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Original Article

Comparison of DEXA-derived body fat measurement to two race-specific bioelectrical impedance equations in healthy Indians

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ABSTRACT

Aim: Prevalence of obesity is increasing in Asian Indians. Reliable, precise and convenient methods to estimate body composition are required. This study aimed to test the accuracy of bioelectrical impedance analysis (BIA) estimates of body composition among Asian Indians according to two BIA equations – one developed for Asians, the other for Caucasians.

Methods: Two hundred apparently healthy Asian Indians (100 males, 100 females; mean age 36.6 ± 7.6 years; mean BMI 16.6–46.7 kg/m^2) underwent BIA assessment of fat mass (FM), fat free mass (FFM) and percentage body fat (%BF) using Tanita Multi-Frequency Body Composition Analyzer MC-180MA (Tanita Corporation, Tokyo, Japan). One set of BIA values was automatically calculated by the analyzer (Caucasian figures), the other set by Tanita (Japanese Asian figures). Results were compared to dual X-ray absorptiometry (DEXA) as the standard measure.

Results: A moderate level of relative agreement was found between the DEXA-derived measurement of %BF and the estimate from both the Caucasian ($r^2 = 0.75$; $p < 0.001$) and Asian equation ($r^2 = 0.7$; $p < 0.001$). Despite this, the level of absolute agreement was poor, with large bias and wide limits of agreement. According to the Caucasian equation the mean difference between methods was −8.3 ± 3.9 (95% limits of agreement −20.10 to 9.40), for the Asian equations mean difference was −5.4 ± 4.3 (95% limits of agreement −20.63 to 11.41).

Interpretation and conclusions: When compared to DEXA, the current Asian and Caucasian Tanita formulae significantly under-estimate the %BF of Asian Indians.

1. Introduction

Globalization and burgeoning economies have increased obesity, abdominal obesity and co-morbid diseases in many developing Asian countries, including India [1]. Using body mass index (BMI) cut-offs for Asian Indians: 23–24.9 kg/m^2 for overweight and ≥25 kg/m^2 for obesity [2] the current prevalence of overweight and obesity ranges from 30% to 65% of urban adults, depending on the population studied [3].

In comparison to white Caucasians, Asian Indians are generally shorter in stature and lower in fat-free mass (FFM), body weight and BMI, yet possess a higher percentage of body mass as adipose tissue [1]. Although their waist circumference tends to be comparatively small, Indians tend to carry higher levels of both subcutaneous abdominal and intra-abdominal fat compared to their white Caucasian counterparts [4]. These anomalies in body fat mass and distribution in Asian Indians are associated with a higher risk of metabolic abnormalities including insulin resistance, dyslipidemia, type 2 diabetes [5] and premature coronary heart disease (CHD) [6]. Migrant Asian Indians living in Western nations are also vulnerable to obesity-related metabolic abnormalities at a lower BMI than white Caucasians [1]. Health figures reveal that Asian Indians living in Western environments fair even more poorly than other ethnic groups in cardiovascular mortality and metabolic abnormalities [7].

From a clinical and research perspective, the ability to accurately determine percentage body fat (%BF), and the change in this parameter over time, will assist in proper healthcare evaluation and appropriate management. In order to carry out %BF assessments within both Asian and Western settings, hospitals, health centres and laboratories need access to inexpensive and reliable methods.

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Dual-energy X-ray absorptiometry (DEXA) is a widely used means of indirect body composition analysis that has been validated against the benchmarks of deuterium-oxide dilutometry for gauging total body water (TBW) and hydro-densitometry (underwater weighing; UWW). Error rates of DEXA varies from 4% to 10% [8,9], it has been used to calculate %BF measurement in individuals across all weight ranges, and among the obese has shown high accuracy and precision [10,11]. Yet although DEXA is considered reliable and accurate, high equipment costs and the need for dedicated staff and facilities limit its accessibility and value as a standard for clinical assessment and research. To overcome this problem, a quick, simple and precise method to calculate %BF is required.

Bioelectrical impedance analysis (BIA) is a low cost, convenient, and non-invasive approach that can be used to derive an estimate of %BF. Bio-impedance analysis measures the resistance or impedance of the body to a small alternating current [12]. Electricity is conducted most readily by the electrolyte-dense body water found in muscle and blood, and comparatively poorly by the low-electrolyte adipose tissue. Assuming that TBW, electrolyte balance and body temperature are normal and stable, equations that take into account the body's impedance to electrical flow and other variables such as weight, height and age, are used to predict body composition [13].

