Correlates, predictors, reference ranges and agreement between percent body fat measured using bioelectric impedance analysis and skinfold-thickness measurements in young nigerian adults

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Abstract

Background: Establishment of population specific normative databases for body composition is important in determining clinically useful cut-points for definition of excessive body fat or obesity for preventive or treatment programmes. This study provides the correlates, predictors, reference ranges and agreement between Percent Body Fat (PBF) measured using Bioelectric Impedance Analysis (BIA) and Skinfold-Thickness Measurements (STM) in young Nigerian adults. **Materials and Methods:** A total of 531 apparently healthy individuals who were within ages 18 and 30 years were consecutively recruited in this study. BIA and STM (from three anatomical sites) were used to estimate PBF while anthropometric parameters were assessed following standard procedures. PBF computation was based on standard formulae. Socio-demographic characteristics were obtained using a proforma. Data were analysed using descriptive and inferential statistics at 0.05 alpha level. **Results:** There was significant difference in PBF measured by BIA and STM (20.69±9.97 vs. 13.4±9.37; t=12.28, p=0.001). There was significant correlation between PBF assessed by BIA and STM (r=0.912; p=0.001). The socio-demographic and anthropometric variables were significantly correlated with PBF (p <0.05) measured by BIA and STM respectively. The variability of the predictive of models for PBF from age, weight and height was 34.0% (R^2 =34.0) and 50.9% (R^2 =50.9) for males and females using BIA, while, the variability for PBF assessed using STM was 49.1.0% (R^2 =49.1) and 40.4% (R^2 =40.4) for males and females. **Conclusion:** This study provides reference values for PBF using BIA and STM in young Nigerian adults. BIA method compared with STM overestimated PBF, although these two methods correlates strongly in the acceptable and moderately overweight range and not among the lean and obese participants. Age, gender and anthropometric factors were significantly determinants of the PBF. Age, height and weight seems to be moderate predictors of PBF but not without significant errors.

Key words: Percent body fat, bioelectric impedance analysis, skinfold-thickness measurements

Introduction

Prevalence of obesity in both developed and developing countries have rapidly grown to epidemic proportions [1]. The upsurge in obesity prevalence from the developing countries have been linked to the rapid western acculturation process resulting in alterations in diet and physical activity patterns [2, 3]. This rise in obesity prevalence represents a pandemic that needs urgent attention if the potential morbidity, mortality, and economic tolls that will be left in its wake are to be avoided [4].

Consequently, establishment of population specific normative databases for body composition is important in determining clinically useful cut-points for the definition of excessive body fat or obesity for preventive or treatment programmes [5]. Literature is replete with numerous techniques for assessing level of body fat, such as underwater weighing, Dual-Energy X-ray Absorptiometry

(DEXA), magnetic resonance imaging, and air-displacement plethysmography and skinfold thickness measurement among others [5-8]. However, most of these techniques are difficult to administer, complicated, expensive, time consuming and requires specialized training and skills [5].

Skinfold-thickness measurements is one of the most extensively used body composition assessment method for Percent Body Fat (PBF) [9]. The skinfold-thickness technique involves measuring skinfold fat at specific anatomical sites and using these values in a regression equation to predict the subject's PBF [10]. However, many researchers and clinicians have questioned the results of body composition assessments performed using skinfold fat measurements [10]. On the other hand, Bioelectrical Impedance Analysis (BIA) offers great potential for non-invasive body composition assessment and has gained increasing popularity in the past decade [5]. The BIA method is reported as a simple, convenient, safe and inexpensive method for assessing body composition [5] with good psychometric properties and high clinical and research applicability in health and disease [11-14]. Hence, BIA has been considered as the 'gold standard' measures of childhood obesity in some studies [15, 16]. Consequently, there has been a proliferation of BIA devices ranging from single-frequency BIA with sensor pads (e.g. hand-held and the foot-foot system BIA machines) to multi-frequency BIA with electrodes (e.g. bipolar and tetrapolar bioimpedance) for research, diagnostic and monitoring purposes.

