Comparison of body fat in Brazilian adult females by bioelectrical impedance analysis

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Comparison of body fat in Brazilian adult females by bioelectrical impedance analysis

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Abstract. Body-fat is essential for human body, provided that its amount is at healthy levels. If in-excess body-fat is deleterious, its lack is otherwise also harmful. Estimated percent body-fat performed with commercially available devices measuring bioimpedance have many advantages, such as easy measurement and low cost. However, these measurements are based on standard models and equations that are not disclosed by manufacturers, and this leads to questioning the validity of these estimates for Brazilian females. The aim of this study was to compare electrical tetrapolar and octapolar impedance results obtained with commercially available equipment: Maltron BF-906 and OMRON 510-W. Data analysis involved descriptive and inferential statistics. Devices used in this study to estimate body fat quantity have not shown any significant differences in results; this is a major issue when selecting equipment based on three factors: study focus, available financial resources, and target population. Results obtained from the two devices have not shown any significant differences, which lead to the conclusion that either device may be reliably used.

1. Introduction
Assessment of body composition is the focus of sciences in the search for the ideal human body composition; however, to date there is not an absolute standard parameter for this “ideal body” both for males and females [1]. The Body Mass Index (BMI) valid for adults above 20 years old, also known as Quetelet’s index, is accepted by the World Health Organization as the official index for calculation of obesity [2], even though this index does not show body composition related to body fat rate.

Among the existing methods to assess body composition, the direct method is the most accurate one, though impracticable, as it requires dissection of the body, and is therefore used for research only. Indirect methods may be mentioned where there is no separate handling of components, but the application of chemical-physical principles to estimate fat and lean mass quantity such as the chemical methods, namely the radioactive potassium count (K40 and K42), deuterium oxide dilution, and urine creatinine clearance, in addition to ultrasound, X-rays, computed tomography, nuclear magnetic resonance, and densitometry [3]. The less precise but easily performed double-indirect methods are the ones routinely used, such as the skinfold measurement or the anthropometric technique, near infrared interactance, and bioimpedance or bioelectrical impedance, validated from indirect methods [4].
Bioelectrical Impedance

Owing to their low operating costs and relatively simple use, the double-indirect methods have been preferably used by Physical Education, Nutrition, and Medicine area professionals. Bioimpedancemetry or bioelectrical impedance (BIA) is an easy, low-cost, non-invasive method, not requiring skilled operator, which may be used in any patient [5]. There is a wide range of commercially available devices to measure bioimpedance, which vary depending on the segment, number, type and location of electrodes used [6]. Among these devices, the tetrapolar one with four electrodes, two of which placed on upper limbs and two on the lower limbs at the right-side of the body in order to measure all body segments, has been validated by several scientific studies and is widely used in clinical practice [7,8]. In addition to the tetrapolar, there are devices that use bipolar, scale-type, foot-to-foot measurement techniques with a metal plate as electrode, but that measure the lower body segment only. Hand-to-hand bipolar devices, also with electrodes, measure specifically the upper segment. More recently, devices called octapolar, with eight body contact points through plates are available. Nevertheless, results are frequently discrepant [9-12], due to methodological differences as for target populations, devices used, and different data collection methodologies [13]. For this reason, more research is required to test the different devices in the market and specificity of their predictive equations for different populations, in order to obtain evidences on result validity, accuracy, and reliability [14]. With this in mind, this trial evaluated two percent body fat measurement techniques in menacone females. The tetrapolar electrical bioimpedance has been first evaluated by using BIA (hands and feet) and then percent fat results (%BF) obtained with octapolar electrical bioimpedance have been compared.

1.1.1. Preliminary:

Human body may be thought as a cylinder divided into five smaller cylinders full of fluids and with electric activity. Biological tissues act as current conductors or isolators, and this current applied to the body will tend to follow the lowest-resistance pathway.

- Tetrapolar method is based on the measurement of total body endurance to the passage of an electric current [15]. This method is considered as the standard in BIA but it does not define body fat distribution, which is of major relevance due to the several changes in lipid profile observed in its distribution in viscera.
- Octapolar: The full-body method calculates the percent fat through segmental measurements, by measuring individual values for arms and legs plus body. For such, eight surface electrodes are used to measure weight, BMI, %BF, percent viscera fat, and percent muscle mass.

