization (WHO) [14] as follows: undernutrition: BMI <18.49 kg/m²; normal weight: BMI between 18.5 and 24.9 kg/m²; excess weight: BMI between 25.0 and 29.9 kg/m²; grade I obesity: BMI between 30.0 and 34.9 kg/m²; grade II obesity: BMI between 35.0 and 39.9 kg/m²; and grade III obesity: BMI >40.0 kg/m². BMIfat, proposed by Mialich et al., was calculated according to the following equation: [(3 weight + 4 fat mass)/height], with weight in kilograms, fat mass as percentage, and height in meters [4]. The ranges proposed by Mialich et al. were considering for the classification of nutritional status based on this adiposity index as follows: 1.35 to 1.65, risk for undernutrition; >1.65 to ≤2.0, normal weight; and >2.0, obesity [5].

The BAI, proposed by Bergman et al., was obtained as the hip to height ratio in meters: BAI = [(hip circumference)/(height^{1.5}) – 18] [6]. The BAIfels, developed by Johnson et al., was obtained using the BAI formula: [1.26 × (hip circumference)/(height^{1.4}) – 32.85] [7]. The CUNBAE, proposed by Lara et al., was calculated using the three variables of a complex expression (i.e., BMI, age, and sex) with a value of 0 being used for men and a value of 1 for women. Thus, the result of fat mass percent is as follows: FM: [–44.988 + [0.503 × age] + [10.689 × sex] + [3.172 × BMI] [0.026 × (BMI × BMI)] + [0.18 × BMI × sex] – [0.02 × BMI × age] – [0.005 × (BMI × BMI) × sex] + [0.00021 × (BMI × BMI) × age]] [8]. Finally, the fat mass index (FMI) proposed by Vanitallie et al., was calculated using the following

Table 1
Description of the new adiposity indices

Index	Reference	Country	n	Adiposity index	Cutoff points
BAI	Bergman et al., 2011 [6]	USA	1733	$BAI = (HC/E^{1.5}) - 18$	≥25% for men and ≥35% for women
BMIfat	Mialich et al., 2011 [4]	Brazil	100	$BMIfat = (3 W + 4 FM)/H$	>1.65 and = 2.0 eutrofic; >2.0 obesity for both
BAIfels	Johnson et al., 2012 [7]	USA	623	$BAIfels = 1.26 \times (HC/H^{1.4}) - 32.85$	≥25% for men and ≥35% for women
CUNBAE	Lara et al., 2014 [8]	USA	40	$CUNBAE = \{-44.988 + [0.503 \times \text{age}] + [10.689 \times \text{sex}] + [3.172 \times \text{BMI}] + [0.026 \times (\text{BMI} \times \text{BMI})] + [0.18 \times \text{BMI} \times \text{sex}] - [0.02 \times \text{BMI} \times \text{age}] - [0.005 \times (\text{BMI} \times \text{BMI}) \times \text{sex}] + [0.00021 \times (\text{BMI} \times \text{BMI}) \times \text{age}]\}$	≥25% for men and ≥35% for women
FMI	Vanitallie et al., 1990 [9]			$FMI = \text{Fat mass (kg)/height (m)}^2$	FM ≥8.3 kg/m ² for men and ≥11.8 kg/m ² for women [10]

BAI, body adiposity index; BAIfels, adiposity index for the Fels Longitudinal Study sample; BMI, body mass index; BMIfat, body mass index adjusted for fat mass; CUNBAE, Clínica Universidad de Navarra-body adiposity estimator; FM, fat mass; FMI, fat mass index; H, height; HC, hip circumference; W, weight; WC, waist circumference

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