

Correlation of Percent Body Fat by Bioelectrical Impedance Analysis with Anthropometric and Metabolic Variables Among Adult Filipinos

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Abstract

Introduction: Bioelectrical impedance analysis (BIA) is a non-invasive method to assess percent body fat (PBF). PBF is the percentage of total body weight that is fat. In the Philippines, there are currently no local data for PBF measurement by BIA and their correlation with anthropometric and metabolic variables.

Objectives: To determine the correlation of PBF with other anthropometric (Body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR) and metabolic variables (fasting blood sugar (FBS), total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides, systolic blood pressure (SBP), diastolic blood pressure (DBP)) among adult Filipinos.

Methods: This is an analytical cross sectional study, which utilized records review of patients seen at weight management center, St.Luke's Medical Center-Quezon City from January 2013 to March 2014. We included adult Filipino patients age 18-70 year old with BMI 16-34 kg/m² in this study. Subjects taking anti-hypertensive, oral hypoglycemic agents, insulin, or lipid-lowering medications were excluded. Pearson correlation coefficients were computed to determine the correlation

of PBF with anthropometric and metabolic variables.

Results: A138 patients were included in the analysis. Only 98 patients had FBS and blood lipid examination. The mean PBF for women was 38.15±6.28% and men with 26.93±4.89%. PBF was significantly correlated with BMI,WC,and WHR for both sexes,with BMI having the strongest correlation ($r=0.902$ for men; $r=0.933$ for women). Among Filipino men, PBF had significant correlation only with SBP ($r=0.288$; $p=0.045$) and DBP ($r=0.511$; $p=0.000$). Among Filipino women, PBF had significant inverse correlation to HDL-C ($r=-0.321$; $p=0.013$) and positive correlation to SBP ($r=0.269$; $p=0.011$) and DBP ($r=0.275$; $p=0.009$). Using the multiple regression analysis, PBF had no significant contribution in explaining metabolic variables.

Conclusion: PBF measured by BIA has a strong and significant correlation with BMI and WC. However, PBF has no significance in predicting the level of FBS, serum lipids, and BP. Other anthropometric measurements (BMI,WC,WHR) were more likely to be useful for predicting metabolic variables than PBF measurements by BIA among adult Filipino.

Keywords: Bioelectrical Impedance Analysis, Percent Body Fat, Metabolic variables.

Introduction

Obesity is an important public health problem worldwide. The percentage of the world population diagnosed with obesity is alarmingly increasing. In the Philippines, the prevalence of obesity on 2003 was 4.9% by body mass index (BMI), and 10.2% and 65.6% by waist-hip ratio (WHR) in men and women respectively.¹ Excess adipose tissue is the primary characteristic of obesity. Studies have shown that the amount of adipose tissue and its central distribution are associated with hypertension, dyslipidemia, impaired fasting glucose, and insulin resistance, which lead to an increase risk of cardiovascular disease.²⁻³

Numerous techniques have been developed to assess adiposity. Anthropometric measurements such as BMI, waist

circumference (WC), and WHR remain the most feasible means for assessing body adipose tissue.

BMI is the most common method for estimating body fat. However, using BMI could not differentiate fat mass and lean mass. In addition to measuring BMI,⁴ WC and WHR are the most common anthropometric parameters used to identify and quantify intra-abdominal fat deposition. WC had higher correlations with Visceral Adipose Tissue (VAT) and health risks than BMI.⁵⁻⁶ WC alone is more strongly correlated with visceral fat than the WHR.⁷⁻¹⁰ Computed Tomography (CT) scan has been considered as the gold standard for body fat measurement.¹¹ Unfortunately, CT scan is costly and involve exposure to ionizing radiation. Thus it is often unsuitable for screening large groups of individuals.

Bioelectrical impedance analysis (BIA) is a simple and non-invasive method to assess fat accumulation. The time required for measurement is only a few minutes, and the instrument is inexpensive and portable. This method requires no advanced skills on the part of the operator, and subject cooperation is minimal. BIA is based on electric resistance difference between the fat and components of other organs.