Although, some studies have reported strong correlation between BIA and skinfold thickness measurements [17-19], however, it remains inconclusive whether BIA over-or-underestimate PBF compared with skinfolds thickness measurements. In addition, most predictive formulae for PBF based on BIA or skinfold-thickness measurements in literature are from Asian, Caucasian, American and European populations. Therefore, it can be contended that the external validity of these predictive models may be limited in other ethnic groups, due to reports that body composition have ethnic and racial influence [20]. Despite recommendations for population-specific body composition databases, there seems to be an apparent dearth of normative databases and predictive equations for PBF among Nigerians. This study provides the correlates, predictors, reference ranges and agreement between PBF measured using BIA and skinfold thickness measurements in young Nigerian adults.

Materials and methods

A total of 531 apparently healthy individuals between the ages of 18 and 30 years were consecutively recruited in this study. The participants included students of the Obafemi Awolowo University (OAU), Ile-Ife, Nigeria and other volunteers from the Ile-Ife community who responded to the research advertisement. Participants for the study were screened via interview to ensure eligibility. Exclusion criteria were a history of endocrinologic and/or metabolic condition; being pregnant; participation in high-intensity regular exercise or elite sports at a competitive level; and a history of metallic implant or cardiac pacemaker in situ or other contraindications to the use of BIA.

Ethical approval for this study was obtained from the Ethical Review Committee of the Obafemi Awolowo University Teaching Hospitals Complex. The participants were fully informed about the purpose of the study and their consent was obtained before measurements were taken. This study was carried out at the gymnasium of the department of Medical Rehabilitation, OAU. Sample size formula for proportions with population greater than 10,000 i.e. $n= z2pq/d^2$ [21] was used for sample size determination in this study.

Where: ***n*** = the desired sample size (when population is greater than 10,000); ***z*** = 1.96 at 95% confidence interval; ***p*** = assumed proportion of persons having knowledge of physiotherapy, (there was no reasonable estimate of the proportion of people having or lacking knowledge of physiotherapy in any community in Nigeria, hence 50% (0.50) was used); ***q*** = 1.0-***p*** = 0.50; and ***d*** = absolute standard error = 0.05. Therefore, ***n*** = (1.962 × 0.5 × 0.5) / (0.05)2 = 384 respondents. In order to allow for attrition, **n** was approximated to at least 400.

Anthropometric and body composition parameters assessed in the study included height, weight, body mass index (BMI), Percent Body Fat (PBF), lean body mass and body fat mass (BFM). A height-meter (Seca Alpha Brand) calibrated from 0 to 200 cm was used to assess height of each participant to the nearest 0.1 cm following standard procedures. Body weight in light clothes was measured to the nearest 0.1 kg using a weighing scale (Inter Ikea systems B.V. 1999) calibrated from 0 to 120kg with the participant in standing position with shoes off.

Bioelectric Impedance Analysis (BIA) machine (Omron BF306; Model HBF-306-E CE, Japan) was used to measure PBF. This method is based on the behaviour of biological structures subjected to a constant low-level alternating current [22]. The participants were instructed to remove all metal objects, e.g. earrings, chains, wrist watches. They were instructed to stand erect with the two feet together and also to hold the machine in both hands such that the palms covered the metal surfaces of the instrument. They were then instructed to hold the arms straight at 90° of shoulder flexion. Dryness of the palms was ensured by using a dry towel for cleaning if the palms were wet, and by also making sure that the participants did not have hyperhidrosis. The height, weight, age and sex of the participants were fed into the micro data processor of the instrument, and the start button was switched on. The participants were then asked to stand still till a new set of data was displayed on the meter [23].

Skinfold-thickness measurements of three anatomical sites (abdomen, suprailiac, triceps) were taken using Lange skinfold calliper on the right side of the body with the participant in the upright standing position. The calliper was placed directly on the skin surface, 1cm away from the thumb and finger, perpendicular to the skinfold, and halfway between the crest and the base of the fold. 1 to 2 seconds was allowed before reading the caliper. The pinch was maintained while reading the caliper. Duplicate measures were taken at each site and were retested if duplicate measurements were not within 1 to 2 mm [24]. The standard description of skinfold sites and procedures is shown on table 1. NDA and CEM carried out the skinfold-thickness measurements for all the participants.

Computations

Body Mass Index was calculated as the ratio of weight in kilograms to height squared i.e.

BMI = Weight (kg) / Height^2 (m^2) [25].

Lean Body Mass (kg) was calculated from the PBF estimate of the BIA by subtracting fat weight (kg) from total body weight (kg). Lean Body Mass = Total body weight – Fat weight.

