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Consuming a low-calorie amount of routine food and drink does not affect bioimpedance body fat percentage in healthy individuals

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ABSTRACT

Objectives: Bioimpedance analysis is a simple, safe, and relatively inexpensive method to assess body composition. The bioimpedance guidelines recommend that the test be performed after fasting and avoiding the consumption of liquids. Studies have verified the effects of consuming liquids and food on bioimpedance; however, these studies used preestablished meals and hydration. The aim of the present study is to identify whether ad libitum food and liquid intake interfere with body composition parameters estimated via bioimpedance.

Methods: The evaluations were carried out over 2 d. On the first d, the hydration protocol was applied and on the second d, the food protocol. In both cases, bioimpedance was performed after an 8-h overnight fast. The test was repeated 30 min after the intake of liquids or food depending on the protocol. The reproducibility between the pre- and posttest evaluations was assessed using the Bland–Altman method. We considered deviations of up to 5% in the limits of agreement to be clinically acceptable.

Results: In the hydration protocol, the mean difference in fat percentage (FP) was −0.50 ($P = 0.05$), the lower limit of agreement was −3.60%, and the upper limit of agreement was 2.61%. In the food protocol, the mean difference in FP was 0.002 ($P = 0.99$), the lower limit of agreement was −3.20%, and the upper limit of agreement was 3.20%.

Conclusions: Our study shows that ad libitum food and liquid intake do not cause a change above clinically acceptable levels in the FP estimated by bioimpedance.

Introduction

Bioelectrical impedance analysis (BIA) is a safe, simple, reproducible, inexpensive, and portable method to assess body composition [1]. BIA assesses body composition indirectly using a low-intensity and low-frequency electrical current. The direct measures assessed by BIA are resistance, reactance, and phase angle. Based on these data, body hydration can be calculated. Based on body hydration, assuming that lean mass contains practically all of the water and conductor electrolytes in the body and that 73% of lean mass is formed from water, fat mass and fat-free mass can be estimated. One of the main limitations of BIA is caused by factors linked to changes in body hydration [2]. Therefore, one of the main limitations of using bioimpedance for clinical practice is the recommendation not to consume liquids and solids for 4 h to 8 h, depending on the guideline, before the examination [3,4]. These recommendations limit the performance of the examination in most clinical practice settings. These recommendations emerged from a series of studies with a population that is not generalizable, specific foods or liquids were consumed, and different cutoff points were used for important clinical difference and outcome assessment times.

Initial studies conducted on young, healthy individuals identified a decrease in body impedance with the consumption of meat broth [5] and orange juice [6], and a decrease in resistance was verified in athletic adults with the consumption of water, isotonic, or hypertonic [7]. An increase in the fat percentage (FP) of physically active adults was verified with water or an electrolytic drink, despite the variations not considered clinically significant [8,9]. In athletes, the consumption of food rich in both carbohydrates and fat causes an overestimation of FP [10]. In healthy adults, over- and underestimations of FP with food [11,12] and water [13] have

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already been demonstrated. On the other hand, two studies failed to find a clinically significant difference with the consumption of food in older men [14], or with water, a sports drink, or food in adults [15]. Finally, in patients with cystic fibrosis, consuming carbohydrates with water left the limits of agreement, analyzed using the Bland–Altman method, above clinically acceptable levels, but the authors argued that the variation in most patients was within clinically acceptable limits [16]. In addition, the studies did not include participants from all life cycles, which limits the generalizability of the results.

In studies conducted to date, the consumption of foods and liquids has been controlled and may not reflect subjects' normal diet. Therefore, the aim of this study is to evaluate the effect of consuming routine food and drinks on FP measurements in healthy individuals from different age groups.

Methods

Study design

A cross-sectional study was conducted, and the protocols to evaluate the effects of hydration and food on BIA parameters were carried out over 2 collection d. The hydration protocol was carried out on the first d and the food protocol was used in the second meeting (Fig. 1). Participants were free to choose what they wanted to eat and drink at each visit of the study according to their habits. Thus, the researchers did not interfere with their choice of food or liquids.

Participants

Healthy children age ≥8 y, adults, and older subjects took part in the study, and were recruited using convenience sampling. The data were collected in the city of Porto Alegre in Brazil. Participants were considered healthy if they reported not being diagnosed with a chronic disease or not using continuous medication. The exclusion criteria were the presence of diseases that affected the electrical resistance of the skin, pregnant women, subjects with a cardiac pacemaker or cardioverter defibrillator, and amputees or people who used prostheses/orthoses.

