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Research Article

Validation of the Ejike-Ijeh equations for the estimation of body fat percentage: A random cross-sectional study in adult Nigerians

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ABSTRACT: **The Ejike-Ijeh equations for the estimation of body fat percentage makes it possible for the body fat content of individuals and populations to be determined without the use of costly equipment. However, because the equations were derived using data from a young-adult (18-29 years old) Nigerian population, it is important to validate the equations in a wider spectrum of adults. This study is an attempt at such validation. A total of 365 adult Nigerians aged 18 to 80 years (52.9% females) participated in this random cross-sectional study. Standard internationally accepted protocols were followed for all determinations and calculations. Appropriate statistical tools were used to analyse the data generated. The mean age of the subjects was 44±16 years. The differences between the mean ages of both sexes was not statistically significant (*P*>0.05). Using BMI as a diagnostic, obesity was found in 12.3% of the population (17.1% in females and 7.0% in males). On the other hand, using percent fat mass (PFM), 16.4% (25.4% females and 6.4% males) were found to be obese. Measured PFM correlated positively and significantly (r=+0.635; *P*<0.001) with the PFM-II in the general population. The correlations were stronger in males (r=+0.736) compared to females (r=+0.563). The Ejike-Ijeh equations appear valid for use in adult Nigerians.**

KEYWORDS: **Body fat, obesity, prediction equations, validation.**

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INTRODUCTION

Globally, as at 2014, there were an estimated 1.9 billion overweight adults and 600 million of these were obese. This represents a more than 2-folds increase from 1980 figures (WHO, 2015). As at 2010 the World Health Organisation estimated that the prevalence of overweight and obesity among adults in sub-Saharan Africa exceeded 60% in men, and 70% in women (Ono *et al.*, 2012). Obesity, without doubt, is currently a public health challenge not just globally, but also in Nigeria (Ejike and Ijeh, 2012). What is more worrisome however is that obesity is linked to an array of chronic diseases, ranging from diabetes mellitus to cancers (Ejike and Ezeanyika, 2008; Bastien *et al.*, 2014).

The body mass index (BMI) is the most widely used index for the diagnosis of obesity. This is due to its simplicity, wide acceptability, and non-requirement of elaborate equipment (Shah and Braverman, 2012). However, BMI neither distinguishes between the lean muscle and fat mass, nor accounts for important contributors to weight such as bone density and blood volume. These limit its utility when quantifying body composition (Bogin and Varela-Silva, 2012). Misclassifications of healthy adults, with more lean muscle mass are therefore fairly common when using BMI. Since the measurement of excess adiposity, not just excess weight is key to identifying individuals truly at risk health-wise, the use of technologies such as underwater weighing, dual-energy X-ray absorptiometry (DXA), bio-electrical impedance analysis (BIA), etc., which define adiposity better than the anthropometric indices (in current use) is warranted. Unfortunately, such technologies are not widely used in epidemiological studies, especially in resource-poor settings such as sub-Saharan Africa, due to constraints of cost and complexity-of-operation (Mei *et al.*, 2002).

Taking the above into cognizance, Ejike and Ijeh (2012) developed equations for the estimation of fat mass using age, sex and anthropometric variables, thus:

Percent Fat Mass (PFM) =

1. 19.524 + 0.174(BMI) + 0.110(Age) – 0.440(Sex); and
2. 8.870 + 0.186(WC) + 0.158(BMI) + 0.098(Age) – 0.488(Sex); where sex = 0 for females and 1 for males; and WC represents waist circumference

The said equations were however derived from data obtained from young adult (18-29 years old) Nigerians, and therefore requires validation in a wider spectrum of adults, hence this study.

SUBJECTS AND METHODS

This is a re-analysis of data collected for a study of the prevalence of impaired glucose tolerance and diabetes mellitus in a population of adult Nigerians. The subjects for the study and relevant methods are as described by Ejike *et al.* (2015). Briefly however, apparently healthy subjects in Umudike, a University town in Abia State, Nigeria, aged 18 years and older, were randomly recruited. Informed consent was obtained from all study participants. The study was carried out between the months of August and September 2014, and the design was in accordance with the Helsinki declaration.

