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Validating InBody® 570 Multi-frequency Bioelectrical Impedance Analyzer versus DXA for Body Fat Percentage Analysis

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ABSTRACT

Miller RM, Chambers TL, Burns SP. Validating InBody® 570 Multi-frequency Bioelectrical Impedance Analyzer versus DXA for Body Fat Percentage Analysis. **JEPonline** 2016;19(5):71-78. The aim of this investigation was to evaluate the relation between body fat percentages determined by dual-energy x-ray absorptiometry (DXA) versus multi-frequency bioelectrical impedance analysis (MfBIA). One hundred and ten recreationally active individuals (72 male, 38 female) completed a 12-hr fast, refrained from exercise for a minimum of 12 hrs, and alcohol consumption 24 hrs prior to testing. After anthropometric measures were assessed, the subjects' body fat percentage was determined from DXA and MfBIA subsequently. Each subject completed both body composition assessments in one visit to the Human Performance Laboratory. Pearson's correlations and paired *t* tests were computed for fat tissue percentage from DXA and MfBIA. Subjects' mean age, height, and weight were 20.72 ± 2 yrs, 174.61 ± 10.09 cm, and 77.94 ± 17.76 kg, respectively. Body fat percentages between the DXA (25.61 ± 10.56%) and MfBIA (20.99 ± 9.34%) were significantly related (r =.94, $P<0.0001$). Body fat percentage determined by DXA shares 88% of the variance with MfBIA, leaving 12% variance unexplained. However, the *t* tests displayed significant differences between modalities for each group comparison ($P<0.0001$). The results of the current study reveal if strict guidelines are adhered to MfBIA is a comparable method for determining body fat percentage when compared to DXA.

Key Words: MfBIA, DXA, Body Fat

INTRODUCTION

Currently, there are several modalities to assess body composition. These methods include: hydrodensitometry (HW), dual-energy x-ray absorptiometry (DXA), isotope dilution (ID), skinfold thickness (SKF) body mass index (BMI), near-infrared interactance (NIR) and bioelectrical impedance analysis (BIA) (9,10,22). Dual-energy x-ray absorptiometry and HW have been classified as 'gold standard', methods for quite some time (5,6,8-10,21). Although labeled 'gold standard' both methods are criticized for their lack of convenience, portability, cost, location, and require a skilled technician (4,5,12,15). The utilization of BMI as a method for assessing body composition has been and will continue to be the most appealing in terms of practicality, versatility, and its relatively robust correlation with body fatness (20). However, this generalized equation doesn't account for lean body tissue or fat tissue, thus leading to the repetitive misclassification of participants. With the increased awareness of body composition and its relation to health; the accessibility and necessity for an assessment that is valid, practical, versatile, and inexpensive is of great interest.

Bioelectrical impedance analyses provide a non-invasive, easy to use, and valid modality for assessing body composition across various populations (1,2,4,8,15,20). This modality became increasingly popular in the 1980s with the rise of technology (19). Since that time advances in technology have allowed BIA to become a more efficient measure. These advances include the increase in number of electrodes positioned on the subject or device and the use of multiple frequencies to achieve a more in depth measure (20). Incorporating more electrodes allows the device to compartmentalize the body into five distinct compartments and measure the impedance of those compartments individually thus leading to a more accurate assessment. Multiple frequency (MfBIA) enhances body composition testing accuracy by reflecting the measures of extracellular water (ECW), intracellular water (ICW), total body water (TBW), as well as penetrating cell membranes. These improvements allow body composition via MfBIA to be analyzed more substantially. Recently, data collected from MfBIA provides pertinent information regarding the subject's fat mass, lean mass, TBW, and distribution of lean and fat mass in a segmental and whole body analysis. When compared to 'gold standard' modalities, MfBIA has been reported to be moderately accurate in assessing body composition (15). Specifically, when compared to DXA correlation values of r =.54 to .93 have been reported for determining body fat percentage (1-12,14,16,18,20).

Dual-energy x-ray absorptiometry has received the 'gold standard' title from many resources (5,6,8-10,21). However, this modality has certain restrictions that don't allow all populations to be scanned with great accuracy. In severely obese, broad, and tall subjects, they cannot fit entirely within the scanning bed. This leads to part of the scan being 'mirrored' or estimated from the side that fits within the box positioned on the scanning bed. Subjects that are too long to fit in the box on the scanning bed will have part of their body not be evaluated when completing a scan. People that have knee replacement, hip replacement, or other surgical procedures resulting in having a metal plate inserted in the body should not utilize the DXA due to inaccuracy of readings (9,10).