Where Fat weight was calculated from the BIA estimate of the percent body fat using the following formula: Percent Body Fat = (fat weight/total body weight) X 100

Therefore, Fat weight = (PBF * total body weight)/100 [23].

Computations of percent body fat from skinfold-thickness measurements -

Males

Sites: (Abdomen, Suprailiac, Triceps)

% Body fat = (0.39287 * sum of three skinfolds) –

(0.00105 * [sum of three skinfolds]2) + (0.15772 × age)– 5.18845

Females

Sites: (Abdomen, Suprailiac, Triceps)

PBF = (0.41563 * sum of three skinfolds) – (0.00112 * [sum of three skinfolds]2) + (0.03661 * age) + 4.03653 [26].

Based on PBF level, participants were classified as lean, acceptable, moderately overweight and overweight following PBF benchmark for the general population by Woods [27]. Lean for male = < 12; Lean for female = < 17; Acceptable for male = between 12 – 21; Acceptable for female = between 17 – 28; Moderately overweight for male = between 21 – 26; Moderately overweight for female = between 28- 33; Overweight for male = > 26; and Overweight for female = > 33.

Data analysis

Data was summarized using descriptive statistics of mean, standard deviation and percentiles. Independent t-test was used to compare PBF between BIA and skinfold-thickness measurements and by gender. Linear regression analysis was used to analyze the relationship between PBF assessed using BIA and skinfold-thickness measurements. Pearson product moment correlation was used to determine the correlates of PBF, while Spearman rank correlation was used to correlate PBF and gender. Chi square test was used to test the association between levels of PBF and gender. Scatter plot with linear curve estimation was use to depict the agreement between BIA and skinfold-thickness measurements PBF. Multivariate analysis of linear regression was used to fit gender specific predictive equations for PBF. Data was analyzed using Statistical Package for Social Sciences (SPSS) software version 16. Alpha level was set at $p<0.05$.

Results

Participants were within age 18 and 30 years with the mean of 21.5±2.3 years. The participants comprised of 280 (52.7%) males and 251(47.3%) females. Independent t-test comparison of participants' general characteristics, anthropometric and body composition variables are presented in table 2. There was significant difference in PBF measured by BIA and STM (20.69±9.97 vs. 13.4±9.37; $t=12.28$, $p=0.001$). The independent t-test comparison results indicate that all the measure of adiposity were significantly higher among female participants ($p<0.05$) (table 2). Table 3 shows the reference ranges by gender for PBF measured by BIA and skinfold-thickness measurements. The mean, standard deviation, range and 25th, 50th, and 75th percentile scores were analysed by gender. Based on PBF classification as lean, acceptable, moderately overweight and overweight, the frequency distribution of all participants' PBF using BIA and skinfold-thickness measurements is presented in table 4. Chi square test of association shows that there was significant association between gender and PBF levels measured by BIA and skinfold-thickness measurements respectively ($p=0.001$).

The linear regression analysis showed a significant correlation between PBF assessed by BIA and skinfold-thickness measurements ($r = 0.912$; $p = 0.001$). The scatter plot revealed a direct linear correlation between BIA and skinfold-thickness measurements PBF (figure 1). Spearman rank correlation analysis found significant direct correlation between gender and each of BIA ($r = 0.605$; $p = 0.001$) and skinfold-thickness measurements ($r = 0.670$; $p = 0.001$) PBF. There was no significant relationship between age and each of BIA ($p = 0.420$) and skinfold-thickness measurements ($p=0.999$) PBF (table 5). However, there was significant correlation between the anthropometric parameters and each BIA and skinfold-thickness measurements PBF ($p<0.05$) (table 5). Regression analysis revealed that age, weight and height were significant predictors of BIA and skinfold-thickness measurements respectively (tables 6 and 7). The variability of the predictive of models for BIA assessed PBF was 34.0% (R^2 =34.0) and 50.9% (R^2 =50.9) for males and females, while, the variability for skinfold-thickness measurements PBF was 49.1.0% (R^2 =49.1) and 40.4% (R^2 =40.4) for males and females.

