Bioelectrical Impedance versus Body Mass Index for Predicting Body Composition Parameters in Sedentary Job Women

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Received: 17 June 2013
Accepted: 2 August 2013
Published in September 2013

Abstract

Objective: Nowadays the value of bioelectrical impedance analysis (BIA) in the estimation of body adiposity both on a clinical basis in the individual and epidemiologically in large populations is of great interest. The current study determine accuracy of BIA compared with body mass index (BMI) measurement for estimating body composition in a group of normal weight employee women with a sedentary job status.

Materials and Methods: Forty normal weight women employed in a private institute in Tehran, Iran, participated in this study. Body composition parameters including percentage body fat, percentage visceral fat, and percentage muscular mass were measured by BIA and BMI was calculated.

Results: There were strong direct correlations between one-year BMI value changes and changes in two body composition indices of percentage body fat, and percentage visceral fat, as well as an adverse correlation with the changes in percentage muscular mass. Similar association was only observed between change in basal metabolic rate (BMR) value measured via BIA and percentage body fat, neither percentage visceral fat nor percentage muscular mass. The observed correlation between percentage body fat and BMR was considerably weaker than the relationship between this composition index and BMI value. According to the ROC curve analyses, both BMR and BMI parameters had acceptable values for discriminating decreased from increased percentage body fat; however, the discriminative power of BMR value (c=0.762) was lower compared with BMI measurement (c=0.887). As we considered BMI as a gold standard value, BIA yielded a sensitivity of 70.0% and a specificity of 70.0% for determining changes in percentage body fat.

Conclusion: BIA technique is not superior to BMI measure as a predictor of body composition parameters.

Keywords: Bioelectrical Impedance, Body mass index, Body composition.

Introduction

Knowledge of different aspects of body composition in both healthy and diseased individuals is a continuing interest of clinicians, because majority of prevalent diseases are originated from abnormalities in body fatness. During recent decade, bioelectrical impedance analysis (BIA) has been identified as a widely used method for estimating body composition (1,2). Because this method is relatively simple, quick, and noninvasive, is currently applied in various clinical settings, including private clinicians' offices, health clubs, and hospitals, and across a spectrum of ages, body weights, and disease states. This technique is not only able to estimate adiposity, but also is beginning to be used in the estimation of body cell mass and muscular mass in a variety of clinical conditions (3,4). Nowadays, the value of BIA in the estimation of body adiposity both on a clinical basis in the individual and epidemiologically in large populations is of great interest. However, review of literatures has indicated a wide inconsistency in the accuracy of BIA as a choice method for estimating body composition (5). Some large epidemiological studies showed that BIA could be useful only for those populations with characteristics similar to those of the reference populations. On the other hand, different characteristics of populations such as ethnicity or their nutritional habits can effectively influence the accuracy of this method (6-8). In addition, because the human body is not uniform either in length, cross-sectional area, or ionic composition, these parameters might also change BIA accuracy (9). Besides, superiority of BIA in comparison with some simple methods such as body mass index has been already questioned. Some studies showed that the two techniques were comparable in term of estimating body composition (10,11). Even, some previous results suggested that BIA is not superior to body mass index (BMI) as a predictor of overall adiposity in the general population (12). Therefore, the current study determine accuracy of BIA compared with BMI measurement for estimating body composition in a group of normal weight employee women with a sedentary job status.

Materials and Methods

In a single center cross-sectional study and among 100 employees in a private institute in Tehran, Iran, 40 normal weight women who underwent body composition for two times participated in this study. All participants were sedentary employees defined as subjects who worked in a seated position at the office for long hours. All subjects were aged 28±3 year and at least 44 kg body weight. None of the subjects were pregnant or taking any prescribed medication affects body weight such as synthroid or diuretics. None had metabolic condition that could affect the results of this study. All women gave written informed consent and all procedures were approved by the Institutional Review Board of our hospital.

