Selection of Sex Does Not Affect Body Composition When Using the InBody770 Bioelectrical Impedance Analysis

Original Research

D.J. Oberlin[1], Adam Mohan[1], Yea Been Kim[2], Levi Vazquez[1], Jane Ekhtman[3]

[1]*City University of New York, Lehman College, Bronx, NY/United States of America.*
[2]*Sungshin Women's University, Seoul / South Korea.*
[3]*City University of New York, City College, New York, NY/United States of America.*

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Abstract

Introduction: Many methods and equations for assessing body composition include sex as a variable. However, sex and gender identity do not always align. Thus, it would be beneficial to have easily performed methods of measuring body composition that did not rely on sex as a component of the assessment. For this purpose, the current study tested whether the InBody770 requires sex input to accurately measure body composition in males and females.

Methods: Cisgender men and women were recruited to the study to have their body composition assessed in duplicate. Assessments were performed in a random order. ANOVAs were performed on the data reported from the InBody770 both within subjects and between groups.

Results: There were no within subject differences for percent body fat (33.6 vs. 33.5 and 15.1 vs. 15.1%), estimated basal metabolic rate (1,438 vs. 1,440 and 1,842 vs. 1,842kcals/day), nor total body water (36.15 vs. 36.24 and 49.89 vs. 49.92 L) regardless of whether their sex was assigned as male or female. There were significant sex differences for percent body fat (33.5 vs. 15.1%), metabolic rate (1,438 vs. 1,842kcals), and total body water (36.15 vs. 49.92L regardless of how the individuals were identified (male or female).

Conclusions: While average sex differences in percent body fat existed between males and females, the imputation of sex on the InBody770 did not influence the data produced.

Key Words: Gender, Body fat, BIA.

Corresponding author: DJ Oberlin, douglas.oberlin@lehman.cuny.edu

Introduction

Body composition is an important component of health and fitness, which many individuals are interested in knowing for the purposes of athletics, aesthetics, or health. The simplest approaches to body composition divide the body into fat mass and fat-free mass, then report the proportion of body mass which is accounted for by fat (percent body fat (%BF)) [1]. Hence, this parameter is frequently assessed but must be interpreted in terms of both age and sex. Sex, in particular, affects the interpretation of body composition with differing ranges of what is considered to be healthy and safe for males and females [2]. This raises questions of how to approach body composition measurement and interpretation if an individual's sex and gender are not aligned.

The concepts of sex and gender are related but are not equivalent. Sex describes biological concepts such as chromosomes, gametes, anatomical features of the body, and hormonal profiles [3-5]. Gender, on the other hand, relates to how individuals self-identify and interact with others within a society [4,6,7]. A thorough review of these topics is beyond the scope of this paper; however, it is important to distinguish between these related concepts when discussing physiologic differences observed between groups of people based on biological sex.

While it is important to understand that sex and gender may not necessarily align, it is also important to acknowledge the sex differences that exist when comparing physical traits. One physical trait with observed differences between males and females is average body composition [8,9]. Following puberty, on average, males will have a lower percent of their total body mass which is composed of adipose tissue when compared to females of a similar age [10,11]. This is related to differences in hormonal concentrations between the sexes that occurs at this time [11]. However, there are individuals whose hormonal profiles are not within normally assumed age/sex ranges [12-14]. These differences may influence body composition and may become confounding depending upon the techniques and equations being utilized, particularly if assumptions are included based on sex.

There are many ways to assess body composition in living humans [1,15,16]. Advanced techniques, such as magnetic resonance imaging (MRI) or dual energy x-ray absorptiometry (DEXA), are precise and reproducible methods which can be used to assess body composition [1]. However, these techniques require expensive equipment and trained personnel [1]. Therefore, gyms and fitness centers have generally had to rely on more attainable techniques, such as skinfold thickness [15-17]. Unfortunately, methods like skinfold thickness can be less reliable, particularly if not consistently performed by a trained individual, or if different equations are used in the calculation of %BF [16,18,19]. Thus, as technologies have improved in measuring body composition, skinfold thickness measurements have fallen out of favor [19]. One such technology that is still reasonably attainable and accurate is bioelectrical impedance analysis (BIA) [20]. There are many devices that can utilize BIA, from those used in medical and research practice, to common bathroom scales, however their quality varies [20].

The accuracy of BIA for body composition depends upon several elements, including: number of electrodes, number of frequencies of electrical currents, the mathematical formulas being performed to analyze impedance, and overall participant compliance [20]. A greater number of electrodes, or points of contact with the body, allow for an assessment of a larger portion of the body's volume [15,20,21]. In addition, taking advantage of multiple frequencies helps to better detect differences in body composition, particularly with respect to total body water [15,21,22]. The cooperation of participants always has the potential to become a confounding variable in assessment, and BIA is no exception [23]. Finally, the electrical impedance measured by BIA is used to calculate a %BF [20,22]. Equations vary based on how the BIA is performed, the population being assessed, and the piece of equipment being used [21]. The accuracy of the BIA will depend upon all of these factors. Despite these caveats, BIA has become a reliable tool utilized in a variety of settings. In particular, the InBody770, a popular BIA, has been shown to have reliable assessments of body composition [23,24].

The purpose of the current study was to determine whether the imputation of sex on the InBody770 BIA influences outcomes for participants. This is relevant for anyone whose sex assigned at birth and gender identity do not align, or individuals who do not want to disclose their sex or gender identity. If imputation of sex does not affect data outcomes, the equipment can be reliably used regardless of gender identity. This is important for accuracy and respecting clients, as well as to make fitness centers, gyms, clinics, etc. inviting and inclusive environments. It was hypothesized that the sex selection on the InBody770 would not influence the outcome measures.

Methods

Participants

To test whether the selection of sex on the InBody770 affected BIA results, 22 participants were recruited from around the New York City metropolitan area. Individuals were screened using an online questionnaire to determine their age, sex, physical activity level, and general health status. Individuals met eligibility criteria if they were between the ages of 25 and 45 and were considered generally healthy/active. All participants were cis gender, meaning that their gender corresponds to their sex assigned at birth. To ensure participants were healthy/active, they were required to pass the Physical Activity Readiness Questionnaire (PARQ+) and accumulate an average of >500 MET minutes per week of physical activity based on the International Physical Activity Questionnaire (IPAQ). Those participants who met inclusion criteria then gave written informed consent. All study procedures and documents, including informed consent, were approved by the Lehman College Institutional Review Board and were in accordance with the Declaration of Helsinki.

Protocol

Participants came to the exercise science lab after an 8 hour fast. They were instructed to refrain from any food or drinks with any caloric load, but to hydrate normally with water. Upon arriving at the lab, participants were asked to use the bathroom if they felt any need to. Following this, their height and mass were measured using a Detecto physician's scale (Cardinal Scale Manufacturing Company, Webb City, MO) scale and stadiometer. Immediately prior to the assessments, the participant was seated directly in front of the InBody770 (Biospace Co. Ltd., Seoul, Korea), and the BIA procedure was explained to them. They were given InBody Tissues to thoroughly clean their hands and feet as recommended in the InBody770 User Manuel. They were then scanned two consecutive times on the InBody770. Between scans they moved off of the scale, sat back in the same chair, and re-wiped their hands and feet before the next scan. Each scan was performed using the guest-scan option rather than entering the participant under either one or two profiles. The two scans were performed in a random order assigning sex as female or male. The measures of weight, total %BF, regional %BFs, total body water, and estimated basal metabolic rate (eBMR) were assessed.

Statistical Analysis

To analyze the data, IBM SPSS (Armonk, NY) version 29.0.2.0 was used. Initial descriptive statistics were run to give an overview of the female and male participants in the study. This included independent samples t-tests to assess baseline sex differences. A Multivariate Repeated Measures ANOVA was run as an omnibus test, comparing dependent variables within participants when scanned as female or male. Follow-up univariate repeated measures ANOVAs were then run for each dependent variable within participant for whether they were scanned female or male, and between groups of true sex designation. For all tests, an alpha level of 0.05 was set a priori.

Results

A total of 22 participants completed the study, with an even division of females and males. There were no significant differences between females and males for age, body mass, or body mass index (BMI) (based on scale and stadiometer), but there were sex differences in measured height as shown in table 1.

Table 1. The table shows the descriptive data for the study participants.

Trait	Females (n=11)	Males (n=11)	p-value
Age (years)	33.36±3.53	32.64±4.48	p=0.68
Mass (kg)	77.13±18.99	80.73±6.38	p=0.56
Height (cm)	165.66±5.15	177.68±6.49	p<0.01*
BMI	28.14±6.92	25.62±2.42	p=0.28

Values are shown as means ± SD. The (*) indicates a significant difference between females and males, *p*<0.05.

The initial results of the multivariate test showed no main effects ($\Lambda=0.98$, $F_{1,21}=0.53$, p=0.47) of the sex identified for the scan across 4 main outcome measures: body mass, BMI, %BF, or eBMR ($\Lambda=0.006$, $F_{3,19}=974.52$, p<0.01). Follow-up univariate repeated measures ANOVAs confirmed that there were no discrepancies in the assessment of weight between the scans across the entire sample (F=3.6, p=0.07), and the same height was used for both scans within participants. Thus, there were no differences seen between scans for BMI (F=3.32, p=0.08) among the entire group. Therefore, the lack of differences in %BF (F=1.20, p=0.29) or eBMR (F=0.58, p=0.45) between scans was not due to differences in the starting height or weight values input or measured between the two scans.

When participant sex is included along with the two assessments for these main measures, there is an interaction between the various measures and sex ($\Lambda=0.13$, $F_{3,18}=40.77$, p<0.01), and there was an overall difference between females and males (F=49.77, p<0.01). Univariate follow-up confirmed differences in %BF between females and males (33.5 vs. 15.1% respectively, F=24.72, p<0.01), but pairwise comparisons showed that the imputation of sex (female or male) did not affect the %BF for either group (33.6 vs. 33.5%, p=0.29 for females and 15.1 vs. 15.1%, p=0.68 for males). There was also a sex difference in eBMR (F=62.03, p<0.01), with higher eBMR for males compared to females (1842.09 vs 1438.64 respectively). There were no within subject effects (F=0.58, p=0.46) and, again, pairwise comparisons showed that the sex entered into the InBody770 for the scan did not affect the outcome for either females or males (p=0.27 and p=0.94 respectively). While there were no differences in body mass within subjects (F=3.78, p=0.07), there were no sex differences noted either (F=0.30, p=0.59). There was a pairwise difference detected for overall body mass of males depending upon whether they were assessed as male (80.36kg) or female (80.43kg) (p=0.03).

The repeated measures MANOVA for the regional assessments approached significance depending on whether female or male was used for the test (Λ=0.83, $F_{1,21}$=4.25, p=0.052), as well as a significant interaction between the two scans and the various measures (Λ=0.47, $F_{5,17}$=3.80, p=0.02). Follow-up univariate repeated measures ANOVA showed no difference in total body water, left-arm fat mass, trunk fat mass, right-leg fat mass, or left-leg fat mass (shown in table 2). However, the scan type approached significance for right-arm fat mass (F=4.15, p=0.054).

When sex is included along with the two assessments for these regional measures, there is an interaction between the various measures and sex (Λ=0.11, F5,16=25.60, p<0.01). Univariate follow-ups showed sex differences between groups for total body water and all regional assessments (shown in table 4). When separated by sex, the two scans still approached significance for right-arm fat mass (F=4.02, p=0.059). This was likely driven by females, although the scan type was not significant within either females or males (p=0.08 and 0.32 respectively). No other regional measures approached significant differences based on whether the test was set to male or female (shown in table 2).

Discussion

The current study confirms the expected sex differences in body composition measurements from the InBody770, but showed that the imputation of sex did not influence these outcomes. The two outcomes should not be confused: 1) the body composition and eBMR between females and males were significantly different within this study, and 2) despite observed sex differences, the imputation of sex on the InBody770 BIA did not impact the results obtained from the BIA as a whole or within females or males as separate groups. These findings have implications for how these procedures are performed in gyms, fitness centers, clinics, etc.

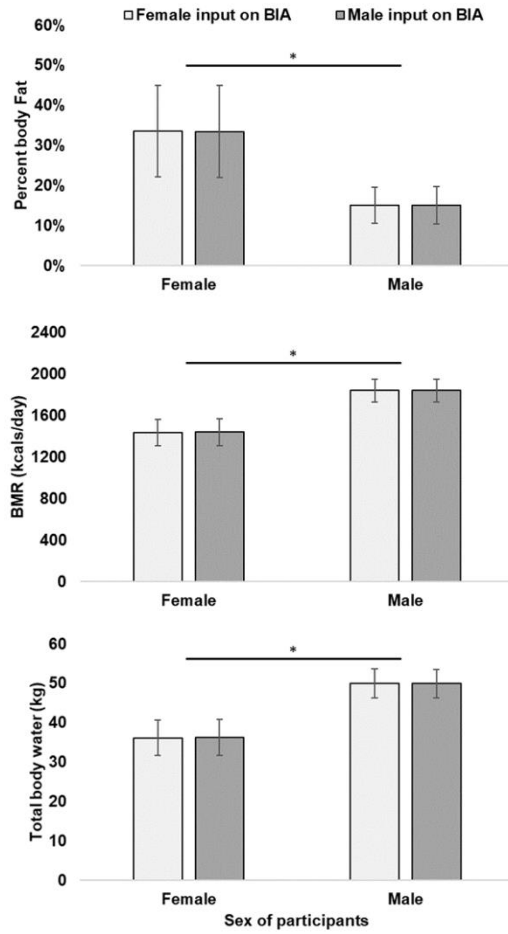

Figure 1. This figure shows the percent body fat (a), estimated BMR (b), and the total body water (c) of all individuals when scanned as either female or male. (*) indicates significant differences between males and females.

Table 2. This table shows the sex differences in regional measures as well as comparisons for each group based on scan settings.

Sex and scan setting	Females (mean ± SD)		Males (mean ± SD)		Comparison p-values			
	Female	Male	Female	Male	* Females vs. males	Within all	Within Females	Within Males
Total body water	36.15±4.43	36.24±4.53	49.89±3.69	49.92±3.68	<0.01	0.56	0.29	0.82
Right-arm fat	2.36±1.73	2.33±1.70	0.52±0.36	0.50±0.36	<0.01	0.06	0.08	0.32
Left-arm fat	2.35±1.75	2.35±1.73	0.50±0.34	0.51±0.36	<0.01	0.81	1.00	0.73
Trunk fat	13.84±7.74	13.76±7.72	6.50±2.50	6.44±2.61	<0.01	0.11	0.19	0.33
Right-leg fat	3.96±1.77	3.92±1.78	1.81±0.54	1.79±0.59	<0.01	0.15	0.16	0.52
Right-leg fat	3.93±1.75	3.91±1.74	1.78±0.53	1.78±0.58	<0.01	0.56	0.51	0.87

All regional measures were significantly different between sex groups. No regional measures were significantly different based on scan type within subjects, even when separated out by sex group.

As previously reported, post pubertal females and males have notable differences in body composition [8,9]. Unsurprisingly, males on average have a lower %BF compared to women, which was the case amongst the current study sample. These findings may not influence cisgender women and men as their gender identity aligns with their sex assigned at birth. However, for those with differing gender identities these findings would allow them to select their preferred gender identity without any loss of precision from the assessment. The selection of sex/gender as either female or male on the InBody770 made no difference in the outcome measures of the BIA test. The differences observed between BIA assessments as either female or male were no greater than have been shown in simple repeated BIA assessments on the InBody770 [24,25]. Unfortunately, this information is not made clear in the user's manual [26]. The manual does state that the machine can be configured to bypass sex/gender: "The examinees can bypass inputting their age or gender if the test environment is designed for testing only adults or a specific gender." [26]. However, this does not make it clear that this information does not affect the outcomes of the BIA tests. Despite this choice being arbitrary and possibly uncomfortable for individuals involved, the lack of clarity may lead to individuals being asked to choose between two genders regardless of their gender identity.

The lack of necessity of sex/gender for the InBody770's performance should be interpreted as a positive aspect of the equipment. Given that the machine does not seem to require this information for computation of %BF, eBMR, or regional assessments, there is no need to potentially misgender someone. In addition, future studies may investigate whether the InBody770 accurately assess body composition among individuals on various forms of hormone therapy, which may influence body composition in ways that diverge from normally assumed age/sex ranges.

There were areas in the current study which could be improved upon. While it is expected that females will present with higher %BF compared to males, the females in this study, when adjusted for sex, were carrying more adiposity than the males. The average male %BF percentile was 70.91±19.85 versus 25.82±32.28 for females [2]. This is likely why there were no differences in body mass between sexes, which is frequently observed. Although this makes the two groups slightly less comparable, the lack of differences within participants, regardless of these differences or sex imputation on the InBody770, make the findings of the study more robust.

Future Directions

Currently it is not entirely understood how treatments which alter sex hormone concentrations affect body composition [27,28]. Although hormone therapies, such as hormone replacement therapy following menopause, do seem to influence body composition [13,29]. Thus, if the InBody770 does not adjust/calculate any data based on imputation of sex, then it may be a potentially useful tool for groups whose body composition may vary from normative age/sex values. Because the choice of sex/gender on the InBody770 does not seem to be necessary to obtain accurate data, the BIA seems to rely less on age/sex assumptions which are influenced by hormonal concentrations. Future studies should include individuals with differences in sexual development or those on hormone therapy to determine whether these differences affect data outcomes relative to gender selection for the BIA.

Conclusions

In conclusion, the InBody770 was able to perform BIA on either women or men regardless of what sex/gender was entered on the machine. There is no need for the sex/gender to be required except, potentially, for client tracking purposes. This information could be updated in the user manual so that operators can choose to either omit this step, or allow individuals to either opt-in or choose the option that best aligns with their gender identity. Additionally, this reduces concerns of skewed BIA results due to the selection of sex/gender based upon the equipment's assumptions and calculations.

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