Discussion

This study assessed correlates, predictors, reference ranges and agreement between PBF measured using BIA and skinfold-thickness measurements in young Nigerian adults. The male participants in this study were significantly taller, and heavier than their female counterparts. Studies have shown that on the average, males are taller and heavier than females [28-30]. Although, the differences in anthropometry and body dimensions vary within and from different populations [31-34]. From this study, the measure of adiposity including BMI and PBF were significantly higher among the female participants. This finding is consistent with previous studies reporting higher adiposity among women compared with men [28, 35-37].

This study showed that BIA method compared with skinfold-thickness measurements significantly overestimated PBF. This finding is at variance with some previous studies that reported BIA to under-estimates body fat compared with skinfold-thickness measurements [38, 39]. Therefore, it is adduced that racial differences in body anthropometry and geometry [40-42], methodological differences regarding number and sites of skinfold-thickness measurements and variations in types of BIA machines may have contributed to the disparities in findings. Specifically, previous studies have reported racial and ethnic differences in regional or subcutaneous body fat distribution [43-45]. Considering relative distribution of subcutaneous fat compared to absolute amounts of fat, it is reported that black Africans tend to have smaller triceps skinfold thicknesses [41, 46], less subcutaneous fat in the extremities [47-49], lower ratios of triceps to subscapular and thigh to subscapular thickness [50], but relatively more subcutaneous fat on the back and lateral portions of the body compared with whites [47-49]. The foregoing, thus introduces variability in skinfold-thickness patterns and limits comparison between studies.

Furthermore, the mean value of BIA assessed PBF for males and females in this study was 12.71±4.81 and 29.5±75.85. A Spanish study by Marta et al. [35] reported mean values of 20·0±5.3 and 29·0±4·1 for PBF assessed using BIA among male and female undergraduate students. Another study by Nayeli et al. [37] among Mexican adults found a mean value of BIA assessed PBF of 25.9 in men and 36.2 in women. The mean value of skinfold-thickness measurements PBF for males and females in this study was 5.28±3.27 and 22.42±4.31. Kagawa et al. [51] in a study among Japanese and Australian-Caucasian young men reported mean values of 16·6±5·1 and 17·3±5·7 respectively for skinfold-thickness measurements PBF. These findings confirm variability in PBF values across different populations. From the result of this study, a significant relationship was found between gender and PBF with female participants having higher PBF values. This pattern is in accordance with the study by Marta et al. [35] and Lo et al. [36] respectively.

Reference values for PBF assessed using BIA are just emerging. McCarthy et al. [52] established a reference charts for PBF in British children from more affluent areas in England. Sung et al. [5] presented tables and percentile charts of PBF for Hong Kong children age 6 to 18 years. It is believed that racial differences have influence on level of adiposity, therefore norm values of one population may not be extrapolated to another [20]. To this end, population-specific reference values data for PBF are important because of the body composition variation according to age, sex, ethnic background, nutritional status, exercise, climate, and the presence of some illnesses and the administration of some drugs [20]. Furthermore, it is often difficult to compare the reference data on PBF from one population with reference standards from other populations because of the variations in sample, assessment methods and equipment. This present study aims to provide preliminary data on PBF among young Nigerians using both the BIA and skinfold-thickness measurements. Most of these young adults in this study were in the 'acceptable' category (44.8%) for PBF assessed by BIA while most participants were in 'lean' category (54.8%) for PBF assessed using skinfold-thickness measurements.

From this study, strong and direct correlation was found between PBF assessed using BIA and skinfold-thickness measurements. This finding validates previous results on the correlation between BIA and skinfold-thickness measurements indicating range between 0.84 and 0.92 [17-19, 36]. Both BIA and skinfold-thickness measurements are simple and indirect methods to assess body composition. Although, skinfold-thickness thickness is a long-established clinical technique for body composition, it still requires training to ensure competence [5]. The result of linear regression analysis in this study showed a significant positive correlation (r = 0.912; p= 0.001) between PBF assessed by both techniques. However, scattered plot analysis revealed that the BIA and skinfold-thickness measurements correlates strongly in the acceptable and moderately overweight range and not among the lean and obese participants. From this study's result, it suggested that the clinical applicability of the BIA and skinfold-thickness measurements in the extreme ranges of body composition need to be validated in this population.