Height and weight were measured at the beginning of the trial by skilled personnel, according to standardized techniques, with light clothes and without shoes. BMI was calculated as weight in kilograms divided by height in meters squared. Body composition parameters were measured by bioelectrical impedance analysis (BIA) using the Wabitsch formula (13). For the BIA measurements, patients were instructed to lie on their backs while electrodes were placed on their wrists and ankles. A low-level alternating current was delivered and measured at distinct frequencies between 5 KHz and 1 MHz. All measurements were performed at baseline as well as after a one-year time interval.

The first endpoint of our study was to determine the changes in body composition in our sedentary workers within one-year of study and the second endpoint was to compare the value of BMI and BIA tools for predicting changes in different parameters of body composition within one-year follow-up of the participants. Results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by absolute frequencies and percentages for categorical variables. Correlation between the quantitative variables was examined using the Pearson's correlation coefficient test. A receiver operating characteristic (ROC) curve was used to identify discriminative power of BMI and BIA tools for predicting changes in body composition parameters. For the statistical analysis, the statistical software SPSS version 20.0 for windows (SPSS Inc., Chicago, IL) was used. P values of 0.05 or less were considered statistically significant.

Results

The mean age of the participants was 28.1±3.9 years ranged from 22 to 35 years. In half of the subjects, weight was increased in the range of 0.1 to 7.0kg during a year, while decreased weight was detected in others in the range of 0.1 to 10.7kg. The range of difference in BMI within the follow-up time was -2.73 to 4.18kg/m^2. In this regard, percentage body fat was increased in 25% of the participants and increasing visceral fat percentage was observed in only 3 (7.5%) subjects. Also, increased and reduced basal metabolism rate (BMR) value measured by BIA was occurred in 62.5% and 37.5%, respectively (Table 1). There were strong direct correlations between one-year BMI value changes and changes in two body composition indices of percentage body fat (β=0.713, p<0.001), and percentage visceral fat (β=0.582, p<0.001), as well as an adverse correlation with the changes in percentage muscular mass (β=-0.520, p<0.001). Similar association was only observed between change in BMR value and percentage body fat (β=0.516, p=0.001), neither percentage visceral fat (β=0.305, p=0.055) nor percentage muscular mass (β=-0.303, p=0.057). Although correlation between BMI and BMR values changes was strongly significant (β=0.758, p<0.001) (Figure 1). Based on the Pearson's correlation coefficient, the observed correlation between percentage body fat and BMR was considerably weaker than the relationship between this composition index and BMI value. According to the ROC curve analyses (Figure 1), both BMR and BMI parameters had acceptable values for discriminating decreased from increased percentage body fat. However, the discriminative power of BMR value (c=0.762, 95%CI: 0.595–0.928) was lower compared with BMI measurement (c=0.887, 95%CI: 0.742–0.999). As we considered BMI as a gold standard value, BIA yielded a sensitivity of 70.0% and a specificity of 70.0% for determining changes in percentage body fat.

Discussion

Our study suggested that BMI measurement can be a choice method for estimating parameters of body composition including body fat, visceral fat as well as muscular mass. On the other hand, these indices can be estimated accurately by BMI, while this accuracy for BIA is shown only for assessing body fat, neither for determining visceral fat nor for muscular mass. Because BMI is considerably cheaper and easier tool for measurement of adiposity than BIA, it is preferred to use former method in clinical settings. It has been previously demonstrated that using BIA has different accuracy in multiethnic populations and many of BIA equations were developed from specific

Table 1. Topographic and body composition parameters at baseline and one-year follow-up

