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Original article

Leg to leg bioelectrical impedance analysis of percentage fat mass in obese patients—Can it tell us more than we already know?

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Abstract

Background: Bioelectrical impedance analysis (BIA) is well tolerated, inexpensive, and readily available, but can it be used to detect with clinical precision aberrant changes in the proportion of fat mass to fat-free mass during weight loss?

Objectives: To assess the variance in percentage body fat mass explained by the readily available inputs and assess residual variance provided by leg-to-leg BIA scales.

Methods: Using cross-sectional data from a cohort of 665 patients of Indian ethnicity presenting for bariatric surgery, we examine the determinants of percentage body fat as provided by leg-to-leg output from Tanita SC-330 BIA scales.

Results: Four input factors—sex, weight, height, and age—contributed to provide 92% and 95% explanation in output variance for percentage fat mass (%FM) and actual fat mass, respectively, in 665 patients. Body mass index alone explained 89% and 81% of variance in %FM output for women and men, respectively. Neither weight distribution, as indicated by waist and hip circumference or waist to hip ratio, nor plasma lipids or markers of glucose metabolism contributed additional variance in %FM when controlled for the 4 key inputs.

Conclusions: Simple, known input variables dominate the leg-to-leg BIA output of %FM, and this may compromise the detection of aberrant changes in %FM and fat-free mass with substantial weight loss. For clinical research, validated methods not largely dependent on known inputs should be used for evaluating changes in body composition after substantial weight loss. (Surg Obes Relat Dis 2016;▮:00–00.) © 2016 American Society for Metabolic and Bariatric Surgery. All rights reserved.

Key Words: Weight loss; Obese; Obesity; Severe obesity; Bariatric-metabolic surgery; Bariatric; Metabolic; Surgery; Health; Quality of life; Mortality; Chronic disease; Body fat; Fat loss; Fat-free mass; Resting energy expenditure; Weight regain; Strength; Function; Sarcopenia; Dual-energy x-ray absorptiometry (DXA); Bioelectrical impedance analysis (BIA); Co-morbidity; Foot-to-foot BIA.

Intentional weight loss is recommended for obese individuals, especially those with clinically severe obesity. Bariatric-metabolic surgery is currently our best therapy for generating and sustaining substantial weight loss in clinically severe obesity. Accompanying the weight loss are major improvements in health, quality of life, and reduced

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overall mortality [1]. However, it is important when treating a chronic disease with long-term therapy, which is usually the intent of bariatric metabolic surgery, to look at any downside of chronic therapy with the view to attenuating any risk [2]. The most commonly performed conventional bariatric procedures provide 15% to 30% sustained weight loss, raising concerns about long-term body composition. Of particular importance has been the aim of maximizing fat loss and attenuating the loss of fat-free mass (FFM), as this is important for maintaining resting energy expenditure (possibly providing some insurance against weight regain), strength, and function as well as preventing sarcopenia and frailty with aging [3].

When and how to measure body composition presents a practical challenge in clinical practice where availability of sophisticated and well-validated body composition methods are time consuming, sometimes physically challenging, and expensive. We have recently shown in an obese European white population that sex, weight, height, and age can together provide 90% of the variance in dual-energy x-ray absorptiometry (DXA), estimated body fat mass (BFM) and 78% of percent body fat (%BF) [4]. Bioelectrical impedance analysis (BIA) is the most commonly reported method for reporting percentage body fat in journals focusing specifically on bariatric-metabolic surgery.

Leg-to-leg bioimpedance measures are obtained when the subject stands with bare feet on scales that incorporate input and output electrodes on the standing platform; additional information such as height, sex, age, level of fitness, and build are manually entered. BIA is well tolerated, cheap, easy to use, readily available, and requires minimal training, but it is unclear how much of its estimate of BFM or %BF is driven by the input variables that have been shown themselves to be critically related to the outcome-independent DXA-derived estimate of %BF. Can the BIA-estimated %BF provide useful additional information about a patient's co-morbidity or metabolic factors before surgery?

We hypothesised that 1) readily available input factors in the BIA algorithm will dominate the %BF output, allowing very limited remaining variance to be influenced by the impedance measures, and 2) the value of BIA beyond the input factors provides no additional insights into cardiometabolic risk and co-morbidity. Therefore, the aim of this analysis was to 1) assess how input factors weight, height, sex, and age are related to the output measure of %BF derived from foot-to-foot BIA in a population of Indian ethnicity, and 2) control for these input factors and then assess any additional value of BIA-derived percentage body fat in predicting obesity-related metabolic factors and obesity-related co-morbidity.

Methods

Patients presenting at the Indian Centre for Obesity & Digestive Surgery (Gamdevi, Mumbai, India) were carefully evaluated before surgery. Assessment included anthropometric measures of height, weight, waist and hip circumference, and waist-to-hip ratio. Obesity-related co-morbidities were detailed, and biochemical analyses included fasting plasma glucose, insulin, lipid panel, liver function, and thyroid function.

BIA analysis was performed using the Body Composition analyzer SC-330 (Tanita Corp, Tokyo, Japan). The analyzer required age, build, sex, and height before analysis of %BF could be provided using the weight measured by the instrument's scales. The instrument provided a 3-compartment body composition model of fat mass, muscle mass (FFM), and bone mass, adding up to the scale-measured weight. The manufacturer also indicated that factors such as exercise, time of day, posture, food and drink intake, foot surface condition, urinary bladder status, ambient temperature and humidity, and transmitter electrical interference may influence the accuracy of measurements. Constant conditions are recommended for taking measurements.

Statistical analyses

The group's characteristics are summarized and presented in Table 1 as n (%), mean (standard deviation), and median (interquartile range) as appropriate. The analysis was performed using linear regression analysis using the BIA-estimated %BF or BFM as the dependent variable. Regression models were assessed entering all variables simultaneously, together with stepwise loading and stepwise removing. Assessment of the variance provided by the 4 individual BIA input factors was performed using a block method after controlling for the other 3 factors. B values and 95% confidence intervals are provided, and individual adjusted R^2 values and cumulative R^2 values are presented along with percentage variance explained. All analysis was performed using SPSS Statistics version 22 (IBM Corp. Armonk, NY).

Results

The characteristics of the 665 adults of Indian ethnicity presenting for weight loss therapy are shown in Table 1. Linear regression analysis was used to assess input measures for their association with the BIA-derived %BF output as the dependent variable.

Using the combined cohort of both men and women, all 4 input factors (sex, weight, height, and age) each contributed to providing the explained variance of the percentage body fat and together contributed 92% ($R^2 = 0.92$) of the variance, leaving 8% for other inputs (Table 2 and Fig. 1A). When combining weight and height as one variable—body mass index (BMI)—the 3 input variables contributed to 93% ($R^2 = 0.93$) of variance. The adjusted R^2 values for each of the 4 input variables (each adjusted for the other 3) are presented in Table 2, and the stepwise build order and additional variance provided with the