Even though the age bracket of the participants in this study was not wide, the results shows that age had significant influence on PBF. This finding is consistent with previous studies [53, 54]. Also, this study found that all the anthropometric variables showed direct correlation with PBF assessed by both BIA and skinfold-thickness measurements. This findings is largely consistent with literature [55-58]. This study provides gender specific prediction equations for PBF from age, height and weight. The variability of the predictive of models for PBF assessed using BIA was 34.0% and 50.9% for males and females, while, the variability for PBF assessed using skinfold-thickness measurements was 49.1.0% and 40.4% for males and females. The level of variability of the prediction models ranges between fair and average. This implies that the predictive equations may not sufficiently predict PBF without significant errors. However, one of the most important reasons for developing BIA estimation and skinfold-thickness measurements equations for specific groups is differences in anthropometry and body geometry. Racial differences in body segments with respect to limb length and trunk height have been established. Marras et al. [59] submitted that females generally have shorter legs and longer torsos than men; and Deurenberg et al. [32] found that limb length and body weight are strongly correlated to ethnicity and environmental factors. Lukaski et al. [60] reported that limb length and body weight are positively related to resistance, which is the main predictor of PBF estimated with BIA. Nonetheless, the prediction equations derived in this should be used with caution because of its levels of variability.

A potential limitation of this study was its limited generalizability owing to non-probability sampling technique used. In addition, this current study used Omron (BF306; Model HBF-306-E CE, Japan) BIA, however, there are several types of BIA devices. The differences in types of BIA device and methodology with respect to either hand-held or electrode; and anatomical placement and number of probes or electrodes limits the comparison of this study with others. Nonetheless, validity of hand-held Omron BIA devices to estimate PBF has been documented [61-63]. Lastly, it is noteworthy that neither BIA nor skin-fold measurements are gold standard methods for PBF estimation but are valid alternative especially in resource-poor settings like Africa.

Conclusion

This study provides reference values for percent body fat measured using BIA and skinfold-thickness measurements in young Nigerian adults. BIA method compared with skinfold-thickness measurements overestimated PBF, although these two methods correlates strongly in the acceptable and moderately overweight range and not among the lean and obese participants. Therefore, BIA may not serve as an adequate alternative for skinfold-thickness measurements for PBF despite the significant relationship between the methods. Age, gender and anthropometric factors were significantly determinants of the PBF. Age, height and weight seems to be moderate predictors of PBF but not without significant errors.

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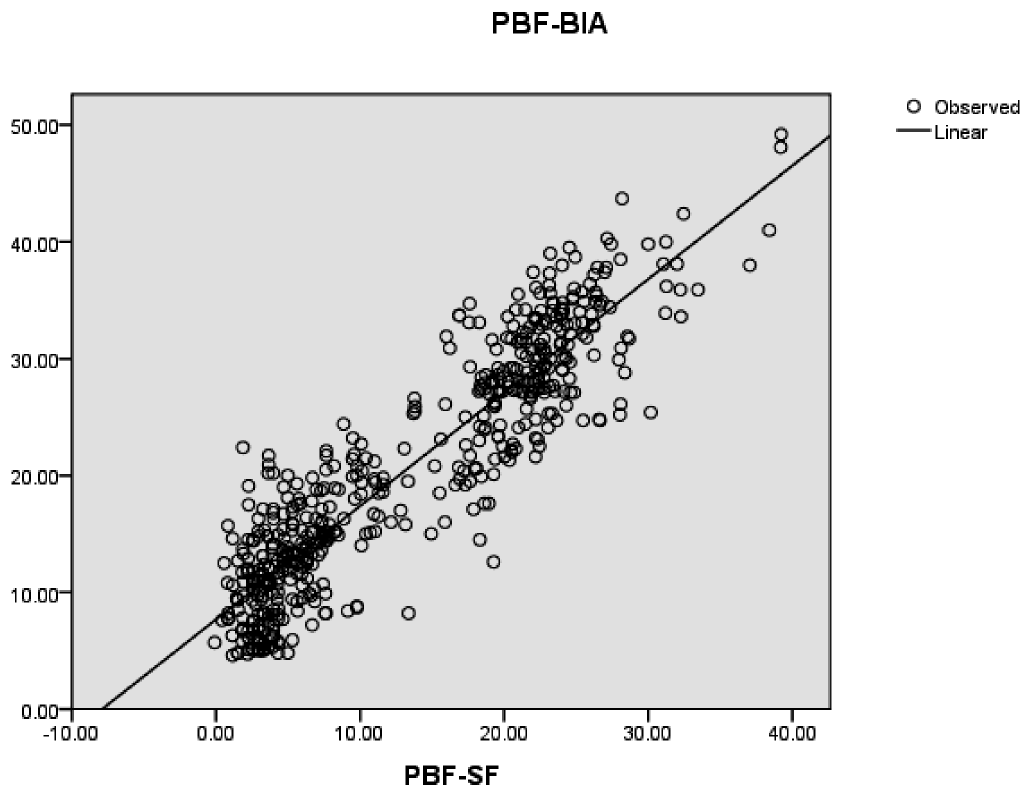