Indices	Mean (SD)	Median	Range
Height (cm)	163.08 ± 5.43	162.5	154.0 – 178.0
Baseline weight (Kg)	62.95 ± 8.27	61.25	44.0 – 79.0
Follow-up weight (Kg)	62.59 ± 8.29	61.35	47.1 – 79.8
Baseline BMI (Kg/m^2)	23.69 ± 3.16	23.24	17.4 – 30.9
Follow-up BMI (Kg/m^2)	23.54 ± 3.01	22.99	18.4 – 31.0
Baseline BF (%)	36.14 ± 5.70	36.95	24.8 – 45.7
Follow-up BF (%)	34.28 ± 5.90	35.35	22.0 – 46.1
Baseline VF (%)	4.70 ± 1.34	5.00	2.0 – 8.0
Follow-up VF (%)	4.35 ± 1.44	4.00	2.0 – 7.0
Baseline MS (%)	26.24 ± 2.02	25.70	23.4 – 30.6
Follow-up MS (%)	27.30 ± 2.24	27.00	23.1 – 32.2
Baseline BMR	1321.18 ± 88.59	1304.00	1106.0 – 1526.0
Follow-up BMR	1329.75 ± 89.61	1313.00	1175.0 – 1550.0

BMI: Body mass index; BMR: Basal metabolism rate; BF: Body fat; VF: Visceral fat; MS: Muscular; BMR

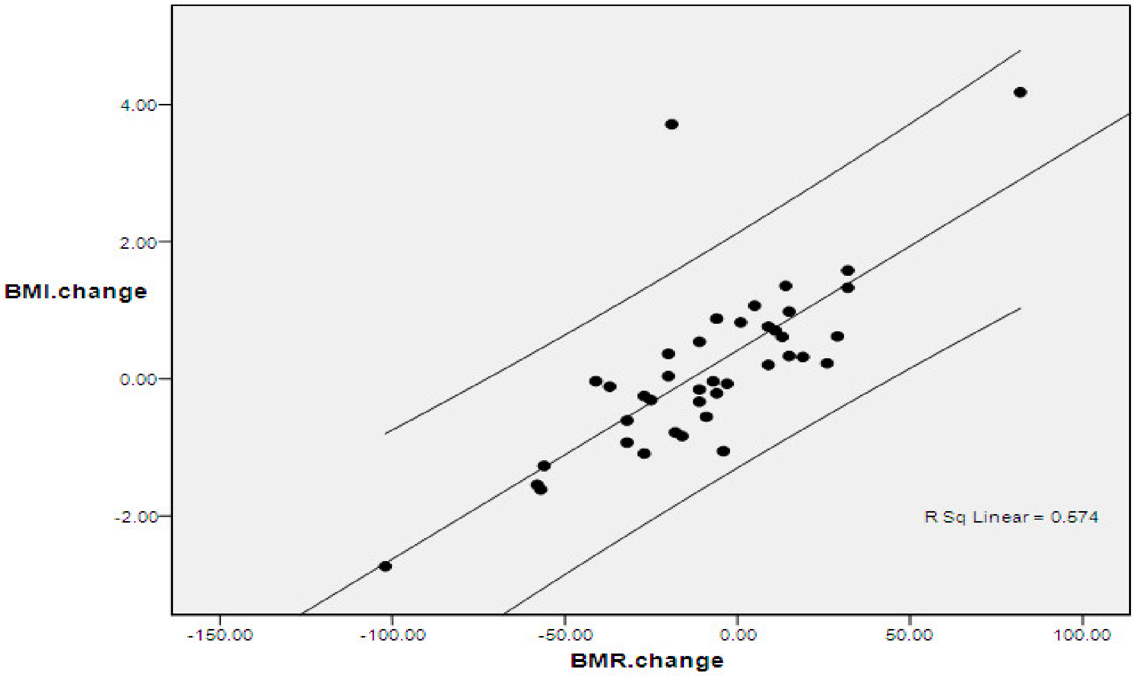

Figure 1. Correlation between the changes in BMI and BMR.