Definitions

Overweight and obesity were defined by two definitions, viz: (1) BMI ≥ 25 but < 30 (overweight) and BMI ≥ 30 (obese) (WHO, 1998); and (2) PFM ≥ 32.0% (overweight) and ≥ 37.1% (obese) in black females and ≥ 21.7% (overweight) and ≥ 28.3% (obese) in black males (Zhu *et al.*, 2003).

Statistics

The estimated percent fat mass (PFM) of the subjects were calculated based on the Ejike-Ijeh equations, to give calculated PFM-I and calculated PFM-II, respectively. Descriptive statistics and frequency counts were done on the data generated and the results reported as means ± standard deviations and percentages, respectively. Pearson's correlation coefficients were calculated to assess the correlation between measured and calculated PFM. Differences between group means were separated (where necessary) using One-Way analysis of variance (ANOVA). The significant threshold for all analyses was fixed at $P < 0.05$. Data analyses were carried out using the statistical software IBM-SPSS version 20.0 (IBM Corp., Atlanta, GA) while graphs were plotted, and estimated PBF calculated, using Microsoft Excel (Microsoft Corp., Redmond, WA).

RESULTS AND DISCUSSION

The mean age and weight of the male and female subjects were statistically similar ($P > 0.05$). The females were however significantly ($P < 0.05$) shorter, and had significantly ($P < 0.05$) higher values for all the other determined values compared to the males (Table 1). Being shorter than the males while having comparable weights necessarily implies that the BMI and waist-to-height ratio (WHtR) of the females would be higher than those of the males. Again, it is in consonance with the female body habitus that they have wider waist and hip circumferences, and thus higher WHtR and waist-to-hip ratio (WHpR) compared to the males. Irrespective of the diagnostic used, only 61-68% of the population had normal weight, the rest were either overweight or obese. By BMI standards, 12.3% of the population (17.1% females and 7.0% males) were obese; while by PFM standards, 16.4% (25.4% females and 6.4% males) were obese. The BMI standards however diagnosed more people as overweight compared to the PFM standards (though when split along sex lines, this is valid for only males) (Figure 1). Ono *et al.* (2012) had reported that 29% of Nigerian men and 45.1% of their women were obese.

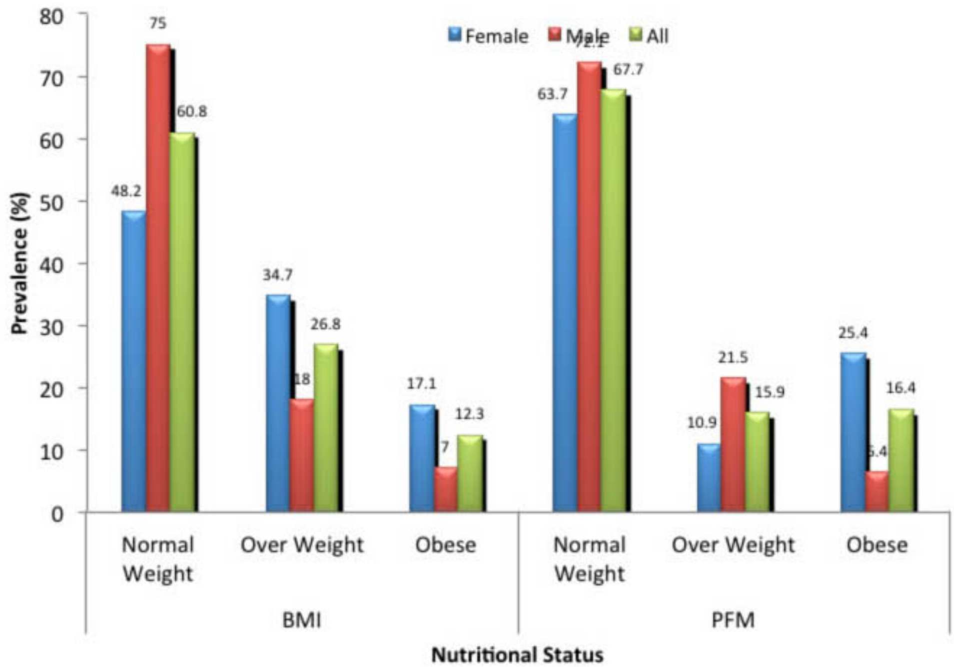

Figure1: Prevalence of overweight and obesity defined by BMI and PFM standards

A more recent study, in Nigeria, reported obesity in 15% and 42% in adult men and women respectively (Akarolo-Anthony *et al.*, 2014). The figures reported in this population are therefore lower than previous reports in adult Nigerians, but higher than the 1.3% (determined by BMI) and 8.9% (determined by PFM) reported in young-adult Nigerians (Ejike and Ijeh, 2012).

