Accuracy of Body Fat Assessment by Bioelectrical Impedance in Japanese Middle-Aged and Older People

Takahiro MITSUI1, Kiyoshi SHIMAOKA1-8, Shigeki TSUZUKI2, Taeko KAJOKA3 and Hisataka SAKAKIBARA4

1 Research Center of Health, Physical Fitness and Sports, Nagoya University, Furocho, Chikusa-ku, Nagoya, 464–8601, Japan
2 Body Design Medical Institute Japan, 1–15–87B, Masaki, Naka-ku, Nagoya, 460–0024, Japan
3 Department of Health Science, Faculty of Educational and Physical Science, Aichi Gakuin University, 12, Araike, Iwasaki-cho, Nisshin, Aichi 470–0195, Japan
4 Department of Health Sciences, School of Medicine, Nagoya University, 1–1–20, Daiko Minami, Higashi-ku, Nagoya 461–8673, Japan

(Rceived December 2, 2005)

Summary Bioelectrical impedance analysis (BIA) is commonly used to measure the percentage of body fat (%BF), but its accuracy is controversial. In addition, the equations are specific to the group for which they were established. As far as we know, there is no study examining the accuracy of BIA in Japanese middle-aged and older people. We compared %BF assessed using BIA with that of dual-energy X-ray absorptiometry (DEXA) in 102 female and 51 male local residents aged 40 to 78 y. Simple correlation coefficients were 0.79 for females and 0.69 for males, which are statistically significant ($p<0.001$). However, BIA tended to overestimate %BF in the lower BF group and underestimated it in the BF higher group, and only 45.1% for female and 47.1% for male subjects were measured accurately, i.e., within 10% of the measurement by DEXA. This result suggests that this model of BIA is an alternative for estimating %BF in Japanese middle-aged and older people as well as when subjects are within a normal body fat range, but greater accuracy is needed for lean and overweight subjects.

Key Words body fat, bioelectrical impedance analysis, dual-energy X-ray absorptiometry, Japanese middle-aged and older people

Assessment of percentage of body fat (%BF) is widely performed in various situations such as medical clinics, fitness clubs, and residential homes. The underwater weighing method has been used as a traditional standard, but this method can be difficult for older people and is not suitable for field studies. Air-displacement plethysmography and dual-energy X-ray absorptiometry (DEXA) are two relatively new reference methods. However, use of these methods is limited by inaccessibility and high cost. Therefore, simple methods such as bioelectrical impedance analysis (BIA) and skinfold-thickness measurements are most commonly used in field studies and for public use (1–4). The skinfold-thickness measurement, a traditional alternative method, is based on the underwater weighing method, but it has less precision than other methods because this method is largely dependent on operator technique. On the other hand, the precision of the BIA method is controversial. Several studies have compared the precisions of %BF assessed using BIA and reference methods. Some studies showed that BIA overestimates %BF (5, 6), and others suggested that BIA underestimates %BF (7, 8). Some studies showed a good relationship between BIA and DEXA (9, 10), whereas others indicate that the BIA method lacks accuracy (11, 12). In addition, the equations used in BIA are population-specific and only appropriate for the group for which the equations were established. Most of studies examining the accuracy of %BF assessed using BIA have targeted Western people. As far as we know, there is only one study examining the accuracy of BIA in Japanese, using female college students (7). In this study, we compared %BF using BIA and DEXA in middle-aged and older people in Japan.

Methods Participants and measurement of %BF This study is a part of a long-term project examining the effects of daily exercise on future medical costs. This project is approved by a local ethics committee, and written informed consent was obtained from all participants. One-hundred two female and 51 male apparently healthy middle-aged and older local residents who responded to a public announcement of this project participated in this study. The ages, heights, body weights, and BMI are shown in Table 1. A foot-to-foot bioelectrical impedance analyzer (BIA, TBF-210, Tanita...
Body Fat Assessment by BIA in Japanese

155

Co., Tokyo, Japan) was used to measure body weight and %BF. These results were compared with the %BF assessed using DEXA (DPX-L, GE LUNAR, Madison, WI, USA) equipped with software version 1.2 and 1.3. These procedures were conducted consecutively in a local public hospital. The participants had fasted more than 3 h and wore a thin hospital gown with bare feet.