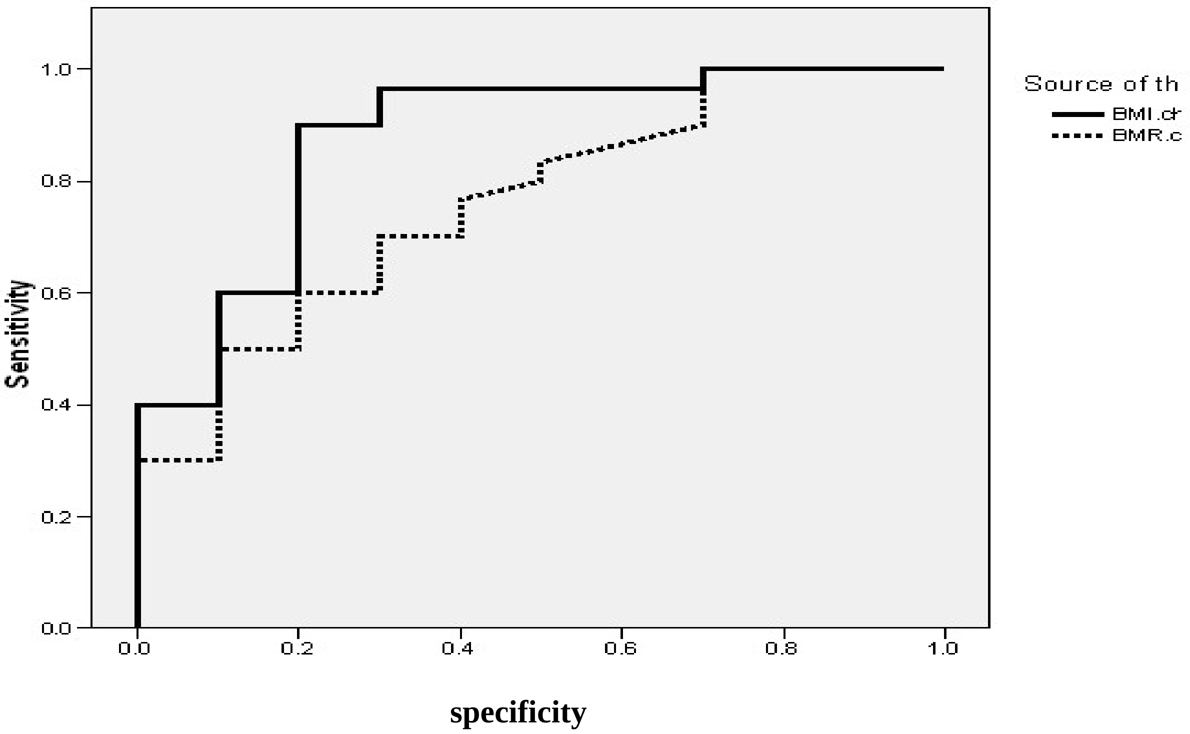

Figure 2. Receiver operator characteristic (ROC) curves were constructed to investigate the diagnostic power of the BMR and BMI for predicting changes in percentage body fat.

populations (12). Some limitations of BIA have been discussed in details. Available data indicates that BIA cannot be useful for in measuring acute changes in body fat in individuals, although it can characterize longer term changes in groups of subjects. However, according to our results, although this tool has an appropriate accuracy for estimating body fat in long-term, but its accuracy for measuring long-term visceral fat and muscular mass seems to be inappropriate. Moreover, using this tool can be accompanied with the error of measurement in some individuals at the extreme of leanness such as in some athletes and patients with wasting diseases. Also, application of BIA in some populations should be considered after appropriate revalidation (14).

The major limitation of BIA technique is its notable prediction error in lean and obese individuals. Because we selected our cases from normal weight women, this error was not appeared in our estimations. This dependency of predicted values on the degree of body fatness was found in several studies. Segal et al (15) observed that the prediction error can be lowered when different prediction formulas are used for lean and obese subjects. In a study in lean and obese women in which the validity of several methods was tested, McNeill et al (16) showed that in obese subjects, body fat was underestimated by impedance. Van der Kooy et al (17) showed that the overestimation of body fat percentage from impedance with several prediction formulas from the literature was more pronounced in obese women before weight loss, and was lower or even disappeared after weight loss. Thus, it seems that the use of BIA method should be limited to lean or obese ones, whereas BMI can be effectively used for all individuals regardless their weight or obesity conditions.