The female preponderance of overweight and obesity and the variations in the prevalence of the disorders as diagnosed by different tools are consistent with previous reports in Nigeria and elsewhere. However, some studies have reported a significant concordance between BMI determined obesity and percent fat mass-defined obesity (Frankenfield *et al.*, 2001). Nonetheless, BMI's inability to identify differences in body composition and body fat distribution remain its greatest challenge (Bogin and Varela-Silva, 2012). Consequent upon this shortcoming, and because it is possible for an individual to be obese yet lacking in the metabolic markers of adverse health risk, BMI-metabolic risk sub-phenotypes have been reported, even in Nigeria (Ejike *et al.*, 2009; Ijeh *et al.*, 2010).

The Ejike-Ijeh equations included age and sex which are not anthropometric variables. Their use is justifiable especially since many cross-sectional and longitudinal studies show that PFM increases with age in both males and females (Sun *et al.,* 2005) but it is usually higher in females relative to males (Zhu *et al.*, 2003) [a fact that this and the Ejike and Ijeh (2012) studies corroborate]. Data from the validation study shows that measured PFM correlated positively, significantly, but weakly with calculated PFM-I; and positively, significantly and strongly with calculated PFM-II, in the general population. The correlations were stronger in the males, irrespective of the equation used, and between measured PFM and calculated PFM-II, irrespective of sex (Table 2). Implicit in these data is that the Ejike-Ijeh equations (especially equation 2) are valid for use in adult Nigerians. The equations apparently would help in situations where the BIA machine or other such sophisticated apparatus are not available but adiposity (not just excess weight) needs to be measured. This is particularly important especially as it is now known that the health risks associated with obesity are in fact due to excess adiposity. The adipose tissues are sites for the synthesis of chemokines that have significant impacts in health and disease (Ijeh *et al.,* 2010). Implicit in this is that the determination of the degree of adiposity is superior to anthropometric measurements/determinations such as the BMI and WC in both the diagnosis of obesity and the monitoring of progress in subjects undergoing therapy.

Table 1: Age and relevant anthropometric characteristics of the studied population

	Age (Yrs)	Height (m)	Weight (kg)	BMI (kg/m^2)	PFM (%)	WC (cm)	HC (cm)	WHtR	WHpR
Females (N=193)	43±16	1.6±0.8	67.1±12.6	25.4±4.7	30.9±8.7	84.5±12.5	98.2±9.7	0.52±0.08	0.86±0.08
Males (N=172)	46±17	1.7±0.8	69.0±18.4	23.6±6.0	18.6±6.8	77.5±9.4	92.2±7.9	0.45±0.06	0.84±0.06
P	0.059	<0.001	0.233	0.001	<0.001	<0.001	<0.001	<0.001	0.009
All (N=365)	44±16	1.7±0.9	68.0±15.6	24.6±5.5	25.2±10.0	81.2±11.7	95.4±9.3	0.49±0.08	0.85±0.07

BMI, PFM, WC, HC, WHtR and WHpR represent body mass index, percent fat mass, waist circumference, hip circumference, waist-to-height ratio and waist-to-hip ratio respectively

Table 2: Correlations between measured and derived percent fat mass

		Calculated PFM 1	Calculated PFM 2
Measured PFM; r (*P*)	Females (N=193)	+0.385 (<0.001)	+0.563 (< 0.001)
	Males (N = 172)	+0.625 (<0.001)	+0.736 (<0.001)
	All (N=365)	+0.467 (<0.001)	+0.645 (< 0.001)

PFM represents percent fat mass

These equations therefore bode well for both the study and management of obesity and its co-morbid conditions especially in economically under-developed or developing countries. Larger validation studies especially in different ethnic groups, socio-economic classes and places of domicile are nonetheless warranted before the equations can be adopted for use in epidemiological studies. This is important because it is known that the distribution of adipose tissues vary in both quantity and location across different ethnic/racial groups. A factor such as WC which is central to equation 2 may therefore need to be ethnic/race-specific, or ethnicity/race may have to be represented in the equations with numbers, just like is the case with sex.

