Body composition measurements determined by air displacement plethysmography and eight-polar bioelectrical impedance analysis are equivalent in African American college students

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Abstract

The purpose of this study was to compare body composition measurements taken with air displacement plethysmography (BOD POD) to eight-polar bioelectrical impedance analysis (BIA) in African American college students. The 143 subjects, aged 17–39 years, visited the participating Human Performance & Leisure Studies laboratory at North Carolina A&T State University, Greensboro, NC, United States, between June 1, 2011 and December 31, 2011. Measurements of body composition, including fat mass (FM), fat free mass (FFM), and % body fat were determined using BOD POD (Life Measurement Inc., California, USA) and an eight-polar BIA (Inbody-720, Biospace, Seoul, Korea). The relationships between body composition measurements taken using BOD POD and eight-polar BIA were assessed using Pearson's r correlation. Results showed that body composition measurements taken using the BOD POD and the eight-polar BIA correlated significantly with respect to FFM (male, r=0.911, p<0.001; female, r=0.918, p<0.001); FM (male, r=0.938, p<0.001; female: r=0.931, p<0.001); and % body fat (male, r=0.871, p<0.001; female, r=0.717, p<0.001). The authors concluded that measurements taken using BOD POD and eight-polar BIA were similar in African American students. These methods are useful for field tests requiring body composition measurements and can be used interchangeably in the field.

Key words: Air-displacement plethysmography, eight-polar bioelectrical impedance analysis, Fat free mass, Fat mass, African American

Introduction

Body composition, such as fat free mass (FFM) and fat mass (FM), is an essential parameter in exercise training for athletes and non-athletes because low fat and high muscle can improve exercise performance in many types of sports and recreational activities. Many studies have reported on traditional measurements of body condition via body mass index (BMI), waist-hip ratio (WHR), waist circumference (WC), and skin-fold thickness (1–3). Recently, several studies introduced the measurement of body composition by magnetic resonance imaging (MRI), dual energy x-ray absorptiometry (DEXA), underwater weighing (densitometry), dilution techniques, bioelectrical impedance analysis (BIA), and air-displacement plethysmography (BOD POD) (4–6). Although these measurements are reliable and show validity, MRI, DEXA, densitometry, and dilution techniques are very expensive and inconvenient for the participants, and not feasible to conduct in the field because they require large specialized equipment. For these reasons, the use of these techniques is limited in many studies. By contrast, measurements using BIA and BOD POD are relatively simple, require only a few minutes to complete, and are non-invasive. Further, these methods deliver reliable measurements of body composition (5–6). Studies have compared the measurements of body composition parameters, such as FM, FFM, and % body fat, among simpler methods such as BIA and BOD POD and more complex methods such as DEXA, MRI, and densitometry. Studies com-

paring BOD POD and DEXA have shown that the correlation between BOD POD and DEXA in predicting FM and FFM was very close to 1.00, ranging from 0.99 to 1.02 (7–9). A good correlation between BIA and DEXA in predicting FM and FFM was also shown (10–11).

Most of the previous studies of BOD POD and BIA have compared the accuracy of simple measuring methods, such as BOD POD and BIA, to more complex methods. Data comparing BOD POD and BIA to each other are lacking. In addition, previous studies on BIA were conducted using four-polar BIA with a single impedance frequency but not eight-polar BIA or impedance at multiple frequencies. Furthermore, very few of these studies have been conducted on the African-American ethnic minorities (11). Therefore, the purpose of this study was to compare measurements of body composition parameters, such as FM, FFM, and % body fat, between BOD POD and eight-polar BIA in African American college students.

Methods

Subject

The study cohort comprised 143 African American college students (64 males, 79 females), aged 17–39 years, who visited the participating Human Performance & Leisure Studies laboratory at North Carolina A & T State University in Greensboro, NC, USA between June 1, 2011 and December 31, 2011. The FFM, FM, and % body fat of all subjects were determined via eight-polar BIA with impedance at multiple frequencies (Inbody720, Seoul, Korea) and BOD POD (Life Measurement Inc., Concord, California, USA). All study procedures were approved by the Institutional Review Board at North Carolina A & T State University.

Experimental procedures

The FFM, FM, and % BF were evaluated using an eight-polar BIA with multiple impedance frequencies (Inbody720, Seoul, Korea) and BOD POD (Life Measurement Inc., Concord, California, USA). The BIA instrument measures the resistance of the right arm, left arm, trunk, right leg, and left leg at 6 frequencies, (1, 5, 50, 250, 500, and 1000 kHz) via 30 impedance measurements in each of the 5 sites. The device uses 8 tactile electrodes: 2 in contact with the palm and thumb of each hand, and 2 with the anterior and posterior aspects of the sole of each foot (12). Subjects wore light clothing and removed all metal items that could interrupt the electronic current during the measurements.

The BOD POD instrument takes measurements using chamber pressure amplitudes, which were calibrated before each test by using a 50-L calibration cylinder. The subjects wore a tight-fitted swimsuit or body suit, and the FFM, FM, and % BF was determined in the chamber. The thoracic gas volume was measured in a separate step, in which the subject was required to sit quietly in the BOD POD chamber and breathe through a disposal tube and filter connected to the reference chamber at the rear of the BOD POD apparatus. After 4 or 5 breaths, the airway was occluded midway during exhalation, and the subject was instructed to blow 3 quick, light, panting breaths into the tube.