In conclusion, BIA is not superior to BMI as a predictor of body composition parameters. In fact, although BMI can accurately estimate different indicators of body composition including percentage body fat, percentage visceral fat, and muscular mass in long-term, BIA can only estimate effectively percentage body fat with lower sensitivity and specificity compared with BMI measurement.

Acknowledgement

This study was supported by the Shahid Beheshti University of Medical Sciences. The authors thank the authorities of Tosan Institute especially Dr. Seyed Vali Fatemi (managing director) for preparing software associated with the project.

Conclusion

All authors declare they have no conflict of interest

References

1. Ellis KJ, Bell SJ, Chertow GM, Chumlea WC, Knox TA, Kotler DP, et al. Bioelectrical impedance methods in clinical research: a follow-up to the NIH Technology Assessment Conference. Nutrition 1999;15(11):874-80.
2. Houtkooper LB, Lohman TG, Going SB, Howell WH. Why bioelectrical impedance analysis should be used for estimating adiposity. The American journal of clinical nutrition 1996;64(3):436-48
3. Roubenoff R. Applications of bioelectrical impedance analysis for body composition to epidemiologic studies. Am J Clin Nutr. 1996;64:459–62.
4. Young RE, Sinha DP. Bioelectrical-impedance analysis as a measure of body composition in a West Indian population. Am J Clin Nutr. 1992;55:1045–50.
5. Flegal KM, Shepherd JA, Looker AC, Graubard BI, Borrud LG, Ogden CL, et al. Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults. The American journal of clinical nutrition 2009;89(2):500-8.
6. Deurenberg P, Deurenberg-Yap M, Schouten FJ: Validity of total and segmental impedance measurements for prediction of body composition across ethnic population groups. Eur J Clin Nutr 2002;56:214-20.
7. Kyle UG, Piccoli A, Pichard C: Body composition measurements: interpretation finally made easy for clinical use. Curr Opin Clin Nutr Metab Care 2003;6:387-93.
8. Heyward VH, Wagner DR: Body composition and ethnicity. Applied body composition assessment. Human Kinetics 2004:135-72.
9. Pietrobelli A, Heymsfield SB: Establishing body composition in obesity. J Endocrinol Invest 2002, 25:884-92.
10. Jackson AS, Pollock ML, Graves GE, Mahar MT. Reliability and validity of bioelectrical impedance in determining body composition. Journal of Applied Physiology 1988;64:529-34.

11. Amani R. Comparison between bioelectrical impedance analysis and body mass index methods in determination of obesity prevalence in Ahvazi women. Eur J Clin Nutr. 2007 Apr;61(4):478-82.
12. Willett K, Jiang R, Lenart E, Spiegelman D, Willett W. Comparison of bioelectrical impedance and BMI in predicting obesity-related medical conditions. Obesity (Silver Spring). 2006 Mar;14(3):480-90.
13. Wabitsch M, Braun U, Heinze E, Muche R, Mayer H, Teller W, et al. Body composition in 5-18-y-old obese children and adolescents before and after weight reduction as assessed by deuterium dilution and bioelectrical impedance analysis. The American journal of clinical nutrition 1996;64(1):1-6.
14. National Institutes of Health Technology Assessment Conference Statement. Bioelectrical Impedance Analysis in Body Composition Measurement. 1994'. Available in: (ftp://public.nlm.nih.gov/hstat).
15. Segal KR, Van Loan M, Fitzgerald P1, Hodgdon JA, Van Itallie TB. Lean body mass estimation by bioelectrical impedance analysis: a four site cross-validation study. Am J Clin Nutr 1988:47:7-14.
16. McNeill G, Fowler PA, Maughan RJ, McGaw BA, Fuller MF, Gvozdanovic D, et al. Body fat in lean and overweight women estimated by six methods. British Journal of Nutrition 1991;65(02):95-103.
17. Van der Kooy K, Leenen R, Deurenberg P, Seidell JC, Weststrate JA, Hautvast JGAJ. Changes in fat free mass in obese subjects after weight loss: a comparative study. mt J Obes 1992;16:675-83.