Figure 1. Scatter plot of the correlation between PBF (BIA) and PBF (SF).

Table 1. Description of Skinfold Sites and Procedures used in this study

Site	Direction of fold	Anatomical reference	Measurement
Triceps	Vertical	Acromial process of scapula and olecranon process of ulna	Posterior midline of the upper arm, halfway between acromion and olecranon processes, with the arm held freely to the side of the body.
Abdomen	Vertical	Umbilicus	2 cm to the right side of umbilicus.
Suprailiac	Diagonal	Iliac crest	In line with the natural angle of the iliac crest taken in the anterior axillary line immediately superior to the iliac crest.

Table 2. Participants' general characteristics, anthropometric and body composition

Variables	Male Mean ±SD	Female Mean ±SD	t-cal	p-value	All participants
Age (years)	21.57±2.25	21.43±2.35	0.726	0.468	21.5±2.3
Height (m)	1.73±0.06	1.65±0.06	14.783	0.001*	1.69±0.08
Weight (kg)	62.03±7.17	60.45±9.83	2.144	0.033*	61.28±8.56
BMI (kg/m^2)	20.71±2.03	22.18±2.98	-6.736	0.001*	21.41±2.62
LBM	54.02±5.57	42.22±4.97	-25.611	0.001*	48.43±7.92
BFM	8.03±3.60	18.23±6.34	-23.407	0.001*	12.86±7.20
PBF (BIA)	12.71±4.81	29.57±5.85	-36.369	0.001*	20.69± 9.97
PBF (SF)	5.28±3.27	22.42±4.31	-51.885	0.001*	13.4±9.37

Key: BMI = Body Mass Index; PBF (BIA) = Percent Body Fat by BIA; PBF (SF) = Percent Body Fat by Skinfold calliper; BIA = Bioelectric Impedance Analysis; SF = skinfold

* Indicates significant difference between groups

20.69± 9.97 vs. 13.4±9.37

Table 3. The mean and percentile data for PBF (BIA) of all the participants by age and gender

Age	Gender n	No.	Mean±S.D	minimum	25th percentile	median	75th percentile	95th percentile	maximum
PBF measured by BIA									
18 – 30yrs	M	280	12.71±4.81	4.60	8.90	12.70	15.80	20.90	31.40
18 – 30yrs	F	251	29.57±5.85	8.20	26.10	29.30	33.60	38.58	49.20
18 – 30yrs	M + F	531	20.69±9.97	4.60	12.40	19.70	29.1	36.15	49.20
PBF measured by Skin fold method									
18 – 30yrs	M	280	5.29±3.27	0.09	2.97	4.62	7.13	11.06	23.95
18 – 30yrs	F	251	22.42±4.31	12.82	19.57	22.21	24.35	31.11	39.22
18 – 30yrs	M + F	531	13.40±9.37	0.09	4.31	11.03	22.12	27.24	39.22

Table 4. Frequency distribution and Chi – Square test of association between gender and PBF levels

Lean Gender	Acceptable (%)	Moderate (%)	Overweight (%)	X^2 (%)	p – value	
PBF measured by BIA						
Male	126(96.9)	141(59.2)	13(14.4)	0(0)	2.403	0.001
Female	4(3.1)	97(40.8)	77(85.6)	73(100)		
Total	130(24.5)	238(44.8)	90(16.9)	73(13.8)		
PBF measured by skin fold method						
Male	273(93.8)	7(3.2)	0(0.0)	0(0.0)	436.12	0.001
Female	18(6.2)	210(96.8)	18(100)	5(100)		
Total	291(54.8)	217(40.9)	18(3.4)	5(0.9)		

NB: PBF classification for the general population benchmark (Woods, 2005)

Lean for male = < 12; Lean for female = < 17; Acceptable for male = between 12 – 21; Acceptable for female = between 17 – 28; Moderately overweight for male = between 21 – 26; Moderately overweight for female = between 28- 33; Overweight for male = > 26; and Overweight for female = > 33.