Data collected

The anthropometric measures calculated included height and body mass per the international standards for anthropometric evaluations. Height was evaluated using a metal stadiometer (Cescorf, Brazil) attached to a vertical bar. Individuals were instructed to remain barefooted with their arms along their bodies and their heads in the Frankfort horizontal plane. Body mass was evaluated using a 200 kg capacity and 100 g precision calibrated digital balance (Charder MS6121 model, Brazil), wearing the least amount of clothing possible and no shoes or metal objects on the body. Using the body mass and height values, the body mass index was calculated based on the formula weight (kg)/height^2 (m^2).

The bioelectrical impedance analysis was carried out using a portable device, the multifrequency InBodyS10 (InBody USA; Cerritos, CA) per the manufacturer's guidelines. The electrodes were placed at 8 precise tactile points on the body to achieve a segmented analysis frequency. A total of 30 impedance measurements were obtained using six different frequencies: 1, 5, 50, 250, 500, and 1000 kHz. These were used in the following five body segments: right and left arms, trunk, and right and left legs. The BIA was carried out with the participants lying down in the dorsal decubitus position on a non-conductive surface, with their legs apart and arms away from their bodies, wearing the least amount of clothing and no metal jewelry.

The anthropometric and BIA calculations were made by three evaluators trained to carry out the techniques. All participants received instructions on preparing for the BIA test and were told to consume at least 2000 mL of water on the day before collection. Participants fasted overnight (8 h) before the BIA, and were asked to urinate before being weighed. Next, their height was measured and the BIA test was conducted. After the baseline BIA, participants were told to consume liquids (chosen freely, according to their personal habits), and the BIA was repeated after 30 min. The type of liquid and quantity consumed were recorded.

In the food protocol, after the first BIA measurement, participants consumed a routine meal, and the BIA was repeated after 30 min. The quantity and type of food consumed were recorded, and energy and micronutrient quantities in percentages of energy quantity (carbohydrates, lipids, and proteins) were calculated. The Dietbox nutrition software was used for calculation purposes [17].

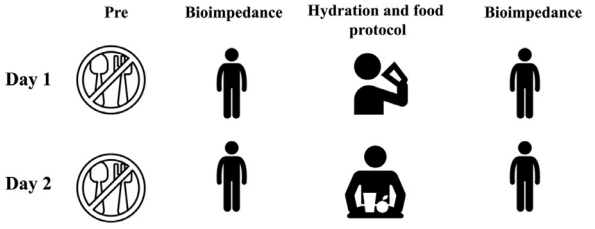

Fig. 1. Hydration and food protocol.

Statistical analysis

The results are presented as absolute and relative frequency, mean ± standard deviation, or median (interquartile range) according to the symmetry of the variables. A paired *t* test was used to compare means differences in FP between before and after the intervention. The reproducibility and effect of the interventions studied were evaluated using the Bland–Altman model. We considered a deviation of up to 5% in the 95% limit of agreement clinically acceptable (relative bias within 1.96 × standard deviation) [18]. Intraclass correlation coefficient (ICC) was used for the reliability analysis. The data were analyzed using R software, version 3.5.3. Results with $P < 0.05$ were considered significant.

The study was approved by the ethics committee at the Catholic Pontifical University of Rio Grande do Sul in Brazil (CAAE: 62912616.7.0000.5336). Informed consent was obtained from the parents of pediatric participants.

Results

The sample was composed of 43 volunteers, 24 (55.8%) of whom were male, with a mean age of 30.3 ± 13.6 y. The mean body mass index was 24.1 ± 3.8 kg/m^2. The mean liquid intake was 277 ± 114 mL, and the mean calorie intake was 199 ± 141 kcal. The mean macronutrient intake was 59% carbohydrates, 14% proteins, and 28% lipids (Table 1).

Mean FP before the hydration protocol (21.94% ± 9.43%) and before the feeding protocol (22.43% ± 8.9%) did not show significant differences ($P = 0.190$). In relation to reproducibility for the baseline measurement, the mean difference in FP was −0.49 (95% confidence interval [CI], −1.25 to 0.26; $P = 0.19$). The lower limit of agreement was −4.72 (95% CI, −6.02 to −3.42), and the upper limit was 3.73 (95% CI, 2.43–5.03). The ICC was 0.986 (95% CI, 0.97–0.99; $P < 0.001$).

In the hydration protocol, averages of the percentage of fat before (21.59% ± 9.60%) and after the hydration protocol (22.09% ± 9.53%) did not present significant differences ($P = 0.05$). In relation to reproducibility, the mean difference in FP was −0.50 (95% CI, −0.98 to −0.01; $P = 0.05$). The lower limit of agreement was −3.60 (95% CI, −4.44 to −2.76), and the upper limit was 2.61 (95% CI, 1.77–3.45). The ICC was 0.993 (95% CI, 0.98–0.99; $P < 0.001$).

In the food protocol, averages of the percentage of fat before (23.21% ± 8.72%) and after (23.21% ± 8.86%) the feeding protocol, and did not present significant differences ($P = 0.99$). In relation to reproducibility, the mean difference in FP was 0.002 (95% CI, −0.51 to 0.51; $P = 0.99$). The lower limit of agreement was −3.20 (95% CI, −4.08 to −2.32), and the upper limit was 3.20 (95% CI, 2.32–4.07). The ICC was 0. 991 (95% CI, 0.98–0.99; $P < 0.001$).

Table 1
Sample characteristics

Variables	n = 43
Age, y	30.3 ± 13.6
Sex, male, n (%)	24 (55.8)
Income, R$, n (%)	
<1575	10 (21.7)
1576–3152	7 (15.2)
>3153	29 (43.9)
Body mass index, kg/m^2	24.1 ± 3.8
Liquid intake, mL	277 ± 114
Food intake, kcal	199 ± 141

Data presented in mean ± standard deviation

Discussion

This study aimed to evaluate the effect of consuming food and drinks on the body FP assessed by a bioelectrical impedance device using a single frequency in healthy individuals. The data suggest that consuming routine food and drinks in the morning of approximately 199 ± 141 kcal does not interfere in the FP calculated using bioelectrical impedance. According to the international guidelines, the bioimpedance test is recommended to be conducted after food and liquid fasting, including alcoholic drinks, for 8 h [3]. Moreover, initial studies in the literature report that any consumption of food or drinks up to 4 h before the analysis causes alterations. The studies present a mean variation in impedance parameters of 4 to 15 Ω during a period of 3 h to 4 h after meals [19,20]. Some studies have shown an increase in FP after food consumption; however, these studies have used different times (20, 40, and 60 min), different BIA equipment (segmented, multifrequency [12], and leg [12,15]), and a higher food intake (919 kcal [12] and 869 kcal [15]) than in our study.

Previous studies [11,14] have evaluated the effects of food on body composition parameters using BIA in healthy individuals, one of which was carried out in older subjects [14]. Slinde and Rossander-Hulthen [11] found a reduction in impedance values (−18 Ω) and body FP (−2%) from 2 h to 4 h after a mean intake of 652 kcal. Vilaca et al. [14], in turn, showed a reduction in fat mass (−0.05 kg) 1 h after a standardized 299 kcal meal in the morning. However, alterations in fat mass <2 kg cannot be visualized owing to limitations in the equipment, but this occurs with older equipment [21].

One possible explanation for our results being different from the other studies is the lower intake of food consumed by the participants in our study. Meals with around 300 to 600 kcal appear not to influence FP. However, another study used a greater food intake than ours (around 900 kcal). Measures were taken after fasting and 20 min after food intake, using three different pieces of equipment (leg-to-leg, segmented, and multifrequency). The results (leg-to-leg: 0.9%; segmented: 1.7%; and multifrequency: 0.8%; $P < 0.05$) presented a reduction in body mass (60–80 g) and increase in impedance (4–9 Ω), leading to a slight increase in FP (0.3%–0.7%) [12]. Slinde and Rossander-Hulthen [11] evaluated impedance 18 times over 24 h in 18 healthy individuals, standardizing three meals (breakfast, lunch, and dinner). Impedance decreased after the consumption of a standard meal. Body FP varied 8.8% from the highest to the lowest measure in women and 9.9% from the highest to the lowest measure in men.

Our results show that consuming a mean of 277 mL of liquid does not generate an alteration in FP. Gomez et al. [7] verified that the volume and type of liquid can influence impedance values given that resistance increased immediately after consuming 1200 mL of water or hypotonic drink or isotonic solution, remaining high for up to 90 min after consuming the liquid. However, with regard to body composition, FP increased only slightly (by approximately 0.5%).

Most potentially clinical body composition methods involve a degree of imprecision in the analyses [22]. The evidence of changes in body composition studied based on bioelectrical impedance derived from the consumption of foods and drinks, both in high- and low-calorie concentrations and volumes [15], is within the imprecision limits for bioimpedance and other body composition analysis methods, suggesting that the effect of consuming foods and drinks is insignificant and should not impede the use of electrical impedance to estimate body fat in most clinical applications. Nonetheless, in our study, the reproducibility values of FP, both in the hydration and food protocols, were within the clinically acceptable 5% limits of agreement.

Conclusions

Although standardized fasting conditions to evaluate bioelectrical impedance are ideal, this study suggests that evaluating FP based on BIA does not require strict adherence to fasting; thus increasing the opportunities for clinical application.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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