The BIA method is being increasingly applied to body composition analysis in a range of clinical and research settings [14,15]. To assess its accuracy a number of studies have evaluated the level of agreement between %BF measurements by BIA and DEXA within groups of various body weight [16,17]. While some of these studies have shown good concordance between methods [16] others have not [17,18]. The inability to draw conclusions from these studies may stem from the limitations of small study size, and variables in the age, race and body weights of sample populations. In individuals with a higher %BF, the assumed norm for TBW may not apply due to potential differences in variables such as body build and water distribution which confound BIA estimates and draw its accuracy and reliability into question [19]. Insofar as BIA assessment of TBW, the newer multi-frequency analyzers are considered superior to those of single-frequency, and are therefore recommended for estimation of %BF among the obese [19].

In addition, the accuracy of BIA-derived measurements of %BF are also dependent on the mathematical formula applied [20]. A number of BIA equations for the estimation of %BF among multi-ethnic (mainly white Caucasian) groups and Asians have been developed [21,22] but thus far no equation has been developed specifically for Asian Indians. We therefore chose to compare BIA estimates of body composition among Asian Indians using two BIA equations – one developed for Asians and the other for Caucasians, and contrast these findings using DEXA as standard.

2. Materials and methods

Between June 2008 and June 2009, apparently healthy men and women attending the medical outpatient department for general health checkup at Fortis Hospital, New Delhi were invited to participate in this body composition study. Subjects were considered eligible if they were aged between 18 and 65 years, and free from any significant known health issue. Persons were excluded from consideration if they had a history of diabetes, cardiovascular disease, chronic diseases of the kidney or liver, tuberculosis, any acute illness or infection, or were afflicted with a skeletal deformity or partial or whole limb amputation. The final study group consisted of 200 ethnic Asian Indians; 100 males and 100 females. The research was approved by the institution's Ethics Committee and conformed to the provisions of the Declaration of Helsinki in 1995 (as revised Edinburgh 2000). Participants were notified that all data obtained would remain anonymous, and written informed consent was obtained.

All anthropometric and body composition measurements were performed on the same day. Before testing, subjects were instructed to avoid all diuretics for 7 days; alcohol for 48 h; intense exercise for 12 h and all fluids for 4 h. After an overnight fast, anthropometric, clinical and BIA measurements were obtained by a single, experienced clinician. Height, age and gender was entered in the machine to get body fat percentage. BIA equations cannot be disclosed as its copyright of Tanita Corporation.

2.1. Anthropometric data

Subjects were weighed without shoes in light clothing on a calibrated electronic scale. Measurements were recorded to the nearest of 0.1 kg. Height was assessed without shoes to the nearest 0.1 cm using a wall-mounted stadiometer with head held in Frankfort plane.

BMI was calculated as weight (kg) divided by height (m) squared. Waist circumference (WC) was measured mid-way between the iliac crest and lowermost margin of the ribs, during quiet breathing. Hip circumference (HC) was measured at the maximum protruding part of buttocks at the level of the greater trochanter with the patient wearing minimal clothing, standing feet together.

2.2. Bioelectrical impedance analysis (BIA)

In addition to abstinence from diuretics, alcohol, intense exercise and fluids as detailed earlier, subjects emptied their bladder 30 min before the BIA measurement was taken. Bioelectrical impedance was measured using the Tanita Multi-Frequency Body Composition Analyzer MC-180MA (Tanita Corporation, Tokyo, Japan); an apparatus with an eight-point footpad-style electrode arrangement. The frequency of impedance calibration was ±2%. Subjects stood in bare feet with the heel and toe of each foot in contact with the metal footpads, with arms hanging to each side, lightly holding the analyzer handgrips. The results for FM, FFM and %BF were automatically calculated by the MC-180MA Body Composition Analyzer. In order to calculate FM, FFM and %BF according to the Asian formula (MC-180JP, herein known as the "Japanese Asian equation"), the results of MC-180MA (herein known as the "Caucasian equation") were provided to Tanita, who transformed the figures according to their Japanese Asian equation.

2.3. Dual energy X-ray absorptiometry (DEXA)

The DEXA measurement of FM and FFM was conducted using the General Electric Lunar Prodigy Advanced scanner with fan beam (GE, USA). The anatomical areas analysed in whole body DEXA scan were trunk, right upper limb, left upper limb, right lower limb and left lower limb. The data were analyzed using software version enCORE software platform for windows XP professional.

2.4. Statistical analysis

Data were presented as either mean ± SD or median (range) as appropriate. Data have been checked for normality and homogeneity. The differences in mean values between male and female characteristics and between DEXA and BIA-derived values for the Asian and Caucasian equations were tested using Student's *t*-test. Independent-samples *t*-tests compared group of males and females. Single linear regression analysis used to test for the relative levels of agreement