Before taking measurements, the subjects were prohibited from performing any exercise for 12 h, consuming anything for 4h, and urinating just before the impedance measurement. All methods employed for assessing body composition followed recommended guidelines (13).

Statistical analysis

All results from this study are represented as mean ± standard deviation. Pearson's r correlations were calculated to examine the relationship between BOD POD and BIA with FFM, FM, and % body fat. Statistical significance was set at $p < 0.05$, and all analyses were performed using SPSS version 18.0 (SPSS, Chicago, IL, USA).

Results

The characteristics of the subjects are shown in Table 1. The average ages of the males and females are 21.66 ± 2.99 years and 19.99 ± 2.83 years, respectively; their average heights are 176.95 ± 6.86 cm and 166.76 ± 8.80 cm, respectively; their average weights are 81.78 ± 14.97 kg and 69.94 ± 14.04 kg, respectively; their average BMIs are 26.11 ± 4.41 kg/m^2 and 25.04 ± 4.05 kg/m^2, res-

pectively; their average waist circumferences are 83.88 ± 9.89 cm and 81.26 ± 9.80 cm, respectively; their average hip circumference are 97.36 ± 8.63 cm and 99.06 ± 10.32 cm, respectively; and their average neck circumference are 38.07 ± 2.28 cm and 32.29 ± 1.99 cm, respectively.

The relationship between BOD POD and eight-polar BIA with respect to FFM, FM, and % body fat measurements are shown in Table 2. BOD POD showed significant positive correlations with eight-polar BIA in FFM (male, r=0.911, p<0.001; female, r=0.918; p<0.001), FM (male, r=0.938, p<0.001; female, r = 0.931, p<0.001), and % body fat (male, r=0.871, p<0.001; female, r=0.717, p<0.001).

Discussion

This study evaluated the correlation between BOD POD and eight-polar BIA in African American college students. The results of this study demonstrated a significant correlation between BOD POD and eight-polar BIA measurements obtained for FFM, FM, and % body fat.

The BOD POD and BIA methods have been widely used in clinics, in sports medicine, in public health centers, and in weight reduction programs (14–16). Many studies have compared predictions of body composition by BOD POD and BIA with measurements made by reference methods such as DEXA and CT (17–19), but, to our knowledge, comparisons of BOD POD and BIA have not yet been reported. This is the first investigation to compare estimations of FFM, FM, and % body fat between BOD POD and eight-polar BIA in African American college students.

Our results showed significant correlations in the measurements taken for FFM, FM, and % body fat between BOD POD and BIA. These observations indicate that although BOD POD is based on the principles of densitometry and BIA is based on the principles of bioelectrical impedance, these methods give similar outputs regarding these body composition parameters. This study shows not only a significant correlation between BOD POD and BIA but also that BOD POD and eight-polar BIA give measurements very close to that of DEXA (7–11). Based on these results, we conclude that BOD POD and eight-polar BIA are useful methods for field testing that requires wide scale use of body composition measurements, and that these methods can be used interchangeably in field.

This study has some limitations. Since the students were recruited from only 1 historically black college and university (HBCU) in Greensboro, NC, USA, the study population did not represent the entire African-American population. Further-

Table 1. Characteristics of subjects (N = 143)

Variable	Male (N = 64)	Female (N = 79)
Age, years	21.66 ± 2.99	19.99 ± 2.83
Height, cm	176.95 ± 6.86	166.76 ± 8.80
Weight, kg	81.78 ± 14.97	69.94 ± 14.04
Body mass index, kg/m^2	26.11 ± 4.41	25.04 ± 4.05
Waist circumference, cm	83.88 ± 9.89	81.26 ± 9.80
Hip circumference, cm	97.36 ± 8.63	99.06 ± 10.32
Neck circumference, cm	38.07 ± 2.28	32.29 ± 1.99

Table 2. The relationship between BOD POD and BIA with FFM, FM, and %body fat in African American (N = 143)

Male (N = 64)	BOD POD	INBODY	r	p
Fat free mass (kg)	65.76 ± 7.61	68.08 ± 8.76	0.911	<0.001***
Fat mass (kg)	15.99 ± 9.90	13.69 ± 8.14	0.938	<0.001***
Body fat (%)	18.49 ± 8.45	15.81 ± 7.07	0.871	<0.001***
Female (N = 79)	BOD POD	INBODY	r	p
Fat free mass (kg)	51.55 ± 7.82	51.64 ± 8.78	0.918	<0.001***
Fat mass (kg)	18.33 ± 9.69	18.31 ± 9.24	0.931	<0.001***
Body fat (%)	25.12 ± 8.83	24.97 ± 8.37	0.717	<0.001***

****p<0.001 by Pearson's r correlations analysis*

more, it comprised only a few a small number of students (N = 143). However, we believe the greatest merits of this research are that it was conducted on subjects from the African-American ethnic minorities and that this is the first study to compare BOD POD and eight-polar BIA with multiple frequencies of impedance.

Conclusion

We concluded that the data of BOD POD and the data of eight-polar BIA were strong significantly correlated in African American students. These methods are useful methods in field test for measuring body composition and it can be used interchangeable in field.

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