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Fat within the body allows almost no electricity to pass through, while electricity pass rather easily through water, much of which is found in muscles. The percentage of fat and other body constituents can be inferred from measurement of this resistance. Percent body fat (PBF) is the percentage of total body weight that is fat. In a study by Ryo et al., there was an excellent correlation between BIA method and CT scan in estimating visceral fat accumulation.¹²

In a study done by Salomon et al., they found out that visceral fat thickness by ultrasonography has a strong correlation with the WC and weak correlation with blood pressure, fasting blood sugar (FBS), high-density lipoprotein cholesterol (HDL-C), and triglyceride among adult urban Filipinos.¹³ However, there is still no data of PBF measurement by BIA in adult Filipinos and their correlation with anthropometric and metabolic variables.

Objectives

The primary objective of this study is to determine the correlation between PBF and other anthropometric variables (BMI, WC, WHR); and to determine the correlation between PBF and metabolic variables (FBS, total cholesterol, HDL-C, Low Density Lipoprotein (LDL-C), triglycerides, Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP)) among adult Filipinos.

The secondary objective is to compare the strength of correlation between these four anthropometric variables (PBF, BMI, WC, and WHR) with metabolic variables.

This research studies the correlation of PBF and the metabolic variables with major premises as follows: 1) there is a strong correlation between PBF and other anthropometric variables, 2) the presence of high PBF would result in an increase of metabolic variables (except for HDL-C), and 3) PBF, compared with other anthropometric variables, would have the strongest correlation with metabolic variables.

Methodology

Research Design and Study Population:

This study is an analytical cross sectional study which utilized records review of patients seen at Weight Management Center, St.Luke's Medical Center – Quezon City from January 2013 to March 2014, who have anthropometric measurements, BIA, blood pressure, FBS, and serum lipid results taken during their visit.

We included adult Filipino patients age 18-70 year old with BMI 16-34 kg/m² in this study. Subjects taking anti-hypertensive, oral-hypoglycemic agents, insulin, or lipid-lowering medications were excluded.

Anthropometric measurements included weight, height, waist and hip circumferences. Using calibrated electronic scales, weight was obtained while subjects wore light clothing and no shoes; height was measured with a fixed

stadiometer. BMI was calculated as weight divided by height squared. WC was measured midway between the bottom of the ribcage and the top of the iliac crest. Hip circumference (HC) was measured at the level of maximum size of the buttocks. WHR was calculated as WC divided by HC.

PBF was determined using 8-electrode BIA (Tanita, Model BC-418). Subjects' weight, height, age, and sex were entered into the BIA machine for analysis with the measured bioelectrical impedance to calculate body composition from the manufacturer's equations.

Statistical Analysis

Descriptive statistics were used to analyse the demographic and clinical data of the patients. Qualitative data were described using the percentages while quantitative data were described using the mean and standard deviation. Data were analysed separately in men and women because of the presumed significant differences in body fat distribution between the sexes.

Pearson correlation coefficients were computed to determine the relationship between PBF with anthropometric variables (BMI, WC, WHR). In addition, Pearson correlation coefficients were computed to determine the relationship between PBF and anthropometric variables (BMI, WC, WHR) with metabolic variables (total cholesterol, HDL-C, LDL-C, triglycerides, FBS, SBP, and DBP).

Data analysis was done using the SPSS version 21. Multiple regression analysis was used to relate each metabolic variable to all anthropometric parameters simultaneously. A p-value of less than or equal to 0.05 means that there is sufficient evidence that the independent variables (sex, BMI, WC, WHR, PBF) have significant contribution in explaining the dependent variables (total cholesterol, HDL-C, LDL-C, triglycerides, FBS, SBP, and DBP).

Results

Based on our inclusion and exclusion criteria, 138 participants were included in the study. Their data were analysed to determine the relationship between PBF with anthropometric variables (BMI, WC, WHR).

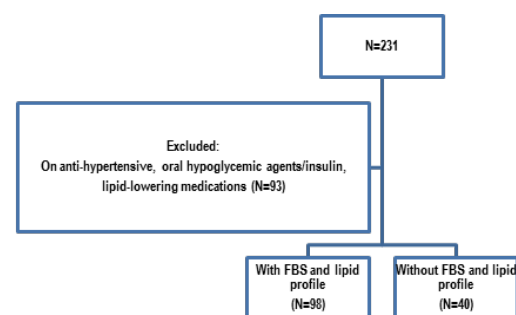


Figure 1. Patients seen at weight management center, St.Luke's Medical Center – Quezon City from January 2013 to March 2014