Main characteristics of both devices are shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Device characteristics.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Device</strong></td>
</tr>
<tr>
<td>Frequency [Hz]</td>
</tr>
<tr>
<td>Current [µA]</td>
</tr>
<tr>
<td>Technique</td>
</tr>
<tr>
<td>Variable</td>
</tr>
</tbody>
</table>

2. Method

2.1. Subjects
A total of 55 volunteer healthy females not on any medications that might affect the results were enrolled to participate in this study. Each signed the informed consent form of IRB’s process 134/2011 protocol CAAE: 0134.0.237/000-11. Previously to the tests, personal data and anthropometric measures were recorded and results are shown in Table 2.

Table 2. Sample characteristics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>35.8</td>
<td>11.1</td>
<td>13</td>
<td>55</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>72.7</td>
<td>16.0</td>
<td>40.8</td>
<td>121.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>159.3</td>
<td>6.0</td>
<td>146</td>
<td>175</td>
</tr>
<tr>
<td>BMI</td>
<td>28.6</td>
<td>5.7</td>
<td>15.4</td>
<td>45.3</td>
</tr>
</tbody>
</table>

2.2. Materials

- Matron tetrapolar bioimpedance apparatus, model BF-906 (Maltron, UK), with placement of adhesive electrodes in silver solution gel as follows: right foot, distal electrode at middle toe base and proximal electrode between middle and side malleoli, and for right hand, distal electrode on middle finger base and proximal electrode matching styloid process. Above 5-cm distance was kept between electrodes, with the subject lying supine with right foot and hand slightly apart from the body.
- Omron octapolar bioimpedance apparatus, model HBF-510W (Omron Inc., USA), with the subject standing up with two plate electrodes attached to the hands and two electrodes to the feet.
- A 300 kg x 100g scale (Balman, Brazil) was used to determine subject body mass and height.
- Portable estadiometer (Balman, Brazil) accurate to 1.0mm, respectively.
- Data collected was recorded in proper form and tabulated in a worksheet prepared by the author using MS-Excel (Microsoft, USA).
- Correlation analysis as well as t-Student test were applied to results for statistical analysis.

2.3. Experimental Protocol

Bioimpedance measurements were carried out once with each apparatus, first lying down, in supine position on a stretcher following a 5-minute rest. Before placement of electrodes on the subject skin, a 70% alcohol solution was applied and then measurement with tetrapolar device was carried out. Following tetrapolar data collection, subjects undergone measurement with octapolar device standing up and contacting the device’s eight metal plates.

3. Results

Table 3 shows the results of percent body fat estimate provided by the devices used in this trial. These values are the result of the pooled sample analysis (n=55) with mean, standard deviation, maximum and minimum values calculated for each equipment.

Table 3. Measurement results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrapolar</td>
<td>37.0</td>
<td>7.9</td>
<td>14</td>
<td>52.3</td>
</tr>
<tr>
<td>Octapolar</td>
<td>38.2</td>
<td>8.1</td>
<td>14.4</td>
<td>54.8</td>
</tr>
</tbody>
</table>

Figure 1 shows regression analysis between standard equipment (Maltron) and target equipment (Octa) indicating high correlation r=0.92 for p<0.05 with n=55.
4. Discussion

Tetrapolar equipment has been chosen as standard in this trial based on scientific papers [7,8].

Another study argues that bioimpedance measurement equipment vary based on the segment under analysis, however, other factors have been analyzed in this study such as number, type and location of electrodes used to measure percent body fat [6].

The comparison of equipment results is also important due to the differences in the price of the devices, as the tetrapolar is much more expensive (almost fivefold) than the octapolar one. Are these devices so different in their results? May cheaper equipment be used in clinical practice?

Correlation values obtained indicate a correlation deemed as high \( r = 0.92 \) for \( p < 0.05 \). Error estimation obtained from a data longitudinal analysis showed that the volunteers with higher measurement values were measured with lower error by Maltron equipment as they presented with higher body fat quantity at the lower body segment. Volunteers with lower measurement values showed higher conformance and lower error with octapolar equipment.

5. Conclusion

Anthropometric measures are essential for the evaluation of clinical treatment progress. The body composition evaluation method based on bioimpedance shows to be effective in clinical follow-up. Devices used in this trial to estimate body fat quantity have now shown significant differences in results; this issue is important when choosing the equipment based on three factors: study focus, available financial resources, and target population. Results obtained from the two devices have not shown any significant differences, which leads to the conclusion that either device may be reliably used.

Figure 1. Correlation analysis between Tetra and Octa
References

[1] Ozenoglu, A; Ugurlu, S; Can, G; Hatemi, H. 2009. Reference values of body composition for adult females who are classified as normal weight, overweight or obese according to body mass index. Endocrine Regulations, v.43, p.29-37.