Data analysis. Simple correlation coefficients were calculated between %BF by BIA and DEXA. The difference in %BF between BIA and DEXA obtained for each group was divided by the %BF assessed by DEXA in the lower (<25%), middle (between 25% and 75%), and higher (>75%) percentiles. In addition, the difference in %BF between BIA and DEXA was classified by age, namely younger, middle, and older, in the female group in the same manner. Because the age range of the older male group was relatively small (approximately 10 y), the %BF difference between BIA and DEXA was not classified by age in the male group. We further evaluated the accuracy of the %BF difference between BIA and DEXA as good (<10%), acceptable (between 10% and 20%), or poor (>20%).

Results
The simple correlation coefficients between %BF measured using BIA and DEXA were 0.79 for females and 0.69 for males, which were both statistically significant (p<0.001). Figure 1 shows the difference in %BF between BIA and DEXA classified by 25th and 75th percentiles for distribution assessed using DEXA were as follows: the lower female %BF is 26.8±5.5% (n=26), the middle is 35.3±1.9% (n=51), and the higher is 41.7±2.0% (n=25); the lower male %BF is 15.3±1.9% (n=13), the middle is 21.1±1.8% (n=26), and the higher is 27.8±2.4% (n=12). Vertical bars represent SDs.

Figure 2. The difference in %BF between BIA and DEXA classified by 25th and 75th percentiles for distribution by age of the female participants were as follows: the younger group is 52.8±5.8% (n=26), the middle 61.4±3.6% (n=51), and the older 73.7±1.4% (n=25). Vertical bars represent SDs.

Table 1. The number, age, and physical characteristics of the participants.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Age (y)</th>
<th>Height (cm)</th>
<th>Body weight (kg)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>102</td>
<td>63.6±8.4</td>
<td>152.6±5.8</td>
<td>56.8±7.7</td>
<td>24.4±2.4</td>
</tr>
<tr>
<td>Male</td>
<td>51</td>
<td>72.8±2.3</td>
<td>162.8±6.2</td>
<td>61.2±8.8</td>
<td>21.2±4.8</td>
</tr>
</tbody>
</table>

All data are expressed as mean±SD.

Discussion
Recently, Sun et al. (13) published a comprehensive study examining the accuracy of BIA. They compared
%BF assessed using BIA with that of DEXA of 591 healthy adults aged 19 to 60 y. They obtained significant relationships between these two methods, 0.85 for women and 0.78 for men, and concluded that BIA is a good alternative when subjects are within a normal body fat range. However, BIA tended to overestimate %BF in lean subjects and underestimate it in overweight subjects. We also obtained statistically significant correlation coefficients, 0.79 for females and 0.69 for males, and observed that BIA tended to overestimate %BF in the lower %BF group and underestimate it in the higher %BF group. The largest difference in the middle age group (64.1±3.6 y) was probably because %BF usually increases with aging up to 60 y and gradually decreases after 70 y (14).

Unfortunately, only 45.1% of female and 47.1% of male subjects measured were within 10% of the DEXA percentage. The error in comparison with the reference method is more important than the correlation coefficient in examining alternative methods. Our less-accurate result than that of Sun et al. is probably because we used a foot-to-foot type BIA. They used a four-electrode BIA (QuadScan 4000; Bodystat, Douglas, UK), which measures the subjects in a supine position on a flat bed. Differences in sensitivity among the models of BIA for academic and home use might be a possible cause of the great discrepancy in the accuracy of BIA among researchers.

Our results suggest that this model of BIA is an alternative for estimating %BF in Japanese middle-aged and older people as well as when subjects are within a normal body fat range, but greater accuracy is needed for lean and overweight subjects. In middle-aged and older women, BIA will tend to underestimate %BF because they have relatively higher BF.

Acknowledgments

The authors would like to thank the public nurses of Yokkaichi City for technical assistance.

REFERENCES