Table I. Characteristics of study participants

	Sex		p-value
	Women (n=89)	Men (n=49)	
	Mean + SD	Mean + SD	
Age (year)	44.28 + 14.22	45.59 + 14.91	0.611
Weight (kg)	63.93 + 11.27	80.52 + 12.99	0.000
Height (cm)	155.44 + 5.61	169.26 + 5.67	0.000
BMI (kg/m ²)	26.41 + 4.16	28.07 + 3.93	0.024
WC (cm)	88.87 + 9.4	97.3 + 12.32	0.000
HC (cm)	100.01 + 8.91	103.06 + 8.04	0.055
WHR	0.89 + 0.06	0.95 + 0.06	0.000
Percent Body Fat (%)	38.15 + 6.28	26.93 + 4.89	0.000
FBS (mg/dL)	95.53 + 18.03	107.69 + 28.69	0.011
Total Cholesterol (mg/dL)	209.58 + 38.91	198.74 + 41.7	0.193
LDL-C (mg/dL)	131.25 + 33.41	130.33 + 31.76	0.892
HDL-C (mg/dL)	55.39 + 13.89	45.08 + 11.01	0.000
Triglycerides (mg/dL)	132.7 + 65.48	132.82 + 61.66	0.992
SBP (mmHg)	113.82 + 11.92	117.14 + 13.07	0.132
DBP (mmHg)	76.18 + 7.91	77.35 + 8.11	0.412

Forty patients did not have FBS & lipid profile results. Hence, their data were not included in the analysis to determine the relationship between PBF and total cholesterol, HDL-C, LDL-C, triglycerides, FBS, SBP, DBP (metabolic variables). (Figure 1)

The average age of the women was 44.28+14.22 years while average age of men was 45.59+14.91 years. Men had significantly higher anthropometric variables values, except for PBF (mean PBF for women 38.15+6.28% vs men 26.93+4.89%). There is no significant difference of metabolic variables between men and women, except for HDL-C and FBS (mean HDL-C was higher among women (55.39+13.89 mg/dL vs 45.08+11.01 mg/dL; $p=0.000$). In contrast, the average FBS was higher among men (107.69+28.69 mg/dL vs 95.53+18.03 mg/dL; $p=0.011$) (Table I).

PBF was significantly correlated with BMI ($p=0.000$ for men & women), WC ($p=0.000$ for men & women), and WHR ($p=0.000$ for men, $p=0.014$ for women). Strongest correlation was observed between PBF and BMI ($r=0.902$ for men; $r=0.933$ for women). Among women, the PBF and WHR had lowest correlation coefficient ($r=0.259$) but it was statistically significant ($p=0.014$). (Table II)

Among Filipino men, PBF had significant correlation only with SBP ($r=0.288$; $p=0.045$) & DBP ($r=0.511$; $p=0.000$). There was no significant correlation between anthropometric variables with serum lipid. Only WHR had significant correlation with FBS

Table II. Correlation coefficient of BMI, WC, WHR with PBF

	Men		Women	
	R	P	R	P
BMI	0.902	0.000**	0.933	0.000**
WC	0.822	0.000**	0.787	0.000**
WHR	0.699	0.000**	0.259	0.014*

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

($r=0.363$; $p=0.023$). Its correlation was positive, implying that higher WHR is associated with higher FBS and vice versa. All anthropometric variables had significant positive correlation with SBP & DBP, but the correlation was moderately weak to moderately strong (Table III).

In Filipino women, PBF had significant inverse correlation to HDL-C and positive correlation to SBP and DBP. HDL was negatively correlated with BMI and PBF, which means higher BMI and PBF were associated with low HDL-C. BMI was the strongest determinant of HDL-C.

BMI showed significant inverse correlation with total cholesterol. There was no significant correlation of anthropometric variables with FBS, LDL-C, and triglyceride. SBP had significant positive correlation with BMI, WC, and PBF. Moreover, DBP was significantly correlated with all anthropometric variables. (Table IV)

We also performed multiple regression analysis to further study the relationship between anthropometric and metabolic variables. Using the multiple regression analysis, PBF had no significant contribution in explaining any of metabolic variables. WHR was the variable that appeared to be significantly contributing in explaining FBS ($\beta=0.524$; $p=0.000$) and triglyceride ($\beta=0.478$; $p=0.002$). Higher WHR had an expected higher FBS and triglyceride.