This study is limited by the small sample size which makes it difficult to study the performance of the equations within narrow age-ranges (as such age ranges would have too few subjects to make any statistical sense). It is however hoped that it would enkindle research and funding interests in this direction such that larger studies can be carried out and ultimately affordable diagnostics could become available especially in countries such as Nigeria where communicable diseases still command more attention, relative to chronic diseases.

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Conflict of Interests

The authors have no real or potential conflicts of interest to declare.

REFERENCES

Akarolo-Anthony SN, Willett WC, Spiegelman D and Adebamowo CA. (2014) Obesity epidemic has emerged among Nigerians. *BMC Public Health*, **14**:455 doi:10.1186/1471-2458-14-455

Bastien M, Poirier P, Lemieux I, Després J-P. (2014) Overview of epidemiology and contribution of obesity to cardiovascular disease. *Prog Cardiovasc Dis*; **56**:369-381

Bogin B, Varela-Silva I. (2012) The Body Mass Index: the Good, the Bad, and the Horrid. *Bull Suisse Soc Anthropol*; **18**: 5–11

Ejike CECC, Ezeanyika LUS. (2008) Metabolic syndrome in sub-Saharan Africa: 'Smaller twin' of a region's prostatic diseases? *Int Urol Nephrol*; **40**: 909-920

Ejike CECC, Ijeh II. (2012). Obesity in young-adult Nigerians: Variations in prevalence determined by anthropometry and bioelectrical impedance analysis, and the development of % body fat prediction equations. *Int Arch Med*; **5**: 22 doi:10.1186/1755-7682-5-22

Ejike CECC, Ugwu CE, Ezeanyika LUS. (2009) Nutritional status, prevalence of some metabolic risk factors for cardiovascular disease and BMI-metabolic-risk sub-phenotypes in an adult Nigerian population. *Biokemistri*; 21: 17-24

Ejike CECC, Uka NK and Nwachukwu SO. (2015) Diabetes and pre-diabetes in adult Nigerians: Prevalence, and correlations of blood glucose concentrations with measures of obesity. *Afr J Biochem Res* **9**:55-60

Frankenfield DC, Rowe WA, Cooney RN, Smith JS, Becker D. (2001) Limits of body mass index to detect obesity and predict body composition. *Nutrition*; **17**:26-30

Ijeh, II, Okorie U, Ejike CECC. (2010) Obesity, metabolic syndrome and BMI-metabolic-risk sub-phenotypes: a study of an adult Nigerian population. *J Med Med Sci*; **1**: 254-260

Mei Z, Grummer-Strawm LM, Pietrobelli A, Goulding A, Goran MI, Dietz WH. (2002) Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. *Am J Clin Nutr*; **75**: 978-985

Ono T, Guthold R, Strong K. (2012) *WHO Global Comparable Estimates: Global Infobase data for saving lives 2005. Available at* https://apps.who.int/infobase/Index.aspx.

Shah NR, Braverman ER. (2012) Measuring adiposity in patients: the utility of body mass index (BMI), percent body fat, and leptin. *PLoS ONE*; **7**:e33308.

Sun G, French CR, Martin GR, Younghusband B, Green RC, Xie YG, Mathews M, Baron JR, Fitzpatriv DG, Gulliver W, Zhang H. (2005) Comparison of multifrequency bioelectrical impedance analysis with dual-energy X-ray absorptiometry for assessment of percentage body fat in a large, healthy population. *Am J Clin Nutr*, **81**:74–78.

World Health Organization. (1998) Obesity: preventing and managing the global epidemic. Report of a WHO consultation on obesity. WHO, Geneva.

World Health Organization. (2015) Overweight and Obesity. WHO factsheet number 311 available at http://www.who.int/mediacentre/factsheets/fs311/en/ accessed 05/04/2015

Zhu S, Wang Z, Shen W, Heymsfield SB, Heshka S. (2003) Percentage body fat ranges associated with metabolic syndrome risk: results based on the third National Health and Nutrition Examination Survey (1988-1994). *Am J Clin Nutr*; **78**: 228-235