Table 5. Correlation matrix of the relationships among participantsgeneral characteristics and percent body fat is illustrated below (N = 531).

	Age	Height	Weight	LBM(BIA)	LBM(SF)	BFM(BIA)	BFM(SF)	PBF(BIA)	PBF(SF)	BMI
Age	1									
	0.001									
Height	0.101	1								
	0.019	0.001								
Weight	0.137	0.486	1							
	0.002	0.001	0.001							
LBM (BIA)	0.091	0.773	0.621	1						
	0.036	0.001	0.001	0.001						
LBM (SF)	0.121	0.732	0.709	0.947	1					
	0.005	0.001	0.001	0.001	0.001					
BFM (BIA)	0.065	-0.271	0.506	-0.361	-0.198	1				
	0.132	0.001	0.001	0.001	0.001	0.001				
BFM (SF)	0.026	-0.300	0.413	-0.398	-0.349	0.930	1			
	0.551	0.001	0.001	0.001	0.001	0.001	0.001			
PBF (BIA)	0.035	-0.473	0.208	-0.624	-0.469	0.935	0.885	1		
	0.420	0.001	0.001	0.001	0.001	0.001	0.001	0.001		
PBF (SF)	0.001	0.452	0.164	0.595	-0.569	0.848	0.952	0.912	1	
	0.999	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
BMI	0.089	-0.171	0.775	0.148	0.277	0.759	0.672	0.574	0.504	1
	0.040	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Table 6. Multiple regression model for PBF measured using BIA

Item	**Df**	**SS**	**MS**	**F**	**p**		
			Male Participants				
Multiple R	0.583	Regression	3	2186.918	728.973	47.168	0.001
R^2	0.340	Residual	275	4250.082	15.455		
Adjusted R^2	0.333						
SEE	3.93126						
			Female Participants				
Multiple R	0.714	Regression	3	4357.179	1452.393	85.515	0.001
R^2	0.509	Residual	247	4195.083	16.984		
Adjusted R^2	0.504						
SEE	4.12118						

p is significant at 0.05
Predictors: (Constant), Age, Weight and Height.
Prediction model for male – Y = B0 + B1 x 1 + B2 x 2 + B3 x 3;
Y = 44.998 + (-36.235) + (0.914) + (0.285);
PBF = 44.998 – 36.235 (Height) + 0.914(Weight) + 0.285(Age)

Prediction model for female – Y = B0 + B1 x 1 + B2 x 2 + B3 x 3
Y = 59.921 + (-38.098) + (0.976) + (0.414)
PBF = 59.921 – 38.098(Height) + 0.976(Weight) + 0.414(Age)
Keys: SS = Sum of Square; MS = Mean Square; SEE = Standard Error of Estimate

Table 7. Multiple regression model for BIA assessed using skinfold-thickness measurements

Item	Df	SS	MS	F	p		
			Male Participants				
Multiple R	0.701	Regression	3	1457.987	485.996	88.330	0.001
R^2	0.491	Residual	275	1513.070	5.502		
Adjusted R^2	0.485						
SEE	2.34565						
			Female Participants				
Multiple R	0.636	Regression	3	1874.945	624.982	55.901	0.001
R^2	0.404	Residual	247	2761.478	11.180		
Adjusted R^2	0.397						
SEE	3.34366						

p is significant at 0.05
Predictors: (Constant), Age, Weight and Height.

Prediction model for male – Y = B0 + B1 x 1 + B2 x 2 + B3 x 3
Y = 14.511 + (-17.428) + (0.756) + (-0.351)
PBF = 14.511 – 17.428(Height) + 0.756(Weight) – 0.351(Age)

Prediction model for female-Y = 27.676 + (-15.967) + (0.624) + (0.208)
PBF = 27.676 -15.967(Height) + 0.624(Weight) + 0.208(Age)
Keys: SS = Sum of Square; MS = Mean Square; SEE = Standard Error of Estimate

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