WC had significant correlation with HDL-C ($\beta=0.487$; $p=0.006$) and triglyceride ($\beta=-0.502$; $p=0.009$). However, WC was positively correlated with HDL ($\beta=0.487$). When WC was high, then HDL was expected to be high as well. On the other hand, people with lower WC had expected higher triglycerides ($\beta=-0.502$). BMI had significant correlation with HDL-C with a negative coefficient estimate ($\beta=-0.470$; $p=0.023$), implied that high BMI was associated with low HDL fixing other independent variables. None of the independent variables had significant correlation with total cholesterol, LDL-C, SBP, and DBP.

Discussion

In this study, we analysed the correlation between PBF measured by BIA, with anthropometric and metabolic

Table III. Correlation coefficient of PBF and anthropometric variables with metabolic variables in men

Men	FBS		Total Cholesterol		LDL-C		HDL-C		Triglyceride		SBP		DBP	
	r	P	R	P	R	P	R	P	R	P	R	P	R	P
BMI	-0.01	0.622	-0.058	0.728	-0.119	0.471	-0.092	0.579	0.233	0.153	0.294	0.04*	0.548	0.000**
WC	0.008	0.961	-0.069	0.675	-0.129	0.432	0.109	0.510	0.009	0.957	0.311	0.03*	0.405	0.004**
WHR	0.363	0.023*	-0.079	0.632	-0.06	0.718	-0.192	0.241	0.303	0.061	0.423	0.002**	0.373	0.008**
PBF	-0.010	0.951	-0.096	0.560	-0.123	0.455	-0.116	0.482	0.174	0.288	0.288	0.045*	0.511	0.000**

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table IV. Correlation coefficient of PBF and anthropometric variables with metabolic variables in women

Women	FBS		Total Cholesterol		LDL-C		HDL-C		Triglyceride		SBP		DBP	
	R	P	R	P	R	P	R	P	R	P	R	P	r	p
BMI	-0.187	0.155	-0.277	0.034*	-0.234	0.075	-0.395	0.002**	0.081	0.540	0.218	0.04*	0.264	0.012*
WC	-0.095	0.476	-0.146	0.270	-0.167	0.206	-0.150	0.256	0.079	0.554	0.342	0.001**	0.323	0.002**
WHR	0.191	0.148	0.140	0.291	0.154	0.243	0.042	0.749	0.177	0.181	0.170	0.112	0.235	0.027*
PBF	-0.214	0.103	-0.180	0.173	-0.190	0.151	-0.321	0.013*	0.140	0.289	0.269	0.011*	0.275	0.009**

** Correlation is significant at the 0.01 level (2-tailed).

variables in 138 patients who were seen at weight management center. The results of our study showed that PBF has a significant correlation with other anthropometric variables (BMI, WC, and WHR). However, simple anthropometric measurements (BMI, WC, and WHR) had better correlation with metabolic variables than PBF measurements by BIA.

We limited the inclusion criteria to subjects with age 18-70 year-old. Changes in body composition occur as part of the normal aging process. In elderly, the amount of lean body mass decreases with age, a process called sarcopenia.¹⁴ Data from the Rosetta Study show that older adults have, on average, more fat than younger adults at any given BMI.¹⁵ The predictive equations which may have been derived in populations of younger ages, might be less valid in elderly individuals. Hence, we included the subjects with maximum age of 70 year-old.

We only included patients with BMI 16-34 kg/m² in this study. Clinical use of BIA in subjects at extremes BMI ranges cannot be recommended for routine assessment and it should be interpreted with caution. BIA results are affected by tissue hydration in severely malnourished patients.¹⁶ The overall effect of severely obese state is overestimation of fat-free mass, and thus an underestimation of PBF.¹⁷

The result of current study demonstrated that PBF had strong and significant correlation with BMI (r=0.902

for men; r=0.933 for women) and WC (r=0.822 for men; r=0.787 for women) among adult Filipino. Among the three anthropometric measurements (BMI, WC, and WHR), BMI had the strongest correlation with PBF. In addition, it is noteworthy that these degrees of correlation differed between the sexes. This agrees with the study by Kobayashi et al., who demonstrated the strong correlation of PBF and BMI among Japanese population (r=0.813 for men; r=0.888 for women).¹⁸ On the other hand, a previous study by Ozenoglu et al showed only moderately strong correlation between PBF with BMI (r=0.584) & WC (r=0.598) among female subjects.¹⁹ Study by Lemos-Santos et al., had similar findings with our study wherein PBF was less correlated with WHR (r=0.55) compared with WC (r=0.90) among Brazilian men.²⁰

We used a regression-based approach to analyze our data. Using a regression-based approach, our findings did not show any significant correlation between PBF with FBS and serum lipids. The limitation of PBF as a predictor of metabolic variables may be attributed to the different contribution of subcutaneous adipose tissue (SAT) and VAT to metabolic dysregulation. Ribeiro-Filho et al. compared several methods for assessing visceral fat with CT scan. They found out that BIA is not useful for visceral fat identification and it showed correlation only with subcutaneous fat.²¹ In some cross-sectional studies, peripheral fat showed low contribution to health risks or even a protective effect.²²⁻²⁴

Hence, percent fat as a global measure of adiposity, may not optimally reflect health risks. PBF measurement by BIA was not useful as predictors of lipid profile and insulin resistance among Singaporean Chinese population.²⁵ This finding was similar with our study's results. However, PBF was significantly correlated with FBS and serum lipids, except for HDL-C, among Japanese. Nevertheless, our data agrees that PBF was not a good predictor of BP.¹⁸ In a study by Ozenoglu et al, among female subjects, PBF were found significantly correlated only with HDL-C ($\beta=0.193$, $p=0.01$), while it had no significant correlation with triglyceride ($\beta=-0.059$, $p=0.408$).¹⁹ The inhomogeneous nature of the various body compartments and large variations in cross-sectional areas are likely responsible for the lack of portability of BIA usage from one population to another. Therefore, there were different results between our study and previous studies.

In contrast, our data showed that simple anthropometric measurement (BMI, WC, and WHR) had more significant contribution than PBF to predict metabolic variables. Previous studies, which have found that PBF measurement by BIA, as a direct indication of adiposity, has no advantage over indirect indices of obesity (BMI, WC, WHR) in the assessment of obesity-related metabolic risk.^{18,25,26,27} Anthropometric measures that take into account the distribution of adiposity, specifically abdominal/visceral adiposity (i.e. WC or WHR), have a stronger association with cardiovascular disease risk factors. Similar with our findings, WHR was the best predictor for fasting triglyceride among Singaporean Chinese.²⁵ HDL-C was also more closely associated with BMI than was PBF by BIA among Japanese population.¹⁸ Patients with increased intra-abdominal fat usually have an atherogenic lipid profile, high FBS, and high BP. These factors contribute to the occurrence of CHD, stroke, or peripheral vascular disease.²⁸ The mechanism of action for the deleterious effects of visceral fat has been suggested to be related to its anatomical location. Adipose tissue located within the abdominal cavity releases high levels of fatty acids into portal circulation.²⁹ In visceral fat, mobilization of free fatty acids is faster because of higher lipolytic activity in visceral adipocytes. Increased delivery of free-fatty acids to the liver is associated with increased hepatic gluconeogenesis, VLDL synthesis, and insulin resistance.³⁰

A major limitation of this study is the cross sectional design. Therefore, caution should be taken when making conclusions regarding the relative importance of PBF and other anthropometric variables in predicting metabolic variables. In addition, our study results should still be viewed with caution because of the relatively small numbers of subjects. Clearly, longitudinal studies with larger numbers of participant are needed to confirm our findings. Other limitation of this study is related to the exclusion of subjects taking anti-hypertensive, oral hypoglycemic agents, insulin, or lipid-lowering medications. They could be classified as having metabolic syndrome. Exclusion of these subjects may cause underestimation of the PBF ability in predicting metabolic variables.

Conclusion

From this study, it can be concluded that PBF measured by BIA has a strong and significant correlation with BMI and WC among adult Filipino population. However, PBF has no significance in determining the level of FBS, serum lipids, and BP. We confirmed that simple anthropometric measurements were more likely to be useful for predicting metabolic variables than PBF measurements by BIA. Therefore, we recommend measuring WC, WHR, or BMI in evaluating obesity-related risk factors for cardiovascular disease among adult Filipino population, especially for large epidemiologic studies consisting of thousands of participants, considering the ease of measurement and low cost.

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