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Regional body fat distribution assessment by bioelectrical impedance analysis and its correlation with anthropometric indices

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ABSTRACT

Objective: The purpose of this study is to assess the validity of Bioelectrical Impedance Analysis (BIA) to characterize the regional fat distribution among female and its correlation with anthropometric indices.

Materials and methods: The following indices were carried out: weight, height, body mass index (BMI), waist circumference (WC), hip circumference (HC), waist hip index (WC + HC) of random samples (209) of women (age, 32–85 years). The segmental body fat percentages were assessed by bioelectrical impedance analysis. Hand-to-Hand and Foot-to-Foot Body Analyzer devices were used to estimate upper and lower body fat percent (BF %), respectively. Upper and lower body fat measurements were used to calculate total body fat. Agreement between the variables was assessed by scatter plots.

Results: The plots of upper and lower percent body fat (BF %) against waist and hip circumferences revealed significant correlation values of ($r = 0.949$) and ($r = 0.942$), respectively. The total of upper and lower body fat ratios showed a stronger correlation with the BMI than those of severally. Weak to fear correlations between upper and lower body fat percent, with BMI were observed.

Conclusion: The results indicated that the BIA technique of estimating segmental body fat percent associated with the anthropometrical indices (WC, HC) has the potential to determine adiposity risk available for use in large epidemiological studies.

1. Introduction

Is bioelectrical impedance valid for using in large epidemiological studies? How accurate is bioelectrical impedance to measure body fat? These are most controversial questions in terms of the accurate measurement for percentage body fat which is strongly associated with the risk of several chronic diseases. Bioelectrical impedance analysis (BIA) is a relatively simple, quick and non-invasive technique to measure body composition. The common BIA devices that are used in the field or at home are hand-to-hand and foot-to-foot models, also referred to as segmental impedance analyzers. These devices are easy to use and require little to no technician/user experience. Furthermore, the BIA estimates total body fat by sending a low electrical current throughout the body using a four electrodes model. However, it measures body fat accurately in controlled clinical conditions but its performance in the field is inconsistent [1]. Due to this limitation, segmental BIA appears to have a potential for assessing the composition of body segments in children, as obtained using dual energy X-ray absorptiometry (DXA) [2]. The studies indicate that visceral fat (waist size) is more important in the disease process than subcutaneous fat or anywhere else in the body. The results indicate that the current clinical guidelines recommend using regional fat distribution instead of body mass index (BMI) for overweight and obesity which represent major risk factors for increased morbidity and mortality [3]. Hence, an obvious question that arises relates to whether these methods are valid in determining the regional body fat or not. Many anthropometric indices, such as waist circumference (WC), hip circumference (HC), have been widely used to predict total and regional body fat [4,5]. Probably, the most widely used method is measuring the waist circumference. There is a variety of techniques available to determine body fat ration using specific devices. The most accurate techniques involve underwater weighing, bioelectrical impedance analysis (BIA), computed tomography (CT) and DXA, but these are rarely used except for in scientific studies. However, the fundamental BIA method has advantages over anthropometry for measuring lower limb tissue composition in healthy individuals [6].

In light of the high needs for convenient methods to assess the body's composition in obesity and its suitability for use in daily clinical practice, and in view of the lack of a practical and low-cost method to

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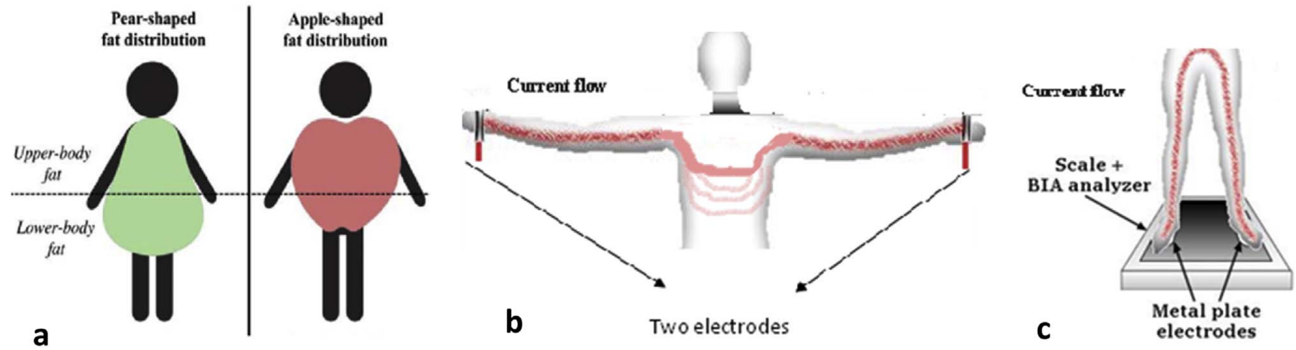

Fig. 1. (a) Body fat distribution, (b) hand - hand electrodes connection for upper limb, (c) leg - leg electrodes connection for lower limb.

verify the total distribution of fat in the body, it is important that such values are estimated by anthropometric Indices. Thus, the objective of the present study is to screen regional body fat using the method of the bioelectrical impedance analysis for the various body segments rather than simply that of the whole body as well as their correlations with WC and HC. The segmental approach is defined and located on the physical demarcation between both the leg to leg electrodes as a lower limb and the hand to hand electrodes as an upper limb as shown in Fig. 1.

2. Subjects and methods

2.1. Study design and ethics

A cross-sectional study was conducted on 209 women aged 32–85 years (the mean = 55.36), who will be called the subjects. The sample has been randomly chosen from women who had referred to 2 main city health centers for their periodic check-up. Because our subjects were not recruited on the basis of adiposity, they were a very heterogeneous population in terms of body composition. There was no pregnancy period and no specific medical problems reported in these subjects. Before taking the tests, all subjects had been informed that data would be used for a research. The subjects were completely conscious of the importance of precision of information during examination. The study protocol was approved by the Research Ethics Committee of the Teaching University Hospital (Azadi) for the University of Duhok.

2.2. Anthropometric measurements

All subjects have been instructed to takes off their shoes and heavy clothing items and remove all items from their pockets before being weighed. In the same way, we make sure that their hair styles do not affect accuracy of height measurement; body weight and height were measured to the nearest 0.1 kg using a digital weighing machine, and 0.1 cm using a graduated elastic tape, respectively. To assess fat distribution, waist circumference (WC) was measured at the midway point between the iliac crest and the lowest rib. Hip circumference (HC) was measured at the widest part of the buttocks to the nearest 0.1 cm [7] for calculating waist-to-hip ratio (WHR) by the simple division of WC/HC. World Health Organization (WHO) cut off points were used as follows: high risk (WC ≥ 80 cm), and very high risk (WC ≥ 88 cm) for females [7]. Hip and Waist circumference measurements were used to calculate waist to hip ratio (WHR) and waist hip index (WHI) which is obtained from (WC + HC).

2.3. Body fat measurements

Body Fat percent was assessed using two BIA devices. One of them is Omron HBF 306 BF analyzer hand-to-hand measurement was utilized for upper limb. The measurements have been carried out as follows: First, the required personal information such as age, gender, weight and height of a person is inputted, and then she grips the device handles (hand-to-hand). Electrodes in the hand sensor pads send a low and safe signal through the body and so BF content and BMI are automatically calculated in seconds. The other device is a body analyzer scale model (BA 833, ADE Fitness, and Germany) foot-to-foot or leg-to-leg. Based on this BIA device measures impedance across the lower limbs and the four electrodes are in the form of stainless steel foot pads mounted on the top surface of platform scale. While the subject stands barefoot on the scale for simultaneous of body weight and impedance and meanwhile with manual inputting of the subject's gender and height into the system via a digital keyboard, the subject's percentage body fat is displayed immediately.

2.4. Statistical analysis

All data were analyzed using the Statistical Package for Social Science (SPSS 20) windows on a PC compatible computer. Descriptive data were expressed with use of standard deviations as means ± standard deviation (mean ± SD) values. Pearson correlation analysis was done to see the linear relationship between anthropometric variables and segmental body fat obtained by BIA. The results were drawn by scatter plots. Furthermore, subjects were classified according to our definition of BMI categories using WHO criteria as illustrated in Table 1.

3. Results

Complete descriptive statistics information on anthropometric measures and questionnaire data for 209 women were summarized as shown in Table 2. Most of subjects are elderly with an average age of 55.36 ± 10.57 and have large waist and hip circumference (106.33 ± 12.29) cm, (109.16 ± 11.29) cm, respectively and highest values of measuring BF% (leg-to-leg 46.56 ± 9.95) as well as (hand-to-hand 43.46 ± 8.49). However, nearly half are categorized in obese class I.

Table 3 shows the correlation coefficient between the anthropometric and segmental body fat percent variables in the total population. WC and HC were strongly correlated with measures of upper BF% (H-H)

Table 1
Number of subjects in different body mass index (BMI) groups (using standard BMI cut-offs).

BMI group	No.
Undernourished (< 18.5)	–
Normal (18.5–24.9)	26
Pre-obese (25–29.9)	48
Obese class I (30–34.9)	91
Obese class II (35–39.9)	31
Obese class III > 40	13
Total	209