Nonetheless, DXA is the selected modality to determine the validity of InBody® 570 multi-frequency bioelectrical impedance analyzer. Establishing the validity of this body composition method could potentially designate a non-invasive, affordable, and portable modality to be efficient in determining body composition. Therefore, the purpose of this study is to validate body fat percentage determined by InBody® 570 versus DXA in recreationally active individuals.

METHODS

Subjects

Subjects were recreationally active individuals attending the University of Central Missouri (N=110). Each subject ranged from 18 to 25 yrs of age, completed a 12-hr fast, refrained from exercise for a minimum of 12 hrs, and alcohol consumption 24 hrs prior to testing. Subjects provided written consent following the verbal explanation of the study upon arrival. The Human Subjects Institutional Review Board at the University of Central Missouri approved the experimental procedure prior to the investigation.

Testing Schedule

All body composition testing occurred in the Human Performance Laboratory at the University of Central Missouri. All measurements were obtained at one visit during the morning in order to allow subjects to more easily comply with fasting requirements. Height was assessed using a wall mounted stadiometer and body weight was determined using a digital scale. Each subject completed two body composition assessments after anthropometric measures in the following order: (a) DXA; and (2) MfBIA.

DXA Assessment

Dual-energy x-ray absorptiometry (GE Lunar Prodigy software version 13.60, Madison, WI) was used to assess body fat percentage. Dual-energy x-ray absorptiometry uses x-rays of high and low electromagnetic energies to measure attenuation by tissues dependent on body thickness, tissue density and chemical composition. This attenuation varies due to the aforementioned variables of tissues within the human body and is constant for all individuals. When photons at the differing energies pass through tissues the absorption can be expressed as a ratio (R) of the attenuation at the lower energy relative to the attenuation at the higher energy (9,10). This ratio is then utilized to calculate values for fat mass, lean soft tissue, and total body bone mineral.

Each day the machine was calibrated according to manufacturer directions using a standardized block provided by the manufacturer. All jewelry and metal were removed prior to the measurement to ensure accuracy. Each subject was positioned in the center of the scanning bed in supine position. Length of scan was dependent on subject thickness ranging from 6 to 12 min.

MfBIA Assessment

Multi-frequency Bioelectrical impedance analysis was completed using InBody® 570 Body Composition Analyzer (Biospace, Inc. Seoul, Korea). Body composition from MfBIA is obtained from the measures of resistance and reactance when an electrical current travels throughout the body. The InBody® 570 is a multi-frequency analyzer and divides the body into five components: two arms, two legs, and a trunk. The electrodes are situated beneath the subject's feet on the platform and on the palms and thumbs attached to handles on the device. Age, height, and gender are manually entered after weight is determined by a scale positioned within device. Total body water, segmental impedance, extracellular and intracellular water were all measured with the subject's bare skin in contact with the electrodes. Body mass and impedance are automatically assessed through the manufacturer software. Equations supplied in the manufacturers proprietary software calculated fat free mass and body fat percentage. Prior to each assessment the electrodes were thoroughly cleansed with InBody® provided tissues. After the device obtained subject weight the client was then instructed from the software to stand fully erect, arms extended and not touching side of the body, and to refrain from moving or talking until the assessment was completed.

Statistical Analyses

Results are expressed as mean ± standard deviation. Correlation analysis was performed to measure the strength of association between DXA and MfBIA excluding and including gender differences. Coefficient of determination was also evaluated to determine the amount of variance shared between methods. Mean differences were calculated and tested for statistical significance by *t* tests. Statistical significance set a priori at $P<0.05$.

RESULTS

Subjects' mean age, height, and weight were 20.72 ± 2 yrs, 174.61 ± 10.09 cm and 77.94 ± 17.76 kg, respectively. Mean body fat percentage for DXA was 25.61 ± 10.56% across genders, 32.92 ± 7.74% women, and 21.77 ± 9.82% men, respectively. Mean body fat percentage for MfBIA was 20.99 ± 9.34% across genders, 27.72 ± 7.27% women, and 17.46 ± 8.33% men.

Pearson's correlation revealed positive correlation r =.94, .90, and .92 ($P<0.0001$) for the entire sample, men, and women accordingly. Coefficient of determination across entire sample, men and women were R2= .88, .86, and .81, respectively. T-tests revealed significant differences ($P<0.0001$) between body fat percentage determined between modalities across entire sample, men, and women.

DISCUSSION

The results of the current study reveal that MfBIA and DXA possess a strong degree of association when evaluating body fat percentage for recreationally active individuals. Determining the strength of association was the primary purpose of this study which revealed a significant correlation r =.94 ($P<0.0001$), and r =.92 and r =.90 for men and women individually. However, a strong correlation doesn't always mean a good agreement between two variables. In fact, it should be acknowledged that there were significant differences ($P<0.0001$) observed between the body fat percent values when comparing modality differences for entire sample and both genders. From the literature reviewed only seven additional studies tested statistical difference between the modalities (2,4,8,11,20,21). However, only three of those investigations utilized MfBIA analysis (18,20,21). Similar to the current study, each of those investigations revealed a statistically significant difference across the entire sample when comparing body fat percentages between modalities.

Dual-energy x-ray absorptiometry, used as the reference modality in this investigation, tended to determine body fat on average four to five percent higher when evaluating entire sample and each gender separately. In the present study all but thirteen subjects (9 males, 4 females) DXA revealed a higher percent body fat percentage. A similar investigation that included 591 subjects investigated the comparison of MfBIA with DXA (3). Similar to the results from the current study, MfBIA tends to underestimate body fat percentage in a majority of subjects. Many reports have revealed similar findings; however, the aforementioned study contained the most subjects (1,6,8,16).

Similar studies evaluating MfBIA and DXA have reported values where MfBIA body fat percentage was within one percentage point of the percent fat determined from DXA (3,8). These results contradict the findings in this current study. Across all 110 subjects, only fifteen had values were within one percent between modalities. Nonetheless, when comparing each modality in subjectively classifying body fat percentage according to American College of Sports Medicine (ACSM) normative values, 42 (30 males, 12 females, 44% total sample) of the subjects' classifications were altered from either: very poor to poor, poor to fair, fair to good, good to excellent, or excellent to very lean. When utilizing ACSM's standards for classifying the subjects, it was easily noted that the healthier the classification typically resulted in the closer values. However, a majority of the fair to very poor classified subjects (16/30, 53%) revealed differences among modalities of between 5.55 to 9.02%.

Some favorable factors associated with the current investigation were the body composition testing schedule and the subject criteria. The most recent attempt to establish validity between MfBIA and DXA was conducted by Rosen and colleagues in 2014. Although the correlation value was significantly related ($r = .96$ $P<0.0001$), modality testing occurred at different places. The subjects performed the first assessment and were then transported to another designated area to complete the procedure. The current study required subjects to complete DXA and then complete MfBIA moments after. The current study's testing procedure negated any of the possible within-subject variability that could occur due to transport. Subjects were required to be recreationally active and be 18 to 25 yrs of age. Having a narrow scope for age requirements negates possible body composition outcomes associated with the aging process. Previous research conducted that had similar restrictions for age range also revealed strong correlation values ($r = .87$-$.93$) (8,11,12). This current study, as well as the previous studies conducted with restricted age limitations reveals that when restrictions are made strong correlations are reported when investigating body fat percentage between modalities. Investigations that have examined an expansive age range tend to have correlation values lower ($r = .54$-$.91$) (1-4,6,7,14,18-21).

The current study is not without limitations. In comparison to previous studies examining the correlation or validity of MfBIA to DXA this study had a relatively small sample size (N=110). However, when comparing to other similar studies, our sample was based off a much more limited age group (18 to 25 yrs). Thus the findings of this current study could be an indication for MfBIA being a valuable tool for assessing body composition in this population. Hydration status, food and alcohol consumption, and exercise tend to effect body composition assessment via MfBIA (9,10,17). Published texts have revealed significant alterations on body composition assessment when the previous variables are not controlled. Those variables tend to alter the measure of resistance, reactance, and impedance (9). Although we informed the subjects of the current investigations guidelines and confirmed they were adhered to; the subjects may or may not have followed the requested directions. Our investigation also did not require women to report current menstrual status. During this time, women have been reported to gain amounts of weight ranging from .2 to 4 kg and a large part of that gain is due to an increase in TBW (9,10). This factor could have potentially altered the results explaining the lowest value for R2 (.80) in this study. Future investigations should be more strict with guidelines related to total body water (i.e. hydration and water retention) especially in regards to women and menstruation.

CONCLUSIONS

The results of this investigation reveal MfBIA and DXA appear to be strongly correlated when evaluating body fat percentage. While MfBIA appears to be a versatile, affordable, and valid measure for general population studies, DXA provides a more accurate and detailed assessment. Nonetheless, when assessing body composition for recreationally active individuals, MfBIA can be deemed a comparable measure when adhering to strict